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Entrapment of the temporal horn: case series and systematic review of literature.

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ABBREVIATIONS:

ADHD = Attention Deficit Hyperactivity Disorder

AVM = Arteriovenous malformation

CN = Cranial Nerve

CSF = Cerebrospinal fluid

ETH = Entrapment of the temporal horn

EVD = External ventricular drain

FLAIR = Fluid Attenuated Inversion Recovery

HGG = High grade glioma

ICH = Intracerebral hemorrhage

POD = Postoperative day

PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-analyses

TBC = Tuberculosis

VAS = Ventriculoatrial shunt

VPS = Ventriculoperitoneal shunt

WHO = World Health Organization

ABSTRACT:

Entrapment of the temporal horn (ETH) is a form of focal, obstructive hydrocephalus. Etiology and clinical presentation are diversified. Though known since 1947, standard treatment has not yet been defined.

The objective of our study was to perform a systematic review on ETH. Data from patients treated at our Institution from 2008 to 2019 were retrospectively collected and analyzed. A systematic PRISMA review of literature was also performed using PubMed and Google Scholar.

121 cases (mean age 41 years; M/F ratio 1/1) were analyzed. In 65 (vs 56) cases (53.7% vs 46.3%) ETH was not surgery related. Headache was the most common symptom (42%). “Major” treatments were (1) ventriculoperitoneal/ventriculoatrial shunt (42 cases, 34.7%), and (2) endoscopic ventriculocisternostomy (12 cases, 9.9%). In the first group, no perioperative complications were found, 39 patients (92.9%) had a favorable outcome, 3 patients (7.1%) died for the underlying disease, 4 cases (9.5%) went through revision; also considering the cases in which another procedure was performed as definitive treatment, shunt failures were 6 (13.6%). In the second group, 1 case (8.3%) developed a deep intracerebral hemorrhage, 11 cases (91.6%) had a favorable long-term outcome, 1 case (8.3%) had a favorable short-term outcome; also considering the cases in which another procedure was performed as definitive treatment, endoscopic ventriculocisternostomy failures were 6 (37.5%).

Described as uncommon, ETH is probably underestimated. Early diagnosis and appropriate treatment are critical. VP shunt is still the most commonly performed treatment. Further randomized clinical trials are, however, needed to establish the gold standard.

INTRODUCTION:

Entrapment of the temporal horn (ETH) of the lateral ventricle is a form of circumscribed, non-communicating hydrocephalus. It is usually secondary to an obstruction of the trigone which seals off the temporal horn from the rest of the ventricular system. ETH has been described as a result of various conditions mainly including tumors, infection, and fibrosis after surgery involving the trigone of the ventricle.[1,2,3,4] Congenital and idiopathic forms are also described in current literature.[5,6] The principal factor involved in the pathogenesis is the continuous secretion of cerebrospinal fluid (CSF) by the choroid plexus distal to the obstruction site, resulting in a progressive dilation of the temporal horn with subsequent compression on adjacent anatomical structures. Accordingly, brain magnetic resonance imaging (MRI) shows, in some cases of ETH, interstitial perilesional oedema.[7] Treatment of this condition lacks standardization and different procedures have been described so far: ventriculoperitoneal shunt (VPS), ventriculoatrial shunt (VAS), temporal-to-frontal internal shunt, ventriculocisternostomy, and fenestration of the choroidal fissure.[3,8] Non-surgically treated cases have been described all the same.[9] In this article we present a systematic literature review on ETH focusing on etiology, presentation, treatment, and outcomes, including 11 cases of our experience treated with VPS.

METHODS:

Literature review

A systematic review of literature was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

A systematic search was performed in PubMed and Google Scholar. The last search was conducted on April 30, 2020 and went back as far as data were available. The following search terms were used: “temporal horn entrapment” [All Fields] OR “trapped temporal horn” [All Fields]. Additional records were identified through other sources (bibliography of other papers). No language restrictions were applied. Articles in which involvement of the temporal horn was specified were included. Articles lacking precise information on management were excluded. The literature searches identified 93 records. 49 articles were excluded (7 duplicated, 39 not pertinent, 2 not meeting inclusion criteria, and 1 – identified through other source – not available). 44 articles met the inclusion criteria and were assessed in detail (Fig. 1).

Study sample

A total of 110 clinical cases from the systematic review of the available literature were analyzed. We also retrospectively reviewed 11 cases of ETH surgically treated by means of VPS at Sapienza

University of Rome, Neurosurgical Department, between January 2008 and December 2019. For every patient, culled from literature or from our experience, demographics, etiology, clinical presentation, treatment, complications, and outcomes were analyzed.

Our series: preoperative assessment and operative technique

Preoperative evaluation of the cases reported was performed through a 3-T magnet (Sonata, Siemens, Policlinico Umberto I, Sapienza University of Rome) and 1.5-T magnet intraoperative magnetic resonance imaging (Brainlab iMRI, Sant'Andrea Hospital, Sapienza University of Rome). The following sequences were acquired: T2, FLAIR, isotropic volumetric T1-weighted magnetization-prepared rapid acquisition gradient echo (MP-RAGE) before and after intravenous administration of paramagnetic contrast agent, and diffusion tensor sequences.

Tractography was performed using the software package DTI task card version 1.6 on a Brain Lab console (Brainlab). Color maps were used to define an appropriate region of interest (ROI), while the filter tracking technique involved the 3D reconstruction of the white matter tracts using fractional anisotropy (FA). The ROI for fiber tracking was positioned in the site of the trapped temporal horn.

Surgical route from temporal scalp incision to ventricular puncture was accurately planned in order to avoid sylvian veins and major middle cerebral artery branches, along with cisternal structures like the optic tract. We chose an entry point 10 mm anterior and 10 mm superior to the superior attachment of the pinna. The catheter was inserted with an antero-lateral to postero-medial trajectory pointing to the center of the trapped horn so as to avoid damage on eloquent temporal cortex. In order to prevent injury to the brainstem, we set a maximum depth for catheter-tip of 35 mm from the dural surface. The catheter was tunnelized superior and posterior to the auricle to reach the mastoid region. Here it was connected to the valve (CODMAN® HAKIM® programmable system) which, in turn, was connected to the distal abdominal catheter.

