Article published online: 2022-08-24

Challenges and Controversies in the Management of Tuberculous Meningitis with Hydrocephalus: A Systematic Review and Sarawak Institution's Experience

Siew-Hong Yiek[1] Albert Sii-Hieng Wong[1]

[1] Department of Neurosurgery, Sarawak General Hospital, Malaysia

AJNS 2022;17:189–198.

Address for correspondence Siew Hong Yiek, MBBS, 2A, Lorong 8A/4 Jalan Lada, 96000 Sibu, Sarawak, Malaysia (e-mail: ysh1989@hotmail.com).

Abstract

Introduction To date, there are no standard practice guidelines available and no universal consensus regarding treatment protocol in management of tuberculous meningitis (TBM) with hydrocephalus. Over the years, diverse views have existed in neurosurgical management of TBM with hydrocephalus. Some authors advocate ventriculo-peritoneal (VP) shunt, while others suggest that external ventricular drainage (EVD) may be the preferable neurosurgical procedure for a poor-grade patient.

Method We systematically reviewed published literature and presented our institution's experience. We performed a retrospective case study in our Sarawak neurosurgical center from 2018 to 2020. We tabulated the outcome according to preoperative classifications, which were Vellore Grading (VG), Modified Vellore Grading (MVG), British Medical Research Council Classification (MRC), and others: author-defined.

Result In our center, there were 20 cases of TBM with hydrocephalus treated by EVD and VP shunt from 2018 to 2020. We systematically searched published medical literature, and 23 articles were retrieved and analyzed. Poor outcomes were observed in poor-grade patients, especially VG/MVG 3/4 and MRC 3, from both institution and systemic review data. Shunt complication rate was lower in our center as compared with published literature.

Conclusion Unfortunately, morbidity and mortality were approximately twofold higher in poor-grade as compared with good-grade patients. However, about one-third of poor-grade patients achieved a good outcome. Cerebrospinal fluid (CSF) diversion would be an unavoidable treatment for hydrocephalus. Poor-grade patients tend to have cerebral infarcts in addition to hydrocephalus. An extended duration of EVD placement could be a potential measure to assess Glasgow coma scale recovery and monitor serial CSF samples.

Keywords
- tuberculous meningitis
- hydrocephalus
- EVD
- VP shunt

DOI https://doi.org/10.1055/s-0042-1750781.
ISSN 2248-9614.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Key Messages

Treating the hydrocephalus did not result in a favorable outcome in all patients with tuberculous meningitis, especially poor grade. Poor-grade patients tend to have cerebral infarcts in addition to hydrocephalus.

Introduction

From the World Health Organization (WHO) global tuberculosis 2020 data, tuberculosis (TB) is one of the top 10 causes of death worldwide. Geographically, most people who developed TB in 2019 were in the WHO regions of South-East Asia (44%), Africa (25%), and the Western Pacific (18%), with smaller percentages in the Eastern Mediterranean (8.2%), the Americas (2.9%), and Europe (2.5%). TB is a disease of public health importance in Malaysia, with 25,173 cases recorded nationally in 2018. Sarawak was in the top three states with new 3,122 TB cases in 2018.

Central nervous system TB accounts for approximately 5 to 10% of all extrapulmonary tuberculosis cases and approximately 1% of all TB cases.[1] Hydrocephalus is one of the most common complications of tuberculous meningitis (TBM). It is almost always present in patients who have had the disease for 4 to 6 weeks.[2] The incidence of hydrocephalus is approximately 76 to 90% in patients with TBM. Hydrocephalus in patients with TBM could be in the form of communicating or obstructive type.

Why It Was Necessary to Conduct This Review

Most patients with poor grade, that is, Vellore Grading (VG) 3 and 4, Modified Vellore Grading (MVG) 3 and 4, British Medical Research Council Classification (MRC) 3, did not achieve good outcomes despite shunting. There was a tendency to shunt all patients with TBM and hydrocephalus, and treating the hydrocephalus did not result in a favorable outcome in all patients. The underlying cause for altered sensorium of patients is multifactorial and cannot be attributed solely to the presence of hydrocephalus.

To date, there are no standard practice guidelines available and no universal consensus regarding the treatment protocol. Over the years, diverse views have existed in neurosurgical management of TBM with hydrocephalus. Some authors advocate ventriculo-peritoneal (VP) shunt, while others suggest that external ventricular drainage (EVD) may be the preferable neurosurgical procedure for a poor-grade patient. Precise indications and management remain controversial.

In our center, we practiced an extended duration of EVD. It allows for more objective identification of patients who will improve clinically post-EVD insertion and, therefore, likely benefit from permanent cerebrospinal fluid (CSF) diversion, that is, VP shunt surgery. This extended period allows for serial CSF sampling and monitoring of the trend of CSF protein and glucose levels (which may affect the outcome of VP shunt). In addition, Glasgow coma scale (GCS) recovery is the leading factor that determines the outcome of the patient. Definitely, this reduces the number of unnecessary VP shunt surgery and associated complications, such as, shunt failures, shunt infection, and shunt revisions.

Aims

We aim to identify all published studies of outcome and survival in patients who underwent CSF diversion using a systematic review process. Then, we will compare our institution data and published studies to produce a narrative review of patient outcomes, risks, and benefits of shunt surgery.

Objectives

Our objectives were to:

1. Compare post-CSF diversion (EVD or VP shunt) outcomes between our institution data and published studies.
2. Review shunt complication rate.
3. Discuss controversial topics in TBM with hydrocephalus such as classification, shunt selection, the role of endoscopic third ventriculostomy (ETV), and other significant prognostic factors.

Materials and Methods

Study Design

We performed a retrospective study in two neurosurgical centers (Sarawak General Hospital and Sibu Hospital) in Sarawak, Malaysia, from 2018 to 2020. The patients were subgrouped according to MVG. Besides, we systematically reviewed all published studies stored in online electronic databases. All original studies that had enrolled at least five patients with TBM and hydrocephalus and reported the outcome following CSF diversion were included for the review.

