



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

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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

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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 Sibul 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/sequelae
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 5/5 (100%), 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

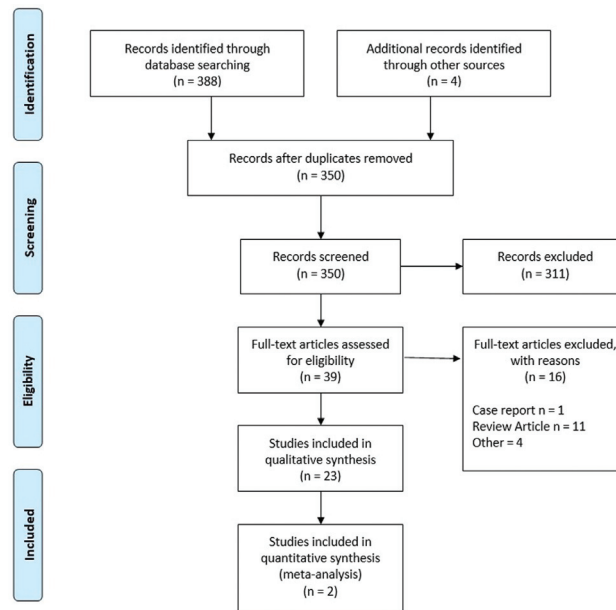


Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of screened and included study.

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 al⁵ and Agrawal et al⁶ 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 al⁷ 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 al⁸ 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 al⁹ 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 al¹⁰ 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 al¹¹ 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 al¹² 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 Harrichandparsingh 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 al⁵ 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 al's initial intention was to ease the assessment of the pediatric patient. Subsequently, Rajshekhkar, 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.

^aThe 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.

^bStudy 18 (Goyal et al⁹) was excluded as the author did not state the number of patients in each MVG.

literature review on 2011²¹ 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 al⁹ 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 al²³ 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 al²⁸ 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 al³⁰ 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 al⁶ 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 al¹² 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 al⁷ 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 Qureshi³²) 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 al¹¹ 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

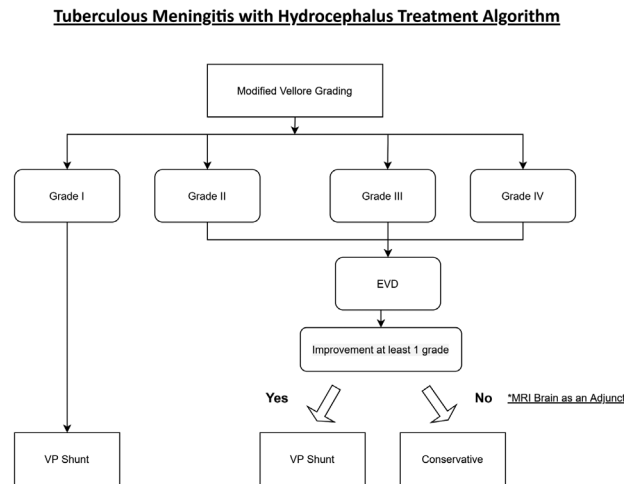


Fig. 2 Suggested treatment algorithm. *MRI brain can be used as an adjuvant if there is any improvement on MVG grade. EVD, external ventricular drainage; MRI, magnetic resonance imaging; VP, ventriculo-peritoneal.

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.

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