MRI-based surgical planning allowed us to drain multiple cystic septations when present. Once the dura mater was opened and coagulated, a volumetric intraoperative MRI (including DTI) was acquired and used to update the navigation data. A specific software (Brainlab) was then used to build the new tractography and to compare it with the previous processed tractography.

RESULTS:

We reviewed 44 articles (all with level of evidence IV), reporting 110 clinical cases, and retrospectively analyzed 11 cases from our institutional surgical experience.

A total of 121 cases were therefore included in our study. The median age was 41 years (range 0.16-81). M/F ratio was 1/1 (60 males, 60 females; in 1 case sex was not reported).

All cases are summarized in Table 1. [1-44]

In 65 cases (53.7%) ETH was not a consequence of cranial surgery. Results regarding etiology are reported in Table 2A.

In 56 cases (46.3%) the development of ETH was secondary to surgery on the trigonal area. The average time from surgery to ETH occurrence was 5.8 months (range 0.03-60); in 6 cases this figure was not reported. Results regarding etiology are reported in Table 2B.

As far as clinical presentation is concerned (data were not reported in 9 cases, 7%), we found with greater frequency: headache (51 cases, 42%), altered mental status (29 cases, 24%), and seizures (21 cases, 17%). A complete overview of symptoms is shown in Table 3.

Regarding treatments, results for each individual procedure are showed below and are summarized in Table 4.

Excluding 25 cases (20.7%) in which ETH resolved with the removal of the cause of obstruction (i.e. treatment of the underlying disease, mainly neoplastic), the most frequently performed treatments for ETH were ventriculoperitoneal/ventriculoatrial (VP/VA) shunt followed by endoscopic ventriculocisternostomy ("major" definitive treatments).

VP/VA shunt was performed in 44 patients. In 6 patients (13.6%) a recurrence of the ETH was seen: in 4 cases (9.1%) for shunt malfunctioning, in 1 case (2.3%) for shunt migration at 312 months, and in 1 case (2.3%) for infection of the system. Of these cases, 4 went through shunt revision with an average time from the first procedure of 6.5 months (range 1-12 months), while in 2 cases another procedure (endoscopic ventriculocisternostomy) was chosen as the definitive treatment. VP/VA shunt was therefore the definitive treatment in only 42 cases (34.7%). Among these procedures, 3 (7.1%) were preceded by endoscopic ventriculocisternostomy failure, 1 (2.4%) by unsuccessful endoscopic trigonal disobstruction, 1 (2.4%) by internal temporal to frontal shunt failure, 1 (2.4%) by open microsurgical ventriculocisternostomy, and 1 (2.4%) by choroid plexus coagulation associated to temporal corticectomy. We did not find perioperative complications in any of the 42 cases. Regarding outcomes, 25 cases (59.5%) had a favorable outcome with an average follow-up of 15.6 months (range 1-108 months), 14 cases (33.3%) were favorable in the absence of mention of long-term follow-up, 3 patients (7.1%) died in the short follow-up for the underlying disease.

Endoscopic ventriculocisternostomy was performed in 16 patients. Recurrence was observed in 6 patients (37.5%). In 2 patients the endoscopic procedure was repeated (average time at recurrence: 3 months, range 2-4 months), while in 4 patients another procedure was chosen as the definitive treatment (VPS in 3 cases, endoscopic trigonal disobstruction in 1 case). Endoscopic ventriculocisternostomy was therefore the definitive treatment in only 12 cases (9.9%). Among these procedures, 2 (16.6%) were preceded by VPS failure at 1 month and VPS migration at 312 months.

As for perioperative complications and outcomes: 1 patient (8.3%) developed a deep intracerebral hemorrhage (ICH) with residual hemiparesis as a complication, 11 patients (91.7%) had a favorable outcome with an average follow-up of 21.3 months (range 3-132 months), while for 1 patient (8.3%) there was a favorable short-term outcome with subsequent worsening for the underlying disease.

Considering total recurrences of the two "major" treatment modalities, the chi-square statistic was 4.1761 with a p-value = 0.040997 (significant at $p < 0.05$). The chi-square statistic with Yates correction was 2.8178 with a p-value = 0.093223 (not significant at $p < 0.05$, but significant at $p < 0.10$). Data regarding outcomes, being very diversified, did not allow us to develop a precise statistical analysis.

Results for "minor" definitive treatments are described below.

7 patients received endoscopic trigonal disobstruction. 1 of these procedures (16,6%) was preceded by endoscopic ventriculocisternostomy failure. Only 2 cases (33.3%) received this procedure alone. In 4 cases (66.6%) an additional procedure was carried out: septostomy in 3 cases (50%) with a favorable outcome at 24 months (range 12-48 months), and residual tumor removal in 1 case (16.6%) with a favorable outcome at 12 months. There were no reported perioperative complications. ETH recurred in 1 patient (14.3%). In this patient VPS was chosen as the definitive treatment. Endoscopic trigonal disobstruction was therefore the definitive treatment in only 6 cases (5%). Regarding overall outcomes, 5 cases (83.3%) had a favorable outcome with an average follow-up of 17.8 months (range 5-48 months), and 1 case (16.6%) had a favorable outcome in the absence of mention of long-term follow-up.

In 5 patients an internal shunt with catheter was performed (temporal-to-frontal shunt in 4 cases, temporal-to-prepontine cistern in 1 case). In 1 patient ETH recurred (20%). In this patient VPS was chosen as the definitive treatment. Thus, internal shunt was the definitive treatment for 4 patients (3.3%). Of the 3 cases (75%) treated with temporal-to-frontal shunt, 2 cases had a favorable outcome in the absence of mention of long-term follow-up, while 1 case developed an expressive aphasia as a postoperative complication which resolved in several weeks. The only case (25%) treated with temporal-to-prepontine cistern shunt had a favorable outcome at 36 months.

5 patients received a temporal corticectomy allowing a communication between temporal horn and subarachnoid space. ETH recurred in 1 patient (20%). VPS was chosen as the definitive treatment for this patient. Temporal corticectomy was therefore the definitive treatment in only 4 cases (3.3%). Among these, 2 cases (50%) received a partial temporal tip lobectomy and had a favorable outcome with an average follow-up of 36 months (range 24-48 months). The other 2 cases (simple corticectomy) had a favorable outcome, in the absence of long-term follow-up.

