THE TORKILDSEN PROCEDURE
A REPORT OF 19 CASES*

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Some ten years have elapsed since Torkildsen performed his new palliative operation for by-passing Sylvian aqueductal obstruction. On September 9, 1937,24 he carried out a ventriculocisternostomy on a 36-year-old man with an inoperable occlusive lesion of the aqueduct of Sylvius. This release of the acquired hydrocephalus was accomplished by inserting one end of a rubber catheter into the posterior horn of the lateral ventricle and carrying the tube beneath the scalp, over the lateral sinus, and suturing its distal end into the cisterna magna. While this operation has been liberally adopted by neurosurgeons, their results and experiences with few exceptions have not been reported in the literature. The authors’ experiences in 19 cases suggested that the procedure in certain types of aqueductal obstruction is most effective, that in certain other instances it may be helpful and in some cases it would appear that it was neither indicated nor helpful. In evaluating this procedure properly it is necessary to refer to shunting operations in vogue prior to Torkildsen’s contribution and to give credit to Hyndman’s12 later employment of the choroid plexus as a method of treating hydrocephalus. This delving into the previous and subsequent surgical procedures that have had as their goal a release of cerebral ventricular hypertension found us involved in the etiologies of Sylvian aqueductal obstruction. A historical review of the procedures designed to release a ventricular hydrocephalus, Torkildsen’s original and subsequent contributions,25,26,27 the results, conclusions and ideas of the essayists gained from a study of their personal experiences in this shunting operation are to be set forth. It is calculated that if the pooled results of neurosurgeons using this procedure were collected, the evaluation of the operation would be more effective. Like Cushing’s recommendation in 192319 regarding the problem of subdural hematomas, the suggestion is a good one but it will likely remain that individual experiences and not collective case reports will write the history of the score of shunting operations.

At the Eighth Congress of Scandinavian Neurologists (1938) Torkildsen24 reviewed the postoperative results in his 3 cases—2 of aqueductal neoplastic occlusion and 1 of a third ventricle glioma. In all 3 there was complete relief of pressure symptoms without untoward surgical complications.

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Four additional cases had been added by 1941,27 2 of tumors of the third ventricle, 1 of a pinealoma, and 1 of an acquired obstructive hydrocephalus of undetermined origin. These seven cases constitute the largest postoperative study yet reported. In 1941 all patients were alive, free from symptoms and working except the original one, who died 6 months after operation of a midbrain glioma. Of the 6 living, 5 had been followed 2 to 4 years subsequent to suboccipital decompression, short-circuiting the spinal fluid, and X-ray treatment in Cases 3 and 6.

Penfield17 in 1942 reported a case of infiltrating glioma of the posterior part of the third ventricle arising from the right thalamus with relief of pressure symptoms following a Torkildsen procedure. A follow-up study was not reported. During the shunting procedure Penfield manipulated the patient’s head in all possible directions to determine the effects of this movement on the catheter. Since the tube is entirely above the highest movable joint, no disturbance of the tube occurred with any head motions. This led to the suggestion that a flexible metal tube could be used in lieu of the rubber catheter. Although pathological studies of the sinus tracts produced by a rubber catheter reveal only a fine smooth, collagenic rim in the wall of the sinus with minimal gliosis in the chronic cases, in more acute cases there are variably sized collections of lymphocytes and polymorphonuclear cells in the neighborhood of the tract. In our Case 15, in which a histologic examination was made 5 days after the catheter had been sutured in place, masses of neutrophilic invasion and early glial proliferation were dominant. Although laboratory cultures and microscopic studies of smears were negative for any organism in this case, it was our suspicion that infection was present. In another of our cases, autopsy was performed 12 months after the rubber tube ventriculocisternostomy, and only gliotic activity was evident histologically.

In 1944, Oldberg15 reported roentgenographic evidence of relief of chronically increased intracranial pressure following a Torkildsen operation. The patient was a 19-year-old girl, and at the time of this report she had been relieved of her ventricular hypertension for a period of 21 months. The etiology was an atresia of the aqueduct of Sylvius. Follow-up films of the skull depicted a complete recalcification of the pressure digital markings and a recession of the suture line separations. Wilson20 found this same radiologic change in 1 of his cases, and we have been able to verify it in 2 of our cases (1 and 2). Another objective sign of decreased ventricular hypertension following ventriculocisternostomy was observed in our Case 13. This patient on follow-up air studies revealed a reduction in the size of the ventricles (Fig. 1). Shenkin22 reported a ventricular size reduction following simple external decompression. His case was one of supratentorial ventricular enlargement, the result of a third ventricle tumor.