We systematically searched published medical studies using the following databases, that is, PubMed, CENTRAL, and ScienceDirect, till January 2021 (►**Table 1**). We also reviewed the bibliographies of primary studies to search for appropriate additional studies. Only English articles were included. Each included study was assessed and evaluated according to the Canadian National Collaborating Centre for Methods and Tools domain-based "Quality Assessment Tool for Quantitative Studies."[3,4]

Data Collection for Retrospective Study

Patients who met the mentioned inclusion criteria for TBM were subgrouped, according to MVG. The baseline data of

Table 1 Keyword search

1	PubMed: ([tuberculous meningitis] AND [hydrocephalus]) AND (shunt)
2	Cochrane Central Register of Controlled Trials (CENTRAL): The abstract words are tuberculous meningitis, hydrocephalus and shunt.
3	ScienceDirect: The words in articles (research article only) are tuberculous meningitis hydrocephalus shunt

enrolled patients were collected upon admission. Diagnosis, CSF diversion surgery (EVD or VP shunt), and outcome were evaluated. The outcome was measured in Glasgow outcome scale (GOS).The primary objective was a prognosis-based good (4–5) or poor (1–3) outcome dichotomized from GOS. The secondary objective was to identify complications arising from EVD and VP shunt.

Data Collection/Analysis for Systemic Review

The data extracted included bibliographic information (author, year of publication), study design, number of patients, follow-up period, and outcome based on preoperative classification.

Preoperative classification (►**Tables 2–4**):

1. VG
2. MVG
3. MRC
4. Others: author-defined

Outcome:

1. Mortality
2. GOS
3. Good outcome was defined as a GOS of 4 or 5 (GOS 5 = good recovery, GOS 4 = moderate disability), author-defined good/full recovery, minor disability/sequelae, mild disability/sequalae
4. Poor outcome was defined as a GOS of 1, 2 or 3 (GOS 3 = Severe disability, GOS 2 = Persistent vegetative state, GOS 1 = death), and author defined severe neurological deficit/disability/retarded/sequelae, major disability/sequelae
5. Others: author-defined

Table 2 Medical Research Council (MRC) grading of tuberculous meningitis

Stage	Presentation
1	Fully conscious, no paresis
2	Decreased level of consciousness, localizing pain
3	Deeply comatose ± gross paresis

Table 3 Vellore Grading of tuberculous meningitis with hydrocephalus

Grade	Presentation
1	Headache, vomiting, fever ± neck stiffness No neurological deficit Normal sensorium
2	Normal sensorium Neurological deficit present
3	Altered sensorium but easily arousable Dense neurological deficit may or may not be present
4	Deeply comatose Decerebrate or decorticate posturing

Table 4 Modified Vellore Grading of tuberculous meningitis with hydrocephalus

Grade	Presentation
1	GCS 15 No neurological deficit present
2	GCS 15 Neurological deficit present
3	GCS 9–14 Neurological deficit may or may not be present
4	GCS 3–8 Neurological deficit may or may not be present

Abbreviation: GCS, Glasgow coma scale.

Articles were reviewed and graded according to Quality Assessment Tool for Quantitative Studies developed by the Effective Public Health Practice Project. Meta-analysis was not done because of differences in methodology, study design, and patient characteristics of the included studies, which conferred a significant amount of heterogeneity to the data. Extracted data were summarized in a tabulated format. The proportion of patients with good outcome and poor outcome were calculated. The frequency of complications was determined

Results

In our center, 20 cases were recruited from 2018 to 2020. There were 1, 6, and 3 patients with MVG 2, 3, and 4, respectively. We observed poor outcomes in patients with MVG 2, 3, and 4, that is, 1/3 (33.33%), 9/11 (81.8%), and 5⁄6 (83.3%), respectively. All patients underwent EVD first and followed by VP shunt if there was an improvement in GCS. The duration of EVD placement before VP shunt insertion was ranged from 2 to 10 days. There was a case that we placed two EVD for a total of 10 days before VP shunt. All other cases had a single EVD insertion with a duration of fewer than 7 days. This case was complicated with septated ventricles, a high CSF protein of 490mg/dL, and EVD was inserted twice on two different occasions before shunt. We performed shunt surgery in 100, 81.8, and 33.33% of patients with MVG 2, 3, and 4, respectively. There were two incidences of shunt revision. The revision was due to shunt malposition and blocked ventricular catheter. There was no reported superimposed shunt infection in our study.

There were 159, 4, and 225 articles found from PubMed, CENTRAL, and ScienceDirect, respectively. Nineteen articles were identified from electronic searches, and four articles were identified after searching bibliographies of primary studies. Finally, 23 studies met the inclusion criteria. All screened and included studies were shown in ►**Fig. 1**. Similar classification and outcome were stratified to tabulate the result. The included studies were summarized in ►**Table 5**. The tabulated data also included author, year of publication, study design, follow-up duration, and outcome. The risk of bias was summarized in ►**Table 6**. Each category's strength was categorized into STRONG, MODERATE, and WEAK. There

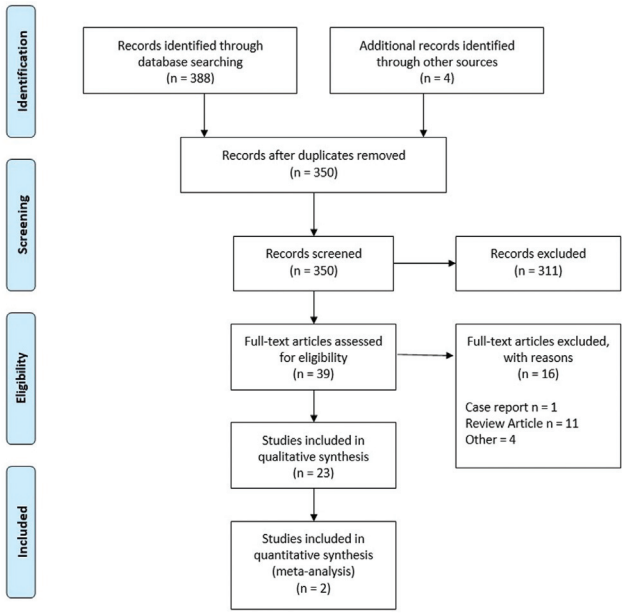

Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of screened and included study.

were 4 studies (study 4, 9, 11, and 18) with a global rating of MODERATE, and the rest was labeled as WEAK.