In 4 patients open choroid plexus coagulation or asportation was carried out. This procedure was

associated with other treatment modalities in 3 cases. In 1 case choroid plexus coagulation was associated with ventriculostomy in the 3rd ventricle, 1 case was treated with coagulation associated to residual tumor removal, and 1 case with coagulation associated to temporal corticectomy. The total amount of failures of the procedure requiring subsequent reintervention was 1 (choroid plexus coagulation associated to temporal corticectomy, 25%): in this case VPS was subsequently performed. Choroid plexus coagulation/asportation was therefore the definitive treatment in only 3 cases (2.5%). Follow-up was available in only 1 case (coagulation associated to residual tumor removal): favorable at 9 months.

2 patients (1.7%) were treated with open microsurgical trigonal fibrosis/adhesions debridement. There were no reported perioperative complications. The outcome was favorable at 8 months (range 6-10 months).

7 patients (5.8%) received a temporary external ventricular drain (EVD), not followed by other procedures. ETH solved itself with a good outcome in only 2 cases (28.6%).

In 16 cases (13.2%) no surgical treatment was performed. Of these, 9 cases (56.3%) had a favorable outcome without mention of long-term follow-up, 4 cases (25%) had a favorable outcome at 39 months (range 12-72 months). In 2 cases (12.5%), the patient died for the underlying disease.

ILLUSTRATIVE CASES

Case 1

66-year-old female patient. Past medical history negative for oncological diseases, recent traumatic events, and for intake of antiplatelet agents or anticoagulants. For about a month she had been going through episodes of dizziness, nausea, and mental confusion. On evaluation, she presented with mild right upper limb paresis and gait disturbance. Brain MRI showed a 30-mm-diameter probable subacute hematoma in the left ventricular trigonal region surrounded by a ring of peripheral oedema with consensual dilation of the temporal horn of the lateral ventricle. After intravenous contrast injection, ectasic vessels appeared in the proximity of the lesion (fig. 2a). Surgical exeresis, in the suspicion of intraventricular cavernous angioma, was carried out. A computed tomography (CT) scan obtained on postoperative day 1 showed surgical outcomes along with a volumetric reduction of the temporal horn (fig. 2b). Regularly discharged on postoperative day 7, she was admitted again 2 weeks after surgery following new onset of mixed aphasia and drowsiness. She was taken to CT which revealed a recurrence in the ETH with peripheral oedema. She repeated MRI which confirmed this finding (fig. 2c).

A VPS was inserted with the aid of a 3D neuronavigation system (Hakim programmable valve at 130 mmH_2O). Postoperative CT showed reduction of midline shift to the right (5 mm vs 8 mm), together

with a dramatic decrease in white matter oedema within the left temporal and ipsilateral frontal and parietal areas. The dilation of the left temporal horn was no longer appreciable, even though there was a residual area of slight hypodensity around it (fig. 2d). In the following days, the patient fully recovered from the aphasic disorder also showed improvement in mental status. Histopathological examination revealed an intraventricular AVM. Subsequent 18-month follow-up showed no recurrence of ETH.

Case 2

58-year-old male patient. He underwent an operation for the exeresis of a left trigonal mass in another country 2 months before (histology not available). He was admitted for headache and language disorder risen in the last 10 days. On neurological examination, he presented mild right hemiparesis and mixed aphasia. Brain MRI showed a large left intra-axial para-trigonal mass with peripheral oedema and intense enhancement after intravenous contrast injection. The lesion presented areas of necrosis and was associated with left ETH (fig. 3a). Surgical exeresis of the tumor was performed. A CT scan obtained on postoperative day 1 showed surgical outcomes along with volumetric reduction of the temporal horn (fig. 3b). He was discharged on postoperative day 7, without neurological deficits. Histopathological examination revealed a glioblastoma (WHO grade IV). 30 days after surgery, he was re-admitted for recurrence of right hemiparesis and mixed aphasia together with development of altered mental status. Brain MRI revealed recurrence of both trigonal glioma and ETH. A second surgical procedure for the exeresis of the recurring lesion was carried out with mild improvement of symptoms. Postoperative course was marked by a drastic and sudden worsening with the onset of global aphasia, right severe hemiparesis and drowsiness. A new brain MRI showed further enlargement of the left temporal horn in the absence of residual tumor (fig. 3c).

A VPS was performed with the aid of a 3D neuronavigation system (Hakim programmable valve at 130 mmH_2O), with complete neurological recovery. He was discharged on postoperative day 8. The CT scan performed on postoperative day 15 revealed good radiological outcome (fig. 3d). Subsequent 6-month follow-up showed no recurrence of ETH. The patient then worsened for the progression of disease.

DISCUSSION:

ETH is a particular form of focal, non-communicating hydrocephalus mainly due to intraventricular obstruction in CSF outflow in the region of the trigone.

Despite the absence of randomized clinical trials, we found a large number of case series through the analysis of current literature.

The etiology of this condition is heterogeneous, just like clinical presentation.

In almost half of the cases, ETH was found to be related to previous intracranial surgery close to or within the area of the trigone. In these cases, cicatricial fibrosis with the creation of adhesions at the trigone may be involved by preventing CSF produced by the choroid plexus of the temporal horn from flowing into the remaining part of the ventricular system. Diseases subject to surgery were above all neoplasms of the trigone (mostly meningiomas, followed by high-grade gliomas). In the remaining minor part, the associated etiologies were vascular and infectious. In the work of Lin et al.[9] 19 cases of ETH following surgical exeresis of trigonal meningiomas are reported. The authors recommend surgical treatment of ETH in case of intracranial hypertension and a strict radiological follow-up in case of mildly symptomatic patients. In our review, we also found some cases resolved with the only observational conservative treatment.

In the other half of the cases, ETH was found in patients who did not experience prior intracranial surgery. Among these, we found a clear prevalence of cases related to infection, followed by cases determined by tumors and cysts of the trigone. In the work of Ellis et al.[34] 13 cases are reported in which the obstacle to CSF outflow from the temporal horn is due to cysts of the trigone. The authors report that surgical treatment, solely by means of the endoscopic removal of the neoplastic or non-neoplastic cystic lesions, was able to restore CSF dynamics and to resolve ETH with a favorable outcome in the medium or long-term follow-up.