Wilson20 published 4 cases in 1946. The patients were all alive and well 6 months to 4 years after a Torkildsen procedure. The nature of the lesion in 3 cases was unknown but presumably involved the region of the aqueduct.
In the 4th case an astrocytoma of the vermis was partially removed and a "prophylactic" tube installed. Rossier, the Swiss surgeon, related an experience with a craniopharyngioma in a 30-year-old woman who 2 months after the insertion of a Torkildsen tube was completely free from intracranial pressure and hemianopsia previously present. Palliation in this case was selected, according to his report, because (1) the tumor had grown deeply into a retrosellar position, (2) such lesions could not be totally extirpated and (3) at an earlier date the patient had refused any kind of surgery.

White and Michelsen in 1941 reported their experiences in 14 cases of neoplastic and non-neoplastic obstructive hydrocephalus in adults. Eleven of these were treated by lamina terminalis puncture and 3 by the Torkildsen operation. In the latter 3, obstruction of the aqueduct of Sylvius was caused by tumor. In all 3 pressure symptoms were relieved, useful vision was restored and the patients were able to return to their work and had continued so for 5 to 18 months.

In 1920 Dandy reported 8 cases of atresia aqueducti in infants and 1 in a 5-year-old. To these he added 11 cases from the literature. This study served primarily to illustrate the need for a surgical method of treatment of this type of hydrocephalus and he proposed a cannulization of the iter, leaving in situ a rubber catheter. Matured by 2 years, the errors of this
method suggested another to Dandy\textsuperscript{5} and he recommended puncture of the lamina terminalis. It is possible that to those who consider the problem of ventriculostomy, puncture from within the ventricle outward might be the superior technique. However, in the hands of the senior author the entrance into the floor of the third ventricle from below has been easier for accurate orientation. Mixter\textsuperscript{4} accomplished an intra-third ventricle rupture by means of a cystoscope and a flexible sound introduced through the foramen of Monro. In 1936 Stookey and Scarff\textsuperscript{23} advocated a double third ventriculostomy, puncturing the lamina terminalis and then passing the probe through the floor of the third ventricle into the cisterna peduncularis. The most recent contribution on ventriculocisternostomy is that procedure devised by Hyndman\textsuperscript{13} (1946), in which a communication between the cisterna venae parvae and a lateral ventricle is established by avulsing a piece of choroid plexus. He used the transparietal approach to the ventricle. These last three methods, all apparently successfully performed, have at least theory to commend them, for all establish an outlet to the subarachnoid space from the cerebral ventricle working from within outward, presuming that the opening will not close or block off and a successful short circuit will continue to function.

Inefficiency of the aqueduct of Sylvius, while alluded to in early writings, was not given sufficient exposé in the literature until 1900. Credit is due Bourneville and Nair (1900), Fouche (1902), Spiller (1902), Orton (1908), Dandy (1920), Kernohan (1930), Stookey (1936), Pennybacker (1940), Globus (1942), and Graf (1946) for bringing this uncommon, but by no means rare situation increasingly to our attention. Non-neoplastic aqueductal stenosis has been attributed to ependymal or subependymal proliferation on a developmental or inflammatory basis.\textsuperscript{16,21} Neoplastic stenosis, in addition to the fairly diffuse spongioblastic stem glioma, finds its pathology in small, local, tumorous proliferation of pineal, subependymal, and heman-gioblastic tissues, a plausible pathogenic basis having been found in heterotopic, extrinsic, and phylogenic factors.\textsuperscript{10,11}