We had graded VG 1 and 2, MRC 2, and MVG 1 and 2 as good-grade whereas VG 3 and 4, MRC 3, and MVG 3 and 4 as poor-grade. The overall outcome was summarized in ►**Table 7**. In summary, overall mortality was 17.08%. Poor outcome was 63.11% in poor-grade patients as compared with 30.32% in good-grade patients. Good outcome was 36.89% in poor-grade patients as compared with 69.69% in good-grade patients.

The majority of the studies were based on preoperative VG, that is, 1 to 13. Most patients underwent VP shunt except for grade 4 patients in Mathew et al[5] and Agrawal et al[6] studies. Shunt was done if there was an improvement after EVD. The outcome from studies 1 to 13 were summarized in ►**Table 7**, with the majority reported in GOS. In VG 1 and 2, the mortality was 34/126 (26.98%), GOS 1–3 (poor outcome) was 46/133 (34.59%), and GOS 4–5 (good outcome) was 87/133 (65.41%). In VG 3 and 4, the mortality was 84/373 (22.52%), GOS 1–3 (poor outcome) was 150/254(59.06%), and GOS 4–5(good outcome) was 104/254 (40.94%). Overall, VG 4 has the highest rate of poor outcomes ranged from 36.85 to 100%. However, there were few studies with relatively lower poor outcome rates. First, Kemaloglu et al[7] classified outcomes based on the severity of hydrocephalus. Poor outcome was 32.7% included vegetative state and death cases. This number did not truly reflect other poor outcome measurements in poor-grade patients such as major disability. Next, Peng et al[8] showed a relatively good outcome in VG 4 patients with a 36.9% poor outcome rates. This study involved 19 patients aged from 1 to 14 years (mean of 5.7 years). However, only 4/19 (21.1%) patient's CSF showed mycobacterium TB. The diagnosis of TBM mainly depends on clinical signs and symptoms, CSF examination, and imaging. The probable diagnosis of TBM may contribute to this bias. Otherwise, VG 3 had a wider outcome variation, and poor outcomes ranged from 22.5 to 100%. All patients in this group underwent shunt. This may give VG 3 patients a better chance to benefit from shunt surgery.

There were four studies, that is, 14 to 17, based on preoperative classification-MRC. There was a variation of reporting the outcome with the mixing of author-defined and GOS. Poor outcomes in MRC 3 ranged from 50 to 84.6% compared with MRC 1 and 2 ranged from 12.5 to 44.4%. In MRC 1 and 2 the mortality was 7/46 (15.22%), poor outcome was 11/51(21.57%), and good outcome was 40/51 (78.43%). In MRC 3, the mortality was 21/64 (32.81%), poor outcome was 48/70 (68.57%), and good outcome was 22/70 (31.43%).

There were two studies, that is, 18 to 19, classified under MVG. Goyal et al[9] reported the mortality of 2/24 (8.3%) in their study. However, the number of patients in each MVG were not stated, no other outcome measurement, and 5/24 (20.83%) was lost to follow-up. Kanesen et al[10] reported poor outcomes (GOS1–3)—21/23 (91.3%) in MVG 3 and 4 patients.

There were four studies, that is, 20 to 23, that used the author-defined classification. The mortality ranged from 0 to 57.1%. Poor outcomes ranged from 3.9 to 85.7%. Kumar et al[11] showed that overall mortality was lower as compared with other studies. He mentioned that VG was used for his study. However, he did not state the number of each group. The outcome measurement was not described in detail, except for mortality. Otherwise, mortality in both VP shunt and ETV in drug-resistant groups was relatively higher-4/7 (57.1%) and ETV: 5/7 (71.4%) as compared with other groups (acute hydrocephalus with active TBM, hydrocephalus without active TBM, chronic/burnt-out disease with hydrocephalus).

A total of 105/478 (21.97%) shunt complications (►**Table 8**) were from 11 published studies. The most common complications were shunt revision (71/478 [14.85%]), followed by shunt infection (43/478 [9%]), shunt blockage/malfunction (26/478 [5.44%]), and intracranial bleeding/Intraventricular bleeding (9/478 [1.88%]). These studies did not mention