Regarding the diagnosis, in addition to the increase in size of the temporal horn found in CT-scans or MRIs, a particularly important role is represented by clinical presentation. As suggested by the results of the review, ETH recognizes both symptoms due to the underlying disease and symptoms typical of the condition of ETH itself, in relation to the proximity of some crucial anatomical structures. Mass effect caused by the enlargement of the temporal horn may result in increased intracranial pressure thus causing headache, gait disturbances, confusion and even loss of consciousness. Compression of the internal capsule and of ipsilateral cerebral peduncle can produce motor deficits up to contralateral hemiparesis. Compression and oedema of hippocampus may result in seizures and memory disorders. Compression of Meyer's loop can cause visual field defects such as contralateral homonymous hemianopia. Involvement of the temporal cortex in the dominant hemisphere may explain the finding of cases with sensory aphasia. In the work of Russell et al.[21] 8 cases of ETH are described in a wider case series of patients affected by hippocampal and parahippocampal tumors. The clinical presentation reported in this series is illustrative of the symptoms concerning the involvement of the temporal-mesial structures of the brain and is similar to that found on average in our literature review for ETH.

ETH treatment involves different modalities. There is no evidence of the superiority of one treatment over the others, also in relation to the lack of randomized clinical trials on this topic. The choice of

treatment is often conditioned by the underlying disease and by surgeons' confidence in performing certain types of procedures. There is no shortage of cases where the patient had undergone several types of procedures before witnessing ETH resolution.

Based on the results of our review of literature, excluding the formerly discussed cases treated with removal of the neoplastic or cystic lesion at the trigone, the most frequently performed treatment is VPS followed by endoscopic ventriculocisternostomy, reported as a treatment for ETH for the first time by Parrent et al. in 2000.[19] Medium and long-term outcomes are favorable for both procedures, without great differences. The results show that relapses with subsequent revision are more frequent with endoscopic ventriculocisternostomy than with VPS (37.5% vs 13.6%). Some authors report among the advantages of the endoscopic procedure: (1) the feasibility in patients affected by intracranial infection, (2) the lower risk of infectious complications, and (3) the absence of risk of peritoneal dissemination in case of malignant intracranial disease.[3,8] With reference to the latter issue, there are three reviews in current literature that show a very low frequency rate of peritoneal spread with VPS in case of malignant disease, concluding for the absence of absolute contraindication for this procedure in cancer patients; metastatic complication should be, however, taken into consideration.[45,46,47] Some authors, such as Paredes et al. and Krähenbühl et al.,[3,30] point out that the endoscopic procedure should be carried out in selected patients, where the mesial wall of the temporal lobe is quite thin and the interpeduncular cistern wide enough, so as to avoid possible damage to intracisternal structures such as the anterior choroidal artery, the optic tract, the third cranial nerve, and the posterior communicating artery. The experience required for endoscopic procedure, combined with the greater confidence of most neurosurgeons in VPS, is probably one of the factors responsible for the higher number of VPSs found in the review compared to the cases treated through endoscopy.

As far as other treatments are concerned, there are too few cases with too variable results.

A possible role for coagulation/excision of the choroid plexus (during the open treatment of intraventricular lesions or endoscopic ventriculocisternostomy) in improving the outcome of ETH patients remains still controversial since there are few cases in the literature, especially when carried out alone.

A potential algorithm for the management of this disease is shown in Fig. 4.

The main limitation of our study is related to the great heterogeneity of the clinical cases reported in literature and the availability of partial information, so as not to be able to develop a comprehensive statistical analysis of the results.

CONCLUSIONS:

Entrapment of the temporal horn is a complication of various diseases or of their treatment. It has been described as not very frequent, but it is probably underestimated in neurosurgical literature so it must be considered where specific symptoms are present. Early diagnosis and appropriate treatment are critical in terms of outcome. Among possible treatments, VPS and endoscopic ventriculocisternostomy appear safe and conclusive in the medium and long-term follow-up. To date, there is no treatment considered the gold standard. VPS is absolutely the most frequently performed treatment since most surgeons are still more familiar with it, compared to endoscopic procedures. However, further randomized clinical trials are needed to develop a treatment protocol.

AUTHORS' CONTRIBUTION:

Study conception and design: M.G., A.K.S.

Acquisition of data: M.G., A.K.S., V.C., A.D.B.

Analysis and interpretation of data: M.G., A.K.S., V.C., A.D.B., P.B.

Drafting of manuscript: M.G., A.K.S., V.C., A.D.B., P.B.

Critical revision: G.D.A., M.S., A.S.

DISCLOSURES:

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

All authors read and approved the final version of the manuscript.

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Table 1 – Case series and systematic review of literature