Pennybacker\textsuperscript{15} in 1940 reviewed Cairns' 18 cases of non-neoplastic aqueductal stenosis treated prior to the introduction of the Torkildsen method. Six of the 13 children and all of the adults were alive and well, 3 months to 7 years after surgery. Three operative methods were employed: decompression (8 cerebellar and 1 subtemporal); third ventriculostomy (4 single, 1 double); and pinealomectomy (4 cases). Judging from the well-being and survival periods, Pennybacker felt that 5 of the best results followed external decompression. In contrast to these impressions Stookey,\textsuperscript{23} who 4 years previously reviewed 16 cases of non-neoplastic stenosis from the literature and added 4 of his own, concluded that decompression was unsound. His decision was necessarily based on rather meager evidence, for in 12 of the 16 cases from the literature no surgery had been performed, except 2 in which ventricular air studies had been made. Of the 4 patients who had been decompressed, 1 died 35 days after operation of erysipelas. Another had an explor-
atology craniotomy with a puncture of the corpus callosum. If survival alone were a criterion, the 10 patients without any surgery whatsoever appear to have outlived any who had undergone operation. Stookey also reviewed 6 cases of neoplastic aqueductal stenosis and added 2 examples. All of these patients had been operated upon; 7 did not survive 2 weeks after operation, and the 8th was alive 7 months after operation and exhibited progressive symptoms.

Howard Brown in 1947 reported a lengthy tolerance of a rubber catheter. This patient had an intraventricular tumor removal on December 17, 1941—"the thin membrane was removed as widely as possible but appeared to merge into the ventricular wall inferiorly." One year later an insertion of a Torkildsen tube was necessary and after 4 years "no untoward reactions developed, no foreign body reaction or evidence of deterioration of the catheter had been demonstrated." The patient was able to work and had no neurologic handicaps.