Table 5 Poor outcome in different preoperative classification

	Author/year	Patient	Follow-up (mo)	Preoperative VG			
				I	II	III	IV
1	Palur et al (1991)[12]	114	45.6	20%	38.7%	51.9%	100%
2	Singh and Kumar (1996)[38]	140	NA	0	0	37%	65.5%
3	Mathew et.al (1998)[5]	28	23.1	–	–	77.8%	90%
4	Nadvi et.al (2000)[28]	30	1	22.2%	60%	71.5%	100%
5	Agrawal et al (2005)[6]	37	9	–	37.5%	60%	100%
6	Sil and Chatterjee (2008)[39]	32	6	–	28.2%		–
7	Srikantha et al (2009)[31]	40	18	–	–	–	55%
8	Savardekar et al (2013)[40]	26	3	–	–	28.5%	80%
9	Sharma et al (2015)[29]	47	5.1	14.3%		69.7%	
10	Kankane et al (2016)[41]	50	3	–	–	22.5%	70%
11	Harrichandparsad et al (2019)[30]	15	1	0	–	100%	100%
12	Kemaloglu et al (2002)[7]	156	8.5	32.7%			
13	Peng et al (2012)[8]	19	29	–	–	–	36.9%
				Preoperative MRC			
				I	II	III	
14	Bullock and Van Dellen (1982)[42]	23	9	–	12.5%	66.7%	
15	Gelabert et al (1988)[43]	11	NA	–	20%	50%	
16	Lamprecht et al (2001)[44]	65	6	–	17.2%	66.7%	
17	Clemente Morgado et al (2012)[45]	22	NA	44.4%		84.6%	
				Preoperative MVG			
				I	II	III	IV
18	Goyal et al (2014)[9]	24	6	8.3%			
19	Kanesen et al (2021)[10]	27	12	0		91.3%	
				Others classification/outcome			
20	Upadhyaya et al (1983)[46]	70	NA	Mortality: 31.6% Severe retarded: 13.2%			
21	Irfan and Qureshi (1995)[32]	30	24	Mortality: 22% Severe disability: 26.7%			
22	Kumar et al (2013)[11]	424	NA	VP shunt mortality: 3.9% ETV mortality:15.5%			
23	Aslam et al (2010)[47]	50	3	Preoperative GCS GCS 15–9: GOS 1–3: 5/43 (11.6%) GCS 8–3: GOS 1–3: 6/7 (85.7%)			

Abbreviation: ETV, endoscopic third ventriculostomy; GOS, Glasgow outcome scale; MRC, British Medical Research Council Classification; MVG, Modified Vellore Grading; NA, not available, VG, Vellore Grading; VP, ventriculo-peritoneal.
Poor outcome was defined as GOS of 1, 2, or 3 (GOS 3 = severe disability, GOS 2 = persistent vegetative state, GOS 1 = death), and author defined severe neurological deficit/disability/retarded/sequelae, major disability/sequelae.

causative agents that lead to shunt infection, antibiotic use, and revision with EVD. Also, there was no description in detail regarding the type of shunt blockages, such as shunt malposition and shunt fracture.

Discussion

In this article, we will discuss some controversial elements in management of TBM with hydrocephalus.

1. **MVG is more reliable.**

   In 1948, the MRC first published a TBM classification according to the severity of the disease, namely BMRC or MRC grading (►**Table 1**). Over the years, these stage groups have been refined and published in different formats. VG, also known as Palur Grading (►**Table 2**) by Palur et al[12] in 1991, is useful to grade the patients, but it has some degree of subjectivity in assessing sensorium.

Table 6 Quality assessment summary for included studies

Global rating	Study (year)	Comment
Weak	Bullock and Van Dellen (1982)[42] Upadhyaya et al (1983)[46] Gelabert et al (1988)[43] Palur et al (1991)[12] A. Irfan and Qureshi (1995)[32] Singh and Kumar (1996)[38] Mathew et al (1998)[5] Lamprecht et al (2001)[44] Kemaloglu et al (2002)[7] Agrawal et al (2005)[6] Sil and Chatterjee (2008)[39] Srikantha et al (2009)[31] Aslam et al (2010)[47] Peng et al (2012)[8] Clemente Morgado et al (2012)[45] Savardekar et al (2013)[40] Kumar et al (2013)[11] Kankane et al (2016)[41] Kanesen et al (2021)[10]	1. The majority of studies were prospective or retrospective cohort studies. There were only one randomized controlled trial (Goyal et al[9]) and one quasi-experimental study (Aslam et al[47]) 2. Studies with global rating—MODERATE generally scored well in confounder, data collection method, and withdrawal sections 3. No study fulfilled global rating—STRONG
Moderate	Nadvi et al (2000)[28] Goyal et.al (2014)[9] Sharma et al (2015)[29] Harrichandparsad et.al (2019)[30]	
Strong	–	

Using the Canadian national collaborating center for methods and tools effective public health practice project Quality Assessment Tool for Quantitative Studies.

Subsequently, MVG (►**Table 3**) was first introduced by Mathew et al[5] in 1998 with the incorporation of GCS, which is more reliable and reproducible across different levels of clinical expertise and different disciplines of healthcare workers. Vellore grading is still being used for most of the studies. So far, there were only four studies (4, 12, 23, 24) that describe the incorporation of GCS into VG. Mathew et als initial intention was to ease the assessment of the pediatric patient. Subsequently, Rajshekhar, one of the cowriters, promoted MVG from his

Table 7A Outcome based on preoperative classification

Preoperative classification	Mortality	Poor outcome	Good outcome
Vellore Grading (VG)[a] -For study 2 (Singh and Kumar[38]), the outcome was classified into mortality and grade improvement -For study 5 (Agrawal et al[6]), the mortality was reported together with GOS, Glasgow outcome scale (GOS) 1–3 as poor outcome -For study 6 (Sil and Chatterjee et al[39]), the study involved VG 2 and 3 only -For study 9 (Sharma et al[29]), only overall mortality was reported -For study 12 (Kemaloglu et al[7]) and 13 (Peng et al[8]), the outcome was not classified according to GOS			
VG 1 and 2	34/126 (26.98%)	46/133 (34.59%)	87/133 (65.41%)
VG 3 and 4	84/373 (22.52%)	150/254 (59.06%)	104/254 (40.94%)
British Medical Research Council Classification (MRC)			
MRC 1 and 2	7/46 (15.22%)	11/51(21.57%)	40/51 (78.43%)
MRC 3	21/64 (32.81%)	48/70 (68.57%)	22/70 (31.43%)
Modified Vellore Grading (MVG)[b]			
MVG 1 and 2	–	0/4 (0%)	4/4 (100%)
MVG 3 and 4	–	21/23 (91.3%)	2/23 (8.7%)
Overall	146/609 (17.08%)	276/535 (51.59%)	259/535 (48.41%)

Poor-grade: VG 3 and 4, MRC 3, MVG 3 and 4.
Good-grade: VG 1 and 2, MRC 2, MVG 1 and 2.
[a]The number of patients was different in terms of mortality and outcome (poor/good) because the authors reported the outcome differently. Hence, the following studies were excluded from the calculation.
[b]Study 18 (Goyal et al[9]) was excluded as the author did not state the number of patients in each MVG.