Case	Author & Year	Age (yrs)	Sex	Associated condition	Postop onset (mos)	Side	Clinical presentation	Management	Perioperative complications	Outcome
1	Cairns & Daniel, 1947[9]	NR	M	penetrating wound		NR	hemiparesis, hemianesthesia, hemianopia, aphasia	choroid plexus coagulation & ventriculostomy into 3rd ventricle		NR
2		19	M	penetrating wound		NR	hemianopia, hemiparesis	resection of choroid plexus		NR
3		0.58	NR	subependymal hemorrhage		NR	NR	diagnosed at autopsy		NR
4	Smith et al., 1979[40]	47	F	trigonal LGG		R	seizures	tumor resection		favorable at 24 mos
5		50	M	UOS trigonal mass		R	seizures, left hemiparesis, left superior quadrantanopia	observational		favorable (NR long-term FU)
6		65	F	intraventricular meningioma		R	headache, syncopal episodes, vomiting	tumor resection		favorable (NR long-term FU)
7	Maurice-Williams & Choksey, 1986[27]	23	F	postop, recurrent temporal HGG	12	R	headache, confusion, left hemiparesis	microsurgical opening of trigone stenosis		dead at 6 mos for recurrence of disease
8		35	F	tuberculous meningitis		R	headache, confusion, seizures, left hemiparesis	choroid plexus coagulation (failed); VAS (no mention of timing)		favorable at 6 mos
9		30	F	postop, parietal AVM with SAH	NR	L	headache, confusion, seizures, right hemiparesis	craniotomy and decompression (failed); VPS (3 mos later)		favorable at 12 mos
10	Kwame Ofori-Kwakye et al., 1986[23]	35	F	cryptococcal meningoencephalitis		R + L	headache, mental status change, seizures, nausea, vomiting	EVD		dead for complications of disease
11	Schlitt et al., 1986[36]	33	F	neurosarcoidosis		L	headache, seizures, right facial and arm weakness, nystagmus	temporal cyst drainage (failed); VPS (2 mos later); VPS revision (1 yr later)	VPS malfunctioning	dead for complications of disease
12	Brück et al., 1991[8]	50	M	xanthogranuloma of choroid plexus		L	headache, aphasia, gait disturbance	lesion resection		favorable (NR long-term FU)
13	Tsugane et al., 1992[43]	34	M	tuberculous meningitis		R	drowsiness, left hemiparesis, left homonymous hemianopia	VPS & pharmacological treatment		dead at 4 mos
14		44	F	multiple streptococcal abscesses		R	headache, drowsiness, left hemiplegia, fever	VPS & pharmacological treatment		favorable (NR long-term FU)
15	Bramwit et al., 1997[7]	63	F	inflammatory pseudotumor of the choroid plexus		R	headache, confusion, left hemiparesis	tumor resection & UOS shunt		favorable at 8 mos (onset of postop left superior quadrantanopia)
16	Cho et al., 1998[11]	33	M	cryptococcal meningitis		L	headache, seizures, fever	UOS shunt & pharmacological treatment		improvement at 5 mos
17		20	F	tuberculous meningitis		R	headache, lower limbs weakness	pharmacological treatment		favorable at 12 mos

18		25	M	cryptococcal meningitis		R	headache, drowsiness, fever, vomiting, CN VI palsy	UOS shunt & pharmacological treatment		favorable at 4 mos
19		18	M	tuberculous meningitis		L	headache, vomiting, coma	UOS shunt & pharmacological treatment		onset of visual field defect at 3 mos
20	Watanabe & Katayama, 1999[44]	16	M	postop, intraventricular AVM with SAH	1	L	right homonymous hemianopia, right hemiparesis	VPS		favorable (NR long-term FU)
21	Coria et al., 2000[12]	70	F	postop, basilar giant aneurysm	60	R	seizures	pharmacological treatment		favorable (NR long-term FU)
22	Parrent, 2000[31]	68	F	cryptococcal meningitis		R	headache, gait disturbance, memory deterioration, left superior quadrantanopia	endoscopic ventriculocisternostomy		favorable at 6 mos
23	Yasuhara et al., 2001[45]	72	M	parieto-occipital brain abscess		R	drowsiness, left hemiparesis	temporal tip lobectomy with temporal horn opening & subdural-peritoneal shunt		favorable (NR long-term FU)
24	Russell & Kelly, 2002[34]	33	M	hippocampal LGG		L	seizures	tumor resection		favorable at 4 mos
25		67	M	hippocampal HGG		R	seizures	tumor resection		favorable at 9 mos
26		48	M	hippocampal HGG		L	dysphasia, visual field defect	tumor resection		favorable at 7 mos
27		64	M	hippocampal HGG		L	right hemiparesis, visual field defect	tumor resection		dead at 15 days
28		59	F	hippocampal HGG		R	visual field defect	tumor resection		favorable at 8 mos
29		65	M	hippocampal HGG		R	headache, memory deterioration	tumor resection		favorable at 5 mos
30		69	F	hippocampal HGG		L	dysphasia, memory deterioration	tumor resection		dead at 15 days
31		63	F	intraventricular meningioma		L	memory deterioration	tumor resection		favorable at 15 mos
32	Baussart et al., 2006[4]	56	F	neurosarcoidosis		R	headache, confusion, fever, memory deterioration, left inferior quadrantanopia	endoscopic biopsy & pharmacological treatment		favorable (NR long-term FU)
33	Mathews et al., 2007[26]	23	M	cryptococcal meningitis		R	headache, drowsiness, vomiting	endoscopic ventriculocisternostomy (failed); VPS (no mention of timing) & pharmacological treatment		favorable (NR long-term FU)
34	Maurya et al., 2007[28]	25	F	trigonal hydatid cyst		L	headache, seizures, vomiting	hydatid cyst removal & temporal cyst decompression		favorable (NR long-term FU)
35	Berhouma et al., 2009[5]	42	F	neurosarcoidosis		R	headache, drowsiness, seizures, left hemiparesis, vomiting, memory deterioration, right pupillary dilation	temporal tip lobectomy with temporal horn opening & pharmacological treatment		favorable at 24 mos

36	Hervey-Jumper et al., 2010[18]	47	M	postop, atrial ependymoma	1.5	L	drowsiness, blurred vision	temporal-to-frontal shunt		persistence of blurred vision, postop aphasia resolved in several weeks
37		70	F	trigonal B-cell lymphoma		R	drowsiness, left hemiparesis, gait disturbance, CN VII palsy	temporal-to-frontal shunt		favorable (NR long-term FU)
38		68	F	postop, temporal HGG	NR	R	drowsiness, left hemiparesis	temporal-to-frontal shunt		drowsiness improved within 3 weeks FU
39	Singh et al., 2010[39]	35	F	neurocysticercosis		R	headache, vomiting	endoscopic atrium fenestration (failed); UOS shunt (no mention of timing)		favorable at 12 mos
40		35	F	neurocysticercosis		R	headache, seizures	temporal horn cyst removal through transcortical approach		favorable (NR long-term FU)
41	Kamali et al., 2011[21]	8	F	trigonal hydatid cyst		R	drowsiness, headache, visual defect	hydatid cyst marsupialization & temporal cyst decompression		favorable (NR long-term FU)
42	Yeon et al., 2011[46]	9	F	parieto-occipital AVM treated with G-Knife	27	R	headache, vomiting	UOS shunt		favorable at 27 mos
43	Chen et al., 2013[10]	41	F	atypical trigonal meningioma in meningiomatosis		R	headache	stereotactic temporal horn–to–prepontine cistern shunt & radiosurgery on the tumor		favorable at 36 mos
44	Krähenbühl et al., 2013[22]	1.25	M	postnatal CNS infection		R + L	psychomotor retardation	bilateral endoscopic ventriculocisternostomy (failed); VPS & endoscopic atrium fenestration (2 mos later)		favorable at 48 mos
45		0.83	F	postop, parietal lesion in systemic juvenile xanthogranulomatosis	5	R	headache, drowsiness	endoscopic ventriculocisternostomy (2 procedures: 1st failed, 2nd procedure 2 mos later)		favorable at 11 yrs
46		66	F	postop, trigonal HGG	0.25	L	right hemiplegia, aphasia	endoscopic ventriculocisternostomy		postoperative improvement; subsequent worsening for recurrence of disease
47		15	F	postop, intraventricular ganglioneuroblastoma	17	R	asymptomatic (postop MRI finding)	endoscopic ventriculocisternostomy		favorable at 3 mos
48	Iaccarino et al., 2013[20]	50	M	incidental finding		R > L	headache, seizures, gait disturbance	bilateral VPS		favorable at 4 mos
49	Quenardelle et al., 2013[32]	26	M	neurosarcoidosis		L	headache, seizures, memory deterioration	VPS		favorable (NR long-term FU)
50	Sharma et al., 2014[38]	22	F	tuberculous meningitis		R	headache, left hemiparesis, fever, vomiting	VPS & pharmacological treatment		favorable (NR long-term FU)