Tumors within the third ventricle and tumors that originate in the region of this cerebral cavity properly require separation to facilitate treatment and prognosis. Dandy early recognized that small tumors lying totally within the third ventricle and essentially free except for a few attachments to the wall are among the more easily extirpated of the brain tumors and that if the somewhat formidable surgical complications are averted or outlasted by the patient, the prognosis is a fairly good one. Unfortunately, preoperatively the separation is a difficult one. Fulton and Bailey and later Dandy, in contrast to Weisenburg, have shown that there is no clinical syndrome of the third ventricle. Air ventriculograms will sometimes unequivocally localize a tumor to a portion of the third ventricle but sometimes the depiction is subject to an "either—or" interpretation. Perhaps a small injection of thorium dioxide immediately following air localization would produce sufficient further contrast to differentiate the "benign group." This suggestion is likely more practical if immediate intraventricular exploration is to be carried out. Moreover, when contrast study is localizing, the decision between palliation and extirpation remains. Many will elect the only accurate way, to expose the growth even though the odds are some five to one against a favorable benign growth in the posterior third ventricle. In reviewing the reported cases of third ventricle tumors, some patients have survived for years either without any form of treatment or merely with external decompression. However, the possibility of partial or complete blindness along with other symptoms of continued pressure exists for patients so managed. Although relief of pressure and considerable regression in the size of hydrocephalic ventricles from simple decompression has been reported, internal decompression through one of the ventriculocisternostomy methods should obviate ventricular hypertension and insure several comfortable years for the patient. Third ventriculostomy by either of the methods of Dandy or Stookey, being below the obstruction, is not entirely feasible. Similarly, Hyndman's operation, while above the lesion, is fraught
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<th>Case</th>
<th>Duration of Illness</th>
<th>Dominant Symptoms</th>
<th>Surgery</th>
<th>Pathology</th>
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<th>Results</th>
<th>Comment</th>
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<tr>
<td>1. M.K.</td>
<td>2 years</td>
<td>Ataxia, choked disks</td>
<td>Ventricular estimation</td>
<td>Aqueductal obstruction</td>
<td>None</td>
<td>Good—36 months</td>
<td>No radiation No new neurological developments Radiologic evidence of recession</td>
</tr>
<tr>
<td>2. L.L.</td>
<td>5 years</td>
<td>Macrocephalus</td>
<td>Ventriculogram</td>
<td>Aqueductal obstruction</td>
<td>None</td>
<td>Good—16 months</td>
<td>No radiation No handicaps</td>
</tr>
<tr>
<td>3. R.R.</td>
<td>3 years</td>
<td>Headaches, choked disks, v. vii, palsy</td>
<td>Ventriculogram</td>
<td>Aqueductal obstruction</td>
<td>None</td>
<td>Excellent—12 mos.</td>
<td>No radiation No residuals</td>
</tr>
<tr>
<td>4. V.B.</td>
<td>2 years</td>
<td>Headaches, choked disks, memory change</td>
<td>Ventriculogram</td>
<td>Aqueductal obstruction Chronic arachnoiditis</td>
<td>None</td>
<td>Excellent—17 mos.</td>
<td>Dated onset of symptoms from severe head injury, Massive hydrocephalus with upper visualization of the aqueduct.</td>
</tr>
<tr>
<td>5. W.P.</td>
<td>4 months</td>
<td>Birth trauma</td>
<td>Right choroidopexectomy</td>
<td>Aqueductal obstruction Thickened arachnoid</td>
<td>8 mos. after section of choroid plexus cerebellar exploration, Later Torkildsen tube, Autopsy</td>
<td>Died 10 days after tube was inserted</td>
<td>4 mos. communicating hydrocephalus 7 mos. obstructive hydrocephalus Aqueduct catheterized and communication established. Recurrence prompted Torkildsen tube.</td>
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<tr>
<td>7. N.H.</td>
<td>6 weeks</td>
<td>Headaches, diplopia</td>
<td>Ventriculogram</td>
<td>Astrocytoma, Posterior 3rd ventricle region</td>
<td>Radiation</td>
<td>Excellent—17 mos. Fair since occipital cerebellar tumor, Radiograph showed symptoms.</td>
<td>With return of headaches, ataxia, bilateral tinnitus, having had full series of x-ray treatments, a direct attack on tumor was made.</td>
</tr>
<tr>
<td>9. L.J.</td>
<td>8 months</td>
<td>Headaches, ataxia, Diplopia, choked disks</td>
<td>Ventriculogram</td>
<td>Anterior 3rd ventricle choroidatoma, Septum pellucidum</td>
<td>None Autopsy</td>
<td>Died—24 hours after Torkildsen procedure</td>
<td>A direct attack on this benign cystic lesion would have offered a more favorable prognosis.</td>
</tr>
<tr>
<td>10. P.P.</td>
<td>6 years</td>
<td>Macocephalus, Headaches, choked disks Exophthalmos Asthenia</td>
<td>Ventriculogram</td>
<td>Posterior 3rd ventricle tumor—unverified.</td>
<td>None</td>
<td>Died 34 days after operation at home.</td>
<td>A suggestive displacement of left lateral ventricle posterior questioned exact location of filling defect. Extreme physical condition prompted the abort.</td>
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<tr>
<td>Case</td>
<td>Duration of Illness</td>
<td>Dominant Symptoms</td>
<td>Surgery</td>
<td>Pathology</td>
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<td>11. S.R.</td>
<td>6 months</td>
<td>Headaches, choked disks</td>
<td>Ventriculogram</td>
<td>Metastatic sarcoma—neurogenic Primary—Intestinal</td>
<td>Autopsy</td>
<td>Died 24 hours after operation.</td>
<td>Considered primary cerebellar lesion, failure to release hydrocephalus initiated the catheter release.</td>
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<td>15. R.M.</td>
<td>14 months</td>
<td>Headaches, falling memory, sphincter loss, Choked disks, moribund</td>
<td>Ventriculogram</td>
<td>Posterior 3rd ventricle tumor, Finoelastoma</td>
<td>None Autopsy</td>
<td>Died 5 days after operation.</td>
<td>Shortly after craniotomy patient recovered consciousness adequate to be fed by mouth. Abrupt respiratory failure.</td>
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<tr>
<td>10. J.M.</td>
<td>4 months</td>
<td>Headaches, ataxia, Choked disks</td>
<td>Ventriculogram</td>
<td>Cerebellar medulloblastoma</td>
<td>Radiation</td>
<td>Excellent—10 mos.</td>
<td>Tube inserted to see if in terminal days of this illness the usual clinical course is to be altered.</td>
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<td>17. F.G.A.</td>
<td>5 months</td>
<td>Headaches, ataxia, Choked disks</td>
<td>Ventriculogram</td>
<td>Cerebellar medulloblastoma</td>
<td>None</td>
<td>Died 6 days after operation.</td>
<td>At time of craniotomy, multiple transplants over cerebellar surfaces. No release of hydrocephalus with gross extirpation of mid-line mass.</td>
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<td>18. B.T.</td>
<td>18 months</td>
<td>Headaches, optic atrophy, Decerebration</td>
<td>Ventriculogram</td>
<td>Posterior 3rd ventricle tumor</td>
<td>None</td>
<td>Died 3 days after operation.</td>
<td>Ventricular drainage for 48 hrs. before craniotomy lesioned the decerebration.</td>
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with the danger of obliteration by a tumor of the cisterna venae parvae. Torkildsen’s operation is, at the present, with or without irradiation therapy as indicated, our choice of the palliative procedures.