Table 7B Outcomes and Grades

Overall	Poor-grade	Good-grade
Poor outcome	219/347 (63.11%)	57/188 (30.32%)
Good outcome	128/347 (36.89%)	131/188 (69.69%)

review[13] in 2009. The outcome was correlated well to VG and to eliminate between-observer variability. However, it was not widely used by most of the studies. Nevertheless, we still use MVG to classify patients in our centers to produce a consistent classification.

2. **Poor outcome in patients with poor grades (VG/MVG 3 and 4, MRC 3) despite shunting.**
   In present studies and literature reviews, it is clearly stated that poor outcome is seen in both patients with poor/severe grades despite shunting. The poor clinical status is not due to hydrocephalus but the vasculitic infarcts in the deep gray nuclei and the brainstem, which is a pathology distinctively seen in TBM. Hsieh et al[14] first described the location of cerebral infarcts in TBM predominately in the TB zone, that is, heads of the caudate nuclei, the anteromedial thalami, the anterior limbs of the internal capsules, and the genus of the internal capsules. However, subsequent evidence suggested the vasculitis occurs in the small perforators, especially at the terminal cortical branches, basal ganglia, and internal capsule.[15–17] The brainstem infarct carries the most deadly outcome. Identifying early or new infarcts will have a significant prognostic value, and magnetic resonance imaging (MRI) is superior compared with computed tomography as the infarcts can be easily determined by using MRI diffusion-weighted imaging, T2-weighted, and fluid-attenuated inversion recovery sequences. Besides, MRI is a better modality to reveal tuberculomas, meningeal enhancements, and brainstem lesions. Lastly, the inflammatory exudate in TBM is produced within the subarachnoid cisterns, and the skull base will cause intense inflammation. This will lead to vasculitis, vasospasm, periarteritis, and even necrotizing panarteritis of affected vessels. These changes jeopardize arterial blood flow, causing ischemia and cerebral infarct.[18]
3. **CSF diversion.**
   The main available options for managing tubercular hydrocephalus are EVD, VP shunt, and ETV. There is no universal consensus regarding the treatment protocol. However, the best treatment decision is still based on the patient's clinical condition, surgeon expertise/experience, and endoscopy resources. Historically, ventriculoatrial shunt was the first surgical procedure to treat TBM with hydrocephalus by Bhagwati[19] in 1971. Subsequently, VP shunt was used since the early 1980s. For the past few decades, the shunts were inserted for most of the patients. VP shunt in the treatment of TBM with hydrocephalus is a well-established procedure. ETV is a relatively newer modality of treatment apart from VP shunt. Since the mid-1990s, the use and role of ETV have evolved continuously. ETV became a viable option for treating TBM and hydrocephalus, and has a theoretical advantage over VP shunt surgery by avoiding the insertion of a foreign body in the form of the shunt. Hence, complications such as shunt infection, blockage, and abdominal pseudo-cyst formation can be avoided. There have been several reports on the use of ETV in these patients with varying degrees of success. ETV Success Score (ETVSS) was developed based on Kulkarni et al study in 2009.[20] It is a simplified means of predicting the 6-month success rate of ETV. He concluded that age was the strongest predictor for ETV success rate. The success rate was highest in the age group of over 10 years (81.6%). Importantly, postinfectious cases only carried a 40% success rate. His subsequent

Table 8 Shunt complications

Author (year)	Total number of complications	Shunt revision	Shunt infection	Shunt blockage/ malfunction[a]	Intracranial bleeding/ intraventricular bleeding
Upadhyaya et al (1983)[46]	6/70 (8.57%)	–	–	–	6
Gelabert et al (1988)[43]	0/11 (0%)	–	–	–	–
Palur et al (1991)[12]	26/114 (22.81%)	26	–	–	–
Irfan and Qureshi (1995)[32]	1/30 (3.33%)	1	–	1	–
Lamprecht et al (2001)[44]	21/65 (32.31%)	16	9	11	–
Agrawal et al (2005)[6]	11/37 (29.73%)	3[b]	5	6	–
Sil and Chatterjee (2008)[39]	19/32 (59.34%)	14	5	14	–
Peng et al (2012)[8]	6/19 (31.58%)	3	2	3	1
Savardekar et al (2013)[40]	6/26 (23.08%)	2	2	2	2
Goyal et al (2014)[9]	4/24 (16.67%)	3	1	3	–
Kankane et al (2016)[41]	5/50 (10%)	3	2	3	–
Total	105/478 (21.97%)	71/478 (14.85%)	26/478 (5.44%)	43/478 (9%)	9/478 (1.88%)

[a]Shunt malfunction: under-drainage or over-drainage.
[b]Only reported three patients under multiple shunt revision. Did not mention all patients with shunt blockage underwent shunt revision.

literature review on 2011[21] showed that the actual ETV success rate from the 15 papers ranged from 31.3 to 92.3%, with a mean of 59.2%. ETVSS may not reflect the actual success rate for TBM with hydrocephalus patients as this scoring is mainly derived from hydrocephalus of varied etiology. Of course, ETV is a well-established mode of treatment for obstructive hydrocephalus with a relatively high success rate, and one wondered whether ETV could be used for treating hydrocephalus of TB origin as well. Few studies pointed out ETV are not suitable during the acute phase of TBM. The floor of the third ventricle is thick because of the presence of basal exudate. The bleeding risk is very high due to granulation tissue that may further obscure the surgical site during the endoscopic procedure. Also, post-inflammatory changes can distort anatomy and obscure the landmark for ventriculostomy. In addition, the third ventricular floor is opaque and thickened in the chronic phase, making ETV a technical challenge.[22,23] Again, the success rate for TBM with hydrocephalus varies due to its underlying pathology and stages of the disease.[24–27]