51	Abderrahmen et al., 2015[1]	7	M	congenital hydrocephalus		R	drowsiness	endoscopic ventriculocisternostomy (failed); VPS (9 mos later)		favorable at 7 yrs
52		7	M	postop, neurohydatidosis	12	R	asymptomatic (postop MRI finding)	observational		favorable at 4 yrs
53		0.33	F	postop, occipital encephalocele	NR	L	asymptomatic (postop MRI finding)	observational		favorable at 6 yrs
54		48	M	postop, HGG	NR	L	aphasia, right homonymous hemianopia	UOS shunt		favorable; worsening and death for recurrence
55		42	F	neurosarcoidosis		R	drowsiness, left hemiparesis, right pupillary dilation	temporal tip lobectomy with temporal horn opening		favorable at 4 yrs
56	Ellis et al., 2015[13]	7	M	atrial arachnoid cyst		L	headache, ADHD	endoscopic cyst removal through occipital horn access		improvement in ADHD at 3 mos
57		0.33	M	atrial & occipital horn arachnoid cyst		L	congenital hydrocephalus	endoscopic cyst removal through occipital horn access		favorable at 5 yrs
58		2	M	atrial subependymal cyst		L	progression in temporal horn enlargement	endoscopic cyst removal through occipital horn access		favorable at 8 yrs
59		5	F	atrial arachnoid cyst		R	headache	endoscopic cyst removal through occipital horn access		favorable at 10 yrs
60		10	F	atrial arachnoid cyst		R	headache, bipolar disorder	endoscopic cyst removal through occipital horn access		improvement at 3 mos
61		4	M	atrial arachnoid cyst		L	headache, seizures, right hemiparesis, ADHD	endoscopic cyst removal through occipital horn access		improvement at 2 mos
62		26	M	atrial cystic HGG		L	right hemiparesis, right hemianopia	endoscopic cyst removal through occipital horn access		favorable; dead at 24 mos for tumor progression
63		35	M	post infectious atrial and temporal horn cyst		NR	headache	endoscopic cyst removal through occipital horn access		favorable; dead at 12 mos for AIDS complications
64		54	M	post infectious atrial cyst		L	hydrocephalus	endoscopic cyst removal through occipital horn access		death at 6 mos for CNS infection
65		0.42	F	atrial arachnoid cyst		R	progression in temporal horn enlargement	endoscopic cyst removal through occipital horn access		favorable at 12 mos
66		3	M	atrial arachnoid cyst		R	progression in temporal horn enlargement	endoscopic cyst removal through occipital horn access		favorable at 36 mos
67		11	F	atrial arachnoid cyst		L	headache in hydrocephalus	endoscopic cyst removal through occipital horn access		persistent headache at 36 mos
68		5	M	atrial arachnoid cyst		R	headache, ADHD, bipolar disorder	endoscopic cyst removal through occipital horn access		persistent headache, improvement in psychiatric disorder at 48 mos

69	Hana et al., 2015[16]	60	M	postop, HGG	0.03	R	drowsiness	tEVD on POD 1; VPS on POD 10 (failed); endoscopic ventriculocisternostomy (1 mo later)		favorable at 10 mos
70	Spallone et al., 2015[41]	58	M	postop, intraventricular UOS tumor and surgical infection	NR	L	aphasia	trigone dilation & internal temporal-to-frontal shunt (failed); VPS (9 days later)		favorable at 9 yrs
71	Bohl et al., 2016[6]	53	M	postop, parieto-occipital AVM with SAH	NR	R	progressive neurological status declining	VPS		favorable (NR long-term FU)
72		63	F	postop, intraventricular abscess drainage	0.43	R	left superior limb paresis	tEVD		postop stabilization; subsequent recurrence of disease requiring hemicraniectomy
73		57	M	postop, HGG	1	R	drowsiness, left hemiparesis	tEVD		favorable (NR long-term FU)
74	Alan et al., 2017[2]	76	M	basal ganglia ICH with IVH		R	drowsiness, left hemiparesis	tEVD (removed on POD 3) & intrahematomal catheter		no clinical improvement
75	Paredes et al., 2017[30]	20	F	postop, temporal AVM	6	L	headache, bilateral papilledema	endoscopic ventriculocisternostomy		favorable at 6 mos
76		5	F	postop, choroid plexus carcinoma	2	L	drowsiness, vomiting	endoscopic ventriculocisternostomy (2 procedures: 1st failed, 2nd procedure 4 mos later)		favorable 4 mos
77		66	M	postop, atrium metastasis	6	R	drowsiness, left hemiparesis	endoscopic ventriculocisternostomy		favorable at 24 mos
78		73	M	postop, atrial tuberculoma	1.5	R	left hemiparesis, left homonymous hemianopia	endoscopic ventriculocisternostomy		favorable at 12 mos
79	Sharifi et al., 2017[37]	16	M	incidental finding		L	headache and stuttering in megalencephaly	microsurgical ventriculo-cysto-cisternostomy (failed); VPS (2 mos later)		favorable at 1 mo
80	Arenas-Ruiz et al., 2018[3]	2	M	multiple fungal abscesses		R > L	drowsiness, left hemiparesis	endoscopic ventricular-cistern-ventriculostomy with trans-cisternal tEVD positioning (removed on postop day 3)		improvement at 3 mos
81	Golpayegani et al., 2018[15]	0.5	M	congenital bilateral temporal horn entrapment		R + L	intracranial hypertension in megalencephaly	bilateral VPS		favorable at 6 mos
82	Hasegawa et al., 2018[17]	42	F	postop, intraventricular AVM		R	headache, numbness in the left extremities	VPS (failed), endoscopic ventriculocisternostomy (26 yrs later)		favorable at 13 mos
83		80	F	cryptococcal choroid plexitis		R	progressive cognitive-motor slowing	endoscopic ventriculocisternostomy	deep ICH	left hemiparesis; no recurrence at 21 mos