Since 1943 the Torkildsen operation has been performed on our neurosurgical services in 18 cases. One other patient in whom the shunting tube had been inserted elsewhere for a basilar arachnoiditis came under our care for subsequent surgical treatment. Since this case illustrated some of the technical pitfalls that may be encountered in this procedure it is added to our series, making a total of 19 cases. Eleven of these patients are alive and well, 7 to 36 months subsequent to their surgery. Five patients (Cases 9, 11, 15, 17, 18) expired within 2 weeks of performing ventriculocisternostomy. Case 9, who had had intracranial symptoms for 8 months, died of a sudden respiratory failure 24 hours following a negative suboccipital exploration. At autopsy a large cholesteatoma occupying the cavum septi pellucidi was demonstrated. From their experiences the authors are of the opinion that had the pathology of this growth been accurately suspected and a direct surgical attack on this tumor been made, the patient’s chances for a “cure” might have been more certain. In Case 18, cranial symptoms had existed for 18 months, and on the 3rd day after the catheter had been inserted a hyperthermia developed and death occurred. There was no autopsy study but clinical and radiological evidence was our basis for the diagnosis of a “tumor unverified” of the posterior third ventricle. In Case 17 respiratory cessation occurred on two occasions prior to the cerebellar craniotomy. Multiple medulloblastic transplants were seen over the cerebellum, a release of the fourth ventricle tumor obstruction was attempted but with each effort mass hemorrhage and respiratory upsets ensued, and a ventricle shunting tube, judged at that time to be the least of a surgical load, was inserted. Suddenly on the 6th day after operation, in the midst of a gratifying recovery, the patient died of an abrupt apnoea. In Case 11 the clinical picture of a cerebellar tumor prompted a posterior fossa exploration. An infiltrating tumor of the vermis, although substantially extirpated, netted no operative evidence of a release of the ventricular obstruction and a lateral ventricle fluid shunt was effected. An autopsy 24 hours later changed our appraisal of what had been considered a primary brain tumor to a diagnosis of a metastatic neurogenic sarcoma from the cecum. There were present five multicentric areas of sarcoma in this intestine and a second brain metastatic growth within the postparietal lobe opposite the cavity into which the cerebral end of the catheter had been inserted. In Case 15, moribund on hospital admission, there was a survival period of 5 days after the ventriculocisternostomy. These 5 cases, failing with even palliative efforts, would suggest that the Torkildsen operation, like other efforts at rerouting obstructed lateral ventricle fluid, may be involved by a multiplicity of factors leading to a fatal outcome even after a release of the hypertension. The original reports of Torkildsen and the subsequent individual case studies simmer with greater optimism than our series of cases suggest.
Seven of the 10 patients with unverified posterior third ventricle tumors survived the hospital postoperative period (average 14 days). Five are well and free from symptoms 6 to 26 months after surgery. Death occurred in Case 10, 20 days after hospital dismissal. In Case 12 a meningitis complicated his Torkildsen operation but this infection responded completely to antibiotic treatment. He evidenced progressive neighborhood neurologic symptoms subsequent to intensive irradiation and finally a direct gross evacuation of his tumor was performed. This procedure he tolerated for 12 days. The tumor was a choroidal papilloma in the posterior third ventricle. At autopsy there were no histologic evidences of his meningitis and microscopically there were no findings to suggest that a removal of the tube would have facilitated the treatment of his meningitis.