To date, there is only one randomized trial to compare the outcome of ETV and VP shunt in TBM and hydrocephalus. Goyal et al[9] reported that the ETV and VP shunt success rates were 41.7 and 54.2%, respectively. There was no significant difference in the *p*-value of 0.236. Further studies with a larger sample size might be needed to address this issue. Complications such as intraventricular hemorrhage and infection (meningitis/ventriculitis) may compromise the success of subsequent shunts. Bhagwati et al[23] pointed out that the success rate is higher in chronic cases in his review. A detailed study of the anatomy landmark of the third ventricle floor before surgery is the key to success rather than using a scoring system to select the patients. Besides, it also requires a surgeon with adequate expertise and experience in the endoscopic field.

4. **Selecting patients who are most likely to benefit from CSF diversion.**

   It is generally agreed that relieving hydrocephalus via VP shunt placement is beneficial in good-grade patients such as VG/MVG 1 or 2. The majority of poor-grade patients did not achieve a good outcome despite shunting. From our systemic review of published literature, there was a tendency to shunt all patients with TBM and hydrocephalus even in a poor grade. However, the morbidity and mortality were high despite shunting.

   One of the most critical factors determining the outcome is the baseline grade when CSF diversion is performed. Of course, various prognostic factors are being discussed in many papers, such as age, duration of illness, and CSF content, but none of these significantly affect the long-term outcome. As the disease progresses, the presence of infarcts will further complicate the prognosis and outcome, especially infarcts over the brainstem/thalamus, which will directly impact baseline GCS.

   Human immunodeficiency virus (HIV)-positive patients had a worse prognosis than HIV-negative patients.[28–30] Nadvi et al[28] performed a prospective comparative cohort study between HIV-positive and -negative groups in TBM with hydrocephalus patients. He showed that all of HIV-positive patient's GCS did not recover (15/15, 100%) compared with HIV-negative patients (9/15; 60%) with a *p*-value of 0.017. In addition, Harrichandparsad et al[30] study also showed 100% poor outcome in HIV-positive patients with VG 3 or 4. Besides, this group of the patient was not on antiretroviral therapy at the time of diagnosis. Agrawal et al[6] study only involved children aged from 1 to 18 years (mean age of 11.42 years) with 100% mortality in VG 4 patients. A pediatric patient may be more vulnerable to this disease.

5. **Why do we choose an extended EVD duration of 5 to 7 days?**

   Palur et al[12] published his management guideline in 1991. He advocated EVD placement for 24 to 48 hours for shunt selection after he observed a high morbidity/mortality rate in the previous case series. Since then, few authors have used this protocol, such as Mathew et al[7] and Agrawal et al.[6] From Mathew et al's study, there were 10 cases of VG 4, and 9 of them were shunted after EVD placement. However, the mortality still was high (88.89%) despite shunting. There was no neurological recovery seen in VG 4 patients after EVD placement in Agrawal et al case series as well. Other authors (Srikantha et al,[31] Kanesen et al,[10] Irfan and Qureshi[32]) did not mention the exact duration of EVD placement. There were many variations in terms of CSF diversion in TBM with hydrocephalus. In our centers, we practiced an extended duration of EVD. We preferred to shunt the patient in our centers when CSF protein is lower to 100 mg/dL. We encountered a shunt failure case due to blockage with high initial CSF protein in our case study. Also, we do not have cases with superimposed bacterial infections. Besides, Kumar et al[11] stated that shunt works best at a protein level less than 200 mg/dL. They will resort to Ommaya's reservoir placement if CSF protein is high after EVD placement in their institute.

   VP shunt insertion does not come without a cost. Shunt surgery complications were reportedly higher in patients with TBM than in patients with other conditions. The high protein and cellular content in the CSF lead to more frequent shunt obstruction. CSF protein is elevated in most patients with TBM, with most series citing a median value of 150 to 200 mg/dL. It predisposes to develop a shunt block leading to shunt revision.[33] Based on Jamjoom et al,[34] catheters left in situ for over 8 days had a higher risk of EVD-related infection (ERI) compared with those removed at 7 days or less (odds ratio = 2.54 [95% confidence interval: 1.14–5.7]; $p = 0.02$). The other studies also have proven that prolonged catheterization duration plays an essential role in ERI.[35–37] The local laboratory requires a 3 to 5 days duration for culturing and sensitivity, which is well within 7 days as excluding of superimposed bacterial meningitis is crucial.

Conclusion

Evidence in this review was derived mainly from cohort studies. There were many variations in indications for

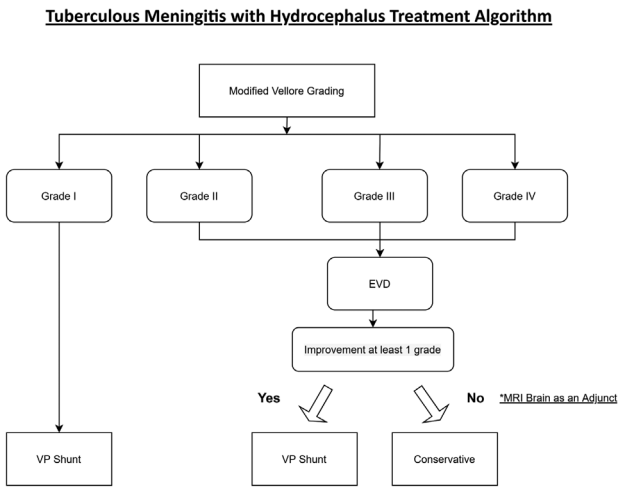

Fig. 2 Suggested treatment algorithm. *MRI brain can be used as an adjuvant if there is any improvement on MVG grade. EVD, external ventricular drainage; MRI, magnetic resonance imaging; VP, ventriculo-peritoneal.

performing a CSF diversion surgery, follow-up method, and outcome assessment. Meta-analysis was not done as differences in methodology among cohorts.