84	Zhang et al., 2018[47]	28	M	postop, intraventricular neurocytoma	24	R	headache, vomiting, gait disturbance	endoscopic atrium fenestration and septostomy		favorable at 12 mos
85		27	F	postop & radiotherapy, intraventricular neurocytoma	12	L	right hemiparesis, memory deterioration, dizziness	endoscopic atrium fenestration and septostomy		no dizziness, improvement in memory function at 12 mos
86		32	F	postop, atrial meningioma	36	L	headache, vomiting	endoscopic resection of tumor and atrium fenestration		favorable at 12 mos
87	Fernández-de Thomas et al., 2019[14]	53	F	chemical meningitis secondary to ruptured spinal epidermoid cyst		R	headache, neck pain	endoscopic exploration of the right lateral ventricle & lumbar decompression with resection of the cyst		improvement at 1 week (NR long-term FU)
88	Huang et al., 2019[19]	0.56	M	ventriculitis and IVH		L	seizures	VPS		favorable at 24 mos
89		0.16	M	porencephalic cyst caused by periventricular encephalomalacic process		L	megalencephaly	endoscopic cystoventriculostomy with fenestration from the trigone to the frontal horn		favorable at 5 mos
90	Lin et al., 2019[24]	32	F	postop, trigonal meningioma	4	NR	memory deterioration, dizziness	observational		favorable (NR long-term FU)
91		30	F	postop, trigonal meningioma	1.5	L	headache, limb weakness	EVD (failed); subsequent (no mention of timing) microsurgical fenestration through craniotomy		favorable at 10 mos
92		32	M	postop, trigonal meningioma	0.2	NR	headache, nausea	EVD & pharmacological treatment		favorable (NR long-term FU)
93		31	M	postop, trigonal meningioma	1.2	L	right homonymous hemianopia	observational		favorable at 2 yrs
94		39	F	postop, trigonal meningioma	8.5	NR	memory deterioration, hemianopia	VPS		favorable (NR long-term FU)
95		58	F	postop, trigonal meningioma	4	NR	headache	observational		favorable (NR long-term FU)
96		52	F	postop, trigonal meningioma	1	NR	headache, hemianopia	pharmacological treatment		favorable (NR long-term FU)
97		38	F	postop, trigonal meningioma	6	NR	headache, nausea, vomiting	EVD (failed); VPS (no mention of timing)		favorable (NR long-term FU)
98		30	F	postop, trigonal meningioma	10	NR	headache	observational		favorable (NR long-term FU)
99		25	F	postop, trigonal meningioma	0.1	NR	seizures	EVD & pharmacological treatment		favorable (NR long-term FU)
100		48	F	postop, trigonal meningioma	4.5	NR	headache, UOS paresis	endoscopic ventriculocisternostomy (failed); VPS (no mention of timing)		favorable (NR long-term FU)
101		57	F	postop, trigonal meningioma	4	L	memory deterioration	observational		favorable at 2 yrs
102		36	F	postop, trigonal meningioma	0.8	L	coma	VPS		favorable (NR long-term FU)

103		6	M	postop, trigonal meningioma	8	NR	headache, nausea, vomiting	VPS		favorable (NR long-term FU)
104		42	F	postop, trigonal meningioma	3	NR	seizures	observational		favorable (NR long-term FU)
105		63	M	postop, trigonal meningioma	0.4	NR	coma	microsurgical exploration through craniotomy (failed); EVD (no mention of timing)		improved but disabled (NR long-term FU)
106		37	M	postop, trigonal meningioma	1	NR	UOS paresis, blurred vision, papilledema, dizziness	VPS; VPS revision (1 mo later)	VPS malfunctioning	favorable (NR long-term FU)
107		52	M	postop, trigonal meningioma	2	NR	memory deterioration, UOS hemianopia	observational		favorable (NR long-term FU)
108		50	F	postop, trigonal meningioma	0.7	NR	headache, nausea, vomiting	VPS		favorable (NR long-term FU)
109	Liu et al., 2019[25]	52	F	postop & G-Knife, trigonal meningioma	2	R	headache, left limb paresis	recurrence/residual tumor resection & choroid plexus coagulation		favorable at 9 mos
110	Sánchez Carteyron et al., 2019[35]	48	M	midline & trigonal HGG		L	mental status change	observational		dead at 18 days for tumor progression
111	Our Series	66	F	postop, trigonal AVM	0.5	L	drowsiness, aphasia	VPS		favorable at 18 mos
112		68	M	postop, trigonal HGG	1	L	drowsiness, right hemiparesis, aphasia	VPS		favorable at 6 mos
113		57	M	postop, parietal HGG	1	L	drowsiness, right hemiparesis	VPS; VPS revision (4 mos later)	infection	favorable at 12 mos
114		81	M	postop, parieto-temporal HGG	3	L > R	drowsiness, right hemiparesis, aphasia	bilateral VPS		favorable at 3 mos
115		64	M	postop, multicentric HGG	5	R	gait disturbance, left homonymous hemianopia, left hemiparesis	VPS		favorable at 3 mos
116		31	M	postop, recurrent parieto-temporo-occipital HGG	1	L	right hemiparesis	VPS		favorable at 6 mos
117		64	M	postop, parieto-temporal HGG	4	R	seizures	VPS; VPS revision (9 mos later)	VPS malfunctioning	favorable at 3 mos
118		45	M	postop, parieto-temporal HGG	0.3	R	drowsiness, left hemiparesis, left homonymous hemianopia	VPS		favorable at 6 mos
119		71	F	postop, intraventricular meningioma	1.5	L	right hemiparesis, aphasia	open-ended VPS		favorable at 12 mos
120		60	M	postop, intraventricular meningioma	1	L	right hemiparesis, aphasia	VPS		favorable at 12 mos
121		63	F	postop, temporal HGG	0.66	L	drowsiness, seizures	VPS		favorable at 6 mos