In 5 of the unverified tumor cases X-ray therapy was given. In Cases 7, 12, 13, and 16 radiation was begun as early after the Torkildsen operation as the patient’s condition would permit. In Case 12 pressure symptoms were reduced but neighborhood symptoms not previously evident appeared during the course of radiation, and 3 weeks after the completion of this therapy transoccipital craniotomy was performed, with evacuation of a papilloma. There were no histologic changes in this papilloma that were attributed to the effects of X-rays. Case 7 received 3 full series of irradiation therapy, spaced over a period of 12 months. Sixteen months after the insertion of her shunting catheter, pressure symptoms, tinnitus and ataxia developed. At this time craniotomy was performed and an astrocytoma in the posterior third ventricle area was grossly evacuated. Her tube, by aspiration, was found to be patent. The cisternal end of this catheter was unmolested and upon completion of her occipital craniotomy the proximal end was reinserted into the lateral ventricle. Aside from a homonymous hemianopsia she remains comfortable and active, now 7 months since our last surgical efforts. In Case 14 pressure symptoms rapidly subsided following the Torkildsen operation and he remained symptom free for 2½ months, at which time he returned to the hospital more miserable than when originally studied. His ventricular studies were repeated (Fig. 2); there was no reduction in his internal hydrocephalus, and there was a more positive depiction of a space-occupying lesion in the posterior third ventricle. A series of X-ray treatments were instituted and now 4½ months since these he is working and there is neither subjective nor objective evidence of his previous handicaps. Case 13 was treated on neurosurgical service of the Lawson Veterans Hospital by Dr. George Perret. Following an outline of a posterior third ventricle growth on air studies, a Torkildsen tube was inserted and his pressure symptoms rapidly disappeared. He was treated with deep X-ray, after which a material reduction in his ventricular dilatations was demonstrated. He remains active and free from symptoms, now for 6 months. Two of the other surviving “unverified tumor cases” have not been treated with X-ray (Cases 6, 8). Our plans are that should symptoms reappear, as they did in Case 14, ventricular air studies will be repeated and maybe a course of irradiation
will be instituted before considering a direct surgical attack on the tumor. Interesting enough, these 2 have gone 18 and 22 months respectively.

Of the patients with aqueductal stenosis all but 1 (Case 5) are alive, asymptomatic, and are occupationally engaged for a period now of 18 to 36 months. Cases 1 and 2 are children 8 and 9 years of age with preoperative symptoms of 2 and 5 years respectively. Cases 3 and 4 are adults 29 and 42 years of age. In these 4 cases the iter was occluded to the passage of a small rubber catheter. The point of obstruction in the aqueduct was demonstrated by air in only 1 case, in 2 the entire aqueduct failed to fill, and in 1 air studies were not done. While the nature of the lesion in these cases is not known, the duration of symptoms before surgery, and the survival period since would suggest a “benign” stenosis, congenital or inflammatory. In none of these suspected stenosis cases has any radiation therapy been administered. In the fatality (Case 5) the 8-month-old, prematurely born, obvious hydrocephalic was considered, after combined ventricular and lumbar puncture studies at 4 months of age, to have a communicating type of ventricular enlargement. At this time a right choroidoplexectomy was done. There was improvement for 2 months, at the end of which time “dye tests” indicated an obstruction somewhere between the lateral ventricles and the lumbar arachnoidal sac. Exploration of the posterior fossa revealed an aqueductal obstruction which was released upon forcing a small catheter through the blockage. One month later obstructive signs again developed and a Torkildsen tube was inserted. There was no improvement and the child died 10 days after this last procedure. At autopsy there was grossly an organized clot extending some 1½ cm. up in to the distal end of the catheter. There was no other evidence of hemorrhage within the operative field. Since the string of organization was gross-

![Fig. 2, Case 14. a, Ventricular studies were not entirely confirmatory of a 3rd ventricle tumor. Cerebellar exploration was negative and a Torkildsen tube was inserted. b, With a return of pressure symptoms, ventricular studies were repeated and a more clear-cut space-occupying defect was depicted.](image-url)
ly one of several days' formation, it was assumed that the plug had been present perhaps from the day of the tube insertion. The question of why the intraventricular hypertension was not adequate to dislodge this softened blood clot remains obscure.