Based on available data, we recommend a trial with an extended EVD duration of 7 days as a preliminary procedure for VP shunt selection in patients with poor grade and allow more objective identification of patients who are most likely to benefit from permanent CSF diversion. Unfortunately, morbidity and mortality were approximately twofold higher in poor-grade as compared with good-grade patients. However, about one-third of poor-grade patients achieved a good outcome. CSF diversion would be an unavoidable treatment for hydrocephalus. Poor-grade patients tend to have cerebral infarcts in addition to hydrocephalus. An extended duration of EVD placement could be a potential measure to assess GCS recovery and monitor serial CSF samples. It may help us to select the patients who are likely to be benefit from shunt surgery. Certainly, patients with good grades should have benefited from CSF diversion.

The MVG system should be used for preoperative classification. It is more reliable and reproducible across different levels of clinical expertise and disciplines of healthcare workers. MRI brain should be used as an adjunct to delineate infarct and help in prognosticating the outcome.

Hence, we have formulated a treatment algorithm (►**Fig. 2**) to improve the outcome of patients with TBM and hydrocephalus.

Conflict of Interest
None declared.

References

1 Thakur K, Das M, Dooley KE, Gupta A. The global neurological burden of tuberculosis. Semin Neurol 2018;38(02):226–237
2 Raut T, Garg RK, Jain A, et al. Hydrocephalus in tuberculous meningitis: Incidence, its predictive factors and impact on the prognosis. J Infect 2013;66(04):330–337
3 Tools NCCfMa. Quality Assessment Tool for Quantitative Studies. 2008 Available from: http://www.nccmt.ca/resources/search/14. Accessed April 25, 2022
4 Deeks JJ, Dinnes J, D'Amico R, et al;International Stroke Trial Collaborative Group; European Carotid Surgery Trial Collaborative Group. Evaluating non-randomised intervention studies. Health Technol Assess 2003;7(27):iii–x, 1173
5 Mathew JM, Rajshekhar V, Chandy MJ. Shunt surgery in poor grade patients with tuberculous meningitis and hydrocephalus: effects of response to external ventricular drainage and other variables on long term outcome. J Neurol Neurosurg Psychiatry 1998;65(01):115–118
6 Agrawal D, Gupta A, Mehta VS. Role of shunt surgery in pediatric tubercular meningitis with hydrocephalus. Indian Pediatr 2005; 42(03):245–250
7 Kemaloglu S, Ozkan U, Bukte Y, Ceviz A, Ozates M. Timing of shunt surgery in childhood tuberculous meningitis with hydrocephalus. Pediatr Neurosurg 2002;37(04):194–198
8 Peng J, Deng X, He F, et al. Role of ventriculoperitoneal shunt surgery in grade IV tubercular meningitis with hydrocephalus. Childs Nerv Syst 2012;28(02):209–215
9 Goyal P, Srivastava C, Ojha BK, et al. A randomized study of ventriculoperitoneal shunt versus endoscopic third ventriculostomy for the management of tubercular meningitis with hydrocephalus. Childs Nerv Syst 2014;30(05):851–857
10 Kanesen D, Kandasamy R, Hieng AWS, et al. Outcome of hydrocephalus in tuberculous meningitis. A retrospective study. Malays J Med Sci 2021;28(05):82–93
11 Kumar A, Singh K, Sharma V. Surgery in hydrocephalus of tubercular origin: challenges and management. Acta Neurochir (Wien) 2013;155(05):869–873
12 Palur R, Rajshekhar V, Chandy MJ, Joseph T, Abraham J. Shunt surgery for hydrocephalus in tuberculous meningitis: a long-term follow-up study. J Neurosurg 1991;74(01):64–69
13 Rajshekhar V. Management of hydrocephalus in patients with tuberculous meningitis. Neurol India 2009;57(04):368–374
14 Hsieh FY, Chia LG, Shen WC. Locations of cerebral infarctions in tuberculous meningitis. Neuroradiology 1992;34(03):197–199
15 Tai MS, Viswanathan S, Rahmat K, et al. Cerebral infarction pattern in tuberculous meningitis. Sci Rep 2016;6:38802
16 Kalita J, Misra UK, Nair PP. Predictors of stroke and its significance in the outcome of tuberculous meningitis. J Stroke Cerebrovasc Dis 2009;18(04):251–258
17 Pienaar M, Andronikou S, van Toorn R. MRI to demonstrate diagnostic features and complications of TBM not seen with CT. Childs Nerv Syst 2009;25(08):941–947
18 Chan KH, Cheung RT, Lee R, Mak W, Ho SL. Cerebral infarcts complicating tuberculous meningitis. Cerebrovasc Dis 2005;19 (06):391–395