ADHD = attention deficit hyperactivity disorder; **AIDS** = acquired immunodeficiency syndrome; **AVM** = arteriovenous malformation; **CN** = cranial nerve; **CNS** = central nervous system; **(t)EVD** = (temporal) external ventricular drain; **F** = female; **FU** = follow-up; **G-Knife** = Gamma Knife; **HGG** = high grade glioma; **ICH** = intracerebral hemorrhage; **IVH** = intraventricular hemorrhage; **L** = left; **LGG** = low grade glioma; **M** = male; **mo/mos** = month/months; **MRI** = magnetic resonance imaging; **NR** = not reported; **POD** = postoperative day; **postop** = postoperative; **R** = right; **SAH** = subarachnoid hemorrhage; **UOS** = unless otherwise specified; **VAS** = ventriculoatrial shunt; **VPS** = ventriculoperitoneal shunt; **yr/yrs** = year/years.

Table 2A – Etiology (non-surgically related ETH cases)

ETH causes: non-surgically related cases	**Cases (n)**	**Percentage (%)**
	65/121	**53.7**
Infectious disease	***22***	***33.8***
Cryptococcosis	6	9.2
Tuberculosis	5	7.7
Cysticercosis	2	3.1
Hydatidosis	2	3.1
Listeriosis	1	1.5
Streptococcal infection	1	1.5
H. influenzae infection	1	1.5
Fungal infection	1	1.5
Others	3	4.6
Neoplastic disease	***15***	***23.1***
HGGs	8	12.3
Meningiomas	3	4.6
LGGs	2	3.1
Lymphomas	1	1.5
Not reported data	1	1.5
Non-neoplastic cystic disease	***11***	***16.9***
Arachnoidal cysts	9	13.8
Others	2	3.1
Inflammatory disease	***7***	***10.8***
Neurosarcoidosis	5	7.7
Others	2	3.1
Spontaneous intracranial hemorrhage	***3***	***4.6***
Congenital	***3***	***4.6***
Trauma	***2***	***3.1***
Idiopathic	***2***	***3.1***

ETH = entrapment of the temporal horn; **HGG** = high grade glioma; **LGG** = low grade glioma

Table 2B – Etiology (surgically related ETH cases)

ETH causes: surgically related cases	Cases (n)	Percentage (%)
	56/121	**46.3**
Neoplastic disease	***44***	***78.6***
Meningiomas	23	41.1
HGGs	14	25
Neurocytomas	2	3.6
Others	5	8.9
Vascular disease	***7***	***12.5***
AVMs	6	10.7
Intracranial aneurysms	1	1.8
Infectious disease	***3***	***5.4***
Tuberculosis	1	1.8
Hydatidosis	1	1.8
Others	1	1.8
Inflammatory disease	***1***	***1.8***
Malformative disease	***1***	***1.8***

AVM = arteriovenous malformation; **ETH** = entrapment of the temporal horn; **HGG** = high grade glioma

Table 3 – ETH symptoms

ETH symptoms	Cases (n)	Percentage (%)
Major symptoms		
Headache	51	42
Altered mental status	29	24
Seizures	21	17
Motor deficits	12	10
Memory dysfunction	12	10
Visual field defects	11	9
Aphasia	7	6
Sensory deficits	6	5
Intracranial hypertension	6	5
No symptoms (incidental diagnosis)	6	5
Minor symptoms		
Megalencephaly, ADHD, CN palsies	-	<3
Not reported data	9	7

ADHD = attention deficit hyperactivity disorder; **CN** = cranial nerve

Table 4 – Results for definitive ETH treatments.

Definitive treatment	Cases	Surgical revision of the definitive treatment (cases, %)	Total recurrences* (cases, %)	Perioperative complications	Favorable average F. up (months)
VP shunt or VA shunt	42	4(9,5%)	6(13.6%)	0	15,6
Trigonal cystic or neoplastic lesion removal	25	0	0	0	26,5
Endoscopic ventriculocisternostomy	12	2(16,7%)	6(37,5%)	1(8,3%)	21,3
Endoscopic trigonal disobstruction	6	0	1(14,2%)	0	17,8
Internal intraventricular or ventriculocisternal shunt with catheter	4	0	1(20%)	1(25%)	36
Temporal corticectomy (communication between temporal horn and subarachnoid space)	4	0	1(20%) †	0	36
Chorioid plexus coagulation or removal through open surgery	3	0	1(25%) †	0	9
Trigonal adhesions debridement through open surgery	2	0	0	0	8
Not surgically treated	16	0	0	0	39

* Cases in which an alternative definitive treatment was performed are included.
† Both procedures were performed in the same clinical case.

FIGURE LEGEND:

Fig. 1 – Prisma flow chart.

Fig. 2 – a) Preoperative T1 C+ MRI shows left peri-trigonal hemorrhage with left ETH and post-contrast enhancement of ectasic vessels running through the later wall of the temporal horn; b) POD 1 CT scan shows surgical outcomes of the exeresis and reduction in size of the temporal horn; c) POD 14 FLAIR MRI shows recurrence of ETH with subcortical oedema; d) CT scan shows correct placement of ventricular shunt and ETH resolution.

Fig. 3 – a) Preoperative T1 C+ MRI shows left paratrigonal mass with inhomogeneous post-contrast enhancement and associated left ETH; b) POD 1 CT scan shows surgical outcomes of the exeresis and reduction in size of the temporal horn; c) POD 35 FLAIR MRI shows severe ETH with subcortical oedema; d) CT scan shows correct placement of ventricular shunt and ETH resolution.

Fig. 4 – Management of ETH: a potential algorithm of treatment.