Torkildsen\textsuperscript{27} carefully pointed out he intended the ventriculocisternostomy procedure for cases of atresia aqueducti, whatever the cause, and for pineal tumors. He felt that "tumors of the posterior fossa fell outside the scope of this operation." With this idea we heartily agree, although in not all of our cases has strict adherence to this agreement been performed. In Case 11, to secure a free flow of fluid from the ventricles above after partially extirpating with extreme difficulty an intrinsic tumor of the vermis, it seemed wiser part of surgical valor to secure a ventricular release by an easier, less risky alternative. Although an immediate histologic operating room diagnosis of a neurogenic tumor was later substantiated, as has already been related, the primary origin was not within the cerebellum but in the cecum. The immediate plan during this operation was to escape a fatality, temporize with the shunting tube and reoperate later in accordance with a final histologic classification of the grossly extirpated tumor. It is our feeling that subtentorial masses should be extirpated. If a partial removal has been necessitated, re-exploration and extirpation until cured has been our policy in all cases of benign growths of the posterior fossa. With malignant posterior fossa growths, gross extirpation is also our policy, supplemented by deep X-ray for those types that are radio-sensitive. In Case 16 a Torkildsen tube was inserted with the idea of evaluating this child's terminal course in comparison with our usual experiences in the treatment of medulloblastomas. Fortunately or unfortunately, should the terminal handicaps be modified, it is proposed to try this procedure in others. It is suggestive from reports in the literature that some surgeons\textsuperscript{25,26} have felt, contrary to Torkildsen, that his operation might be indicated in mass lesions of the posterior fossa. Where it is necessary to remove a benign subtentorial growth by stages, a shunting operation would in our opinion serve to mask warning symptoms and permit a growth to reach perhaps an inoperable size. With malignant tumors of the posterior fossa, primary sarcomatosis and medulloblastosis, the posterior subarachnoid pathways frequently are obliterated early and to by-pass fluid to the great cistern here is to further hasten the inevitable. Hyndman's operation would appear to be the procedure of election in this last instance. By the transparietal route described by him this would of course necessitate a double craniotomy. It has occurred to one of us (G. J. S.) that a transoccipital route could be employed to advantage by extending the suboccipital exposure upward over one occipital pole, reaching the glomus of the plexus through a transcortical incision into the occipital horn. Such an exposure as this at least yields a broad view of the entire lateral choroid plexus.

The possibility of accidentally burying the free end of the catheter in an extra-arachnoid position was specifically warned against by Torkildsen.
The blind sac so produced quickly forms a swelling in the upper cervical region and serves as a warning that all is not well. Symptoms of intracranial hypertension may not occur for some time if the soft tissues yield to the increasing size of the sac as it protrudes itself through an adequate bony decompression. In Case 19, in which the Torkildsen procedure was performed elsewhere, this complication occurred. Apparently the tube, having been moored to the dura with silver clips, broke loose and became displaced some 2 1/2 cm. dorsal to its original attachment. The inadequacy of silver clips employed for such purpose would appear, in retrospect, very obvious. Moreover when a tube has been securely sutured to the dura, the use of clips on the dural margin in the vicinity of the tube may lead quickly to the formation of an occipital meningocele with obliteration of the great cistern. Hyndman, in another connection, has called attention to this error in the use of clips. The displaced free end of the catheter and the tremendous blind sac into which it emptied in Case 19 is illustrated in Fig. 3. In this particular patient obstructive symptoms redeveloped within 2 weeks after her Torkildsen operation. A ventriculogram demonstrated an obstruction below the third ventricle. A third ventriculostomy was performed and she was discharged as improved after 2 weeks' hospitalization. She was quite free from her symp-

\[\text{FIG. 3. Case 19. The tube moored to the dura with silver clips had obviously broken away from its original attachment. This was undoubtedly a factor in the development of the artificial encephalocele.}\]
toms for 6 months. Upon her return to the hospital the tremendous blind cyst was evident and 2 days later a spontaneous spinal fluid fistula occurred. This made a plastic attempt imperative. At operation a large gray-white cyst, lying between the cervical muscles and above the dura, was disclosed. Dangling free in this cyst cavity was the caudal end of the catheter and from it there was a free drainage of lateral ventricle fluid. The Sylvian aqueduct and the fourth ventricle proved to be patent. The roof of the fourth cavity was thickened, bulging and cystic, and its outlet was obstructed. The pathology was that of an adhesive arachnoiditis of the posterior pathways. If this were the original pathology and had we instituted the Torkildsen operation we would have considered the undertaking entirely misguided. Be that as it may, with removal of the catheter and rupture of the fourth ventricle obstruction, the patient is now (6 months) comfortable, has some secondary optic atrophy, still carries a suboccipital, softened subcutaneous fluid reservoir but remains free from pressure symptoms.

In our attempts to establish the patency of the Torkildsen tube we have resorted to intraventricular phenosulphophthalein injection followed within an hour by lumbar spinal fluid studies. These tests may be misleading in attempting to diagnose the situation, as dye from the ventricles may be obtained on lumber puncture. Apparently the dye follows normal channels which are only partially obstructed in spite of a massive hydrocephalus. The lumbar injection of small amounts of air with visualization in the lateral ventricle is subject to the same errors of the retrograde dye test. A gentle downstream injection of \( \frac{1}{2} \) cc. of dye through the scalp directly into the tube, together with a retrograde injection of air may be more diagnostic of a blind sac (Fig. 4). A failure to obtain dye on lumber puncture or to visualize the air on X-ray of the ventricles is indicative of non-patency of the tube, a blind sac, or both.