19 Bhagwati SN. Ventriculoatrial shunt in tuberculous meningitis with hydrocephalus. J Neurosurg 1971;35(03):309–313
20 Kulkarni AV, Drake JM, Mallucci CL, Sgouros S, Roth J, Constantini SCanadian Pediatric Neurosurgery Study Group. Endoscopic third ventriculostomy in the treatment of childhood hydrocephalus. J Pediatr 2009;155(02):254–9.e1
21 Kulkarni AV, Riva-Cambrin J, Browd SR. Use of the ETV Success Score to explain the variation in reported endoscopic third ventriculostomy success rates among published case series of childhood hydrocephalus. J Neurosurg Pediatr 2011;7(02): 143–146
22 Moorthy RK, Rajshekhar V. Endoscopic third ventriculostomy for hydrocephalus: a review of indications, outcomes, and complications. Neurol India 2011;59(06):848–854
23 Bhagwati S, Mehta N, Shah S. Use of endoscopic third ventriculostomy in hydrocephalus of tubercular origin. Childs Nerv Syst 2010;26(12):1675–1682
24 Singh D, Sachdev V, Singh AK, Sinha S. Endoscopic third ventriculostomy in post-tubercular meningitic hydrocephalus: a preliminary report. Minim Invasive Neurosurg 2005;48(01):47–52
25 Siomin V, Cinalli G, Grotenhuis A, et al. Endoscopic third ventriculostomy in patients with cerebrospinal fluid infection and/or hemorrhage. J Neurosurg 2002;97(03):519–524
26 Chugh A, Husain M, Gupta RK, Ojha BK, Chandra A, Rastogi M. Surgical outcome of tuberculous meningitis hydrocephalus treated by endoscopic third ventriculostomy: prognostic factors and postoperative neuroimaging for functional assessment of ventriculostomy. J Neurosurg Pediatr 2009;3(05):371–377
27 Figaji AA, Fieggen AG, Peter JC. Endoscopic third ventriculostomy in tuberculous meningitis. Childs Nerv Syst 2003;19(04): 217–225
28 Nadvi SS, Nathoo N, Annamalai K, van Dellen JR, Bhigjee AI. Role of cerebrospinal fluid shunting for human immunodeficiency virus-positive patients with tuberculous meningitis and hydrocephalus. Neurosurgery 2000;47(03):644–649, discussion 649–650
29 Sharma RM, Pruthi N, Arimappamagan A, Somanna S, Devi BI, Pandey P. Tubercular meningitis with hydrocephalus with HIV coinfection: role of cerebrospinal fluid diversion procedures. J Neurosurg 2015;122(05):1087–1095
30 Harrichandparsad R, Nadvi SS, Suleman Moosa MY, Rikus van Dellen J. Outcome of ventriculoperitoneal shunt surgery in human immunodeficiency virus-positive patients on combination antiretroviral therapy with tuberculosis meningitis and hydrocephalus. World Neurosurg 2019;123:e574–e580
31 Srikantha U, Morab JV, Sastry S, et al. Outcome of ventriculoperitoneal shunt placement in Grade IV tubercular meningitis with hydrocephalus: a retrospective analysis in 95 patients. Clinical article. J Neurosurg Pediatr 2009;4(02):176–183
32 Irfan A, Qureshi A. Role of ventriculoperitoneal shunt in post-tuberculous meningitic hydrocephalous. J Pak Med Assoc 1995;45 (02):37–38
33 Ambekar S, Dwarakanath S, Chandramouli BA, Sampath S, Devi BI, Pandey P. Does CSF composition predict shunt malfunction in tuberculous meningitis? Indian J Tuberc 2011;58(02):77–81
34 Jamjoom AAB, Joannides AJ, Poon MT, et al;British Neurosurgical Trainee Research Collaborative. Prospective, multicentre study of external ventricular drainage-related infections in the UK and Ireland. J Neurol Neurosurg Psychiatry 2018;89(02):120–126
35 Omar MA, Mohd Haspani MS. The risk factors of external ventricular drainage-related infection at hospital Kuala Lumpur: an observational study. Malays J Med Sci 2010;17(03):48–54
36 Tahir MZ, Sobani ZA, Murtaza M, Enam SA. Long-tunneled versus short-tunneled external ventricular drainage: prospective experience from a developing country. Asian J Neurosurg 2016;11(02): 114–117
37 Park P, Garton HJ, Kocan MJ, Thompson BG. Risk of infection with prolonged ventricular catheterization. Neurosurgery 2004;55 (03):594–599, discussion 599–601
38 Singh D, Kumar S. Ventriculoperitoneal shunt in post tubercular hydrocephalus. Indian Pediatr 1996;33(10):854–855
39 Sil K, Chatterjee S. Shunting in tuberculous meningitis: a neurosurgeon's nightmare. Childs Nerv Syst 2008;24(09):1029–1032
40 Savardekar A, Chatterji D, Singhi S, Mohindra S, Gupta S, Chhabra R. The role of ventriculoperitoneal shunt placement in patients of tubercular meningitis with hydrocephalus in poor neurological grade: a prospective study in the pediatric population and review of literature. Childs Nerv Syst 2013;29(05):719–725
41 Kankane VK, Gupta TK, Jaiswal G. Outcome of ventriculoperitoneal shunt surgery, without prior placement of external ventricular drain in Grades III and IV patients of tubercular meningitis with hydrocephalus: a single institution's experience in the pediatric population and review of literature. J Pediatr Neurosci 2016;11(01):35–41
42 Bullock MR, Van Dellen JR. The role of cerebrospinal fluid shunting in tuberculous meningitis. Surg Neurol 1982;18(04):274–277
43 Gelabert M, Castro-Gago M. Hydrocephalus and tuberculous meningitis in children. Report on 26 cases. Childs Nerv Syst 1988;4(05):268–270
44 Lamprecht D, Schoeman J, Donald P, Hartzenberg H. Ventriculoperitoneal shunting in childhood tuberculous meningitis. Br J Neurosurg 2001;15(02):119–125
45 Clemente Morgado T, Kinsky M, Carrara H, Rothemeyer S, Semple P. Prognostic value of computed tomography-evident cerebral infarcts in adult patients with tuberculous meningitis and hydrocephalus treated with an external ventricular drain. World Neurosurg 2013;80(06):e255–e260
46 Upadhyaya P, Bhargava S, Sundaram KR, Mitra DK, George J, Singh DC. Hydrocephalus caused by tuberculous meningitis: clinical picture, CT findings and results of shunt surgery. Z Kinderchir 1983;38(Suppl 2):76–79
47 Khan M, Aslam AA, Udin MM, Imran M, Ashraf J. Ventriculoperitoneal shunt for hydrocephalus secondary to tuberculous meningitis. Pak J Surg 2010;26(04):284–290