The present combined use of antibiotic and chemical therapies would indicate that a complicating meningitis may be cured in the presence of a rubber tube without necessitating its removal. This view is supported by Case 12, in which finally on bacteriologic and ultimately on histologic studies no infectious process could be demonstrated. This experience of course is too meager to decide, first, whether such infection would not be more readily cured without the tube, and, second, whether an adhesive arachnoiditis would be more prone to develop in the presence of a tube plus an infection. Some have postulated a chemical meningitis due to the rubber tube itself. This did occur in several of our cases. All bacteriologic studies were negative, but for fear of a more serious type of meningitis chemo- and antibiotic therapy was instituted in 4 cases. Our lack of courage to take a serious risk likely prevented an accurate evaluation of a chemical versus a bacteriologic meningitis. Dandy's reaction to the Torkildsen procedure is interesting—"I just cannot believe that it can be effective. Such a large tube is unthinkable as a surgical procedure. Moreover, it cannot remain patent. Why not turn the patient over for a third ventriculostomy, or better keep the ventricles trapped
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and do it a few days later?” In support of his convictions he did just this to a patient in whom one of us (E. F. F.) had exposed, biopsied and failed to release the ventricular obstruction in a case of posterior third ventricle tumor. This patient remains free from symptoms 8 years. However the misgivings that Dandy had concerning this unthinkable unphysiological procedure have not been borne out with the passage of time as has been proved by the contributions of the original author, others, and our experiences.

In contrast to Torkildsen, we have elected to place the shunting tube subostea (Fig. 5) rather than subgaleal, this being more expedient, eliminat-

![Diagram](https://example.com/diagram.png)

**Fig. 4.** With the development of a blind sac, the combined use of air and a dye injection directly into the tube may indicate the non-patency of the tube.

ing the bony groove, lending a little more stability to the tube and obviating, should it occur, a massive cervical-occipital extradural sac. No doubt, these are matters of personal choice but if the cerebellar exposure is superior to the inferior edge of the lateral sinus the rubber tube can be passed from the ventricular trephine beneath the skull without further dissection. No adverse dural or bony reaction has been demonstrated in either the operative or autopsy cases in which the track of the catheter has been reviewed days or months after its surgical insertion.

The best results in our series have been in those cases diagnosed as
atresia aqueducti. Space and insufficient number of experiences preclude comparisons with cases treated differently. It is well to bear in mind that in many of these cases of obstruction the patients do well for long periods with any treatment or no treatment at all, so that a few observed for a short period of time as doing well, must be viewed with reservations. Our patients with posteriorly placed third ventricle tumors who have survived have done very well, and in comparison to a previous group in which a direct surgical

![Image](image.jpg)

**Fig. 5.** By placing the tube beneath the skull, then under the large muscles of the neck, over the dura, and suturing the distal end beneath the dura and arachnoid, an acquired meningocele may be prevented.

attack had been made initially upon the tumor, could be said to be doing unusually well. The Torkildsen palliation has been used by us most freely in our most desperately ill patients and in some instances which, in the light of our experiences and Torkildsen’s early advice, may in a manner make our results appear less impressive than in a series of selected cases.

The satisfying feature of the Torkildsen operation is that it permits and necessitates an exploration of the posterior fossa. This is a real advantage over other ventriculocisternostomies as usually practised. Were it possible to make an unequivocable diagnosis of aqueductal stenosis without posterior fossa exploration, the Hyndman operation, eliminating the shunting catheter, might claim priority.
SUMMARY

1. The literature has been reviewed on the Torkildsen operation. The etiologies of Sylvian aqueductal obstruction and operative procedures for release have been commented upon.

2. The experiences of our 19 cases and the results of these to date have been summarized.

3. Some of the complications of the Torkildsen procedure, their diagnosis and prevention have been discussed.

4. The limitations of, and alternative surgery for, the Torkildsen operation have been presented.

5. It would appear that a pooling of all neurosurgeons' results following the use of the Torkildsen operation would form a broader base on which to judge the virtues of this procedure.

REFERENCES

THE TORKILDSEN PROCEDURE


