

Hydrocephalus in Children with Tuberculous Meningitis

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Abstract

Hydrocephalus is an enlarged brain ventricle as a result of an increase of cerebrospinal fluid (CSF) caused by an imbalance between production, circulation and its absorption. Hydrocephalus can be divided into two groups are congenital and acquired hydrocephalus. Central nervous system (CNS) infections such as Tuberculous (TB) meningitis is one of the causes of hydrocephalus. TB meningitis is the most common TB CNS manifestation in total incidence of extrapulmonary TB. Hydrocephalus is a common complication of TB meningitis, and almost always appears at 4-6 weeks after having meningitis. Hydrocephalus in TB meningitis can be communicating or obstructive; between them, communicating hydrocephalus occurs more frequently. Hydrocephalus occurs because of the blockade of the basal cisterna by a thick exudate. Other causes are due to the formation of arachnoid granulation which inhibits absorption of CSF, excessive CSF production because the coronary plexus and ependyma are inflamed, and the formation of scar tissue (skar) in the subarachnoid space in the advanced phase. There are various diagnostic modalities to evaluate the hydrocephalus due to TB meningitis, such as CSF analysis and radiological examinations such as CT scans and MRI. Clinically, the severity of the disease can be determined using the Bhagwati grading system, modified Vellore grading or MRC staging. Conservative treatment does not promise significant improvements and is very susceptible to deteriorating prognosis, so invasive procedures and surgery such as ventricular taps, ventricular shunts, or endoscopic third ventriculostomy (EVT) are necessary.

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INTRODUCTION

Hydrocephalus comes from the word “hydro” which means water and “cephalus” which means head. Medically, hydrocephalus is defined as enlargement of brain ventriculus as a result of an increase of cerebrospinal fluid (CSF) caused by an imbalance between production, circulation and its absorption.

Etiologically, hydrocephalus can be divided into two groups are congenital and acquired hydrocephalus. Congenital hydrocephalus results from developmental disorders during intrauterine, whereas acquired hydrocephalus is caused by subarachnoid bleeding, intraventricular bleeding, trauma, tumors and infections. Meningitis can cause meningeal attachment resulting in obliteration of subarachnoid space so that it can cause hydrocephalus. In tuberculous serous meningitis, meningeal attachment is mainly found in the basal area around the cisternal and interpenduncular cysts. The review of this article will describe the link between tuberculous (TB) meningitis and hydrocephalus

TUBERCULOUS MENINGITIS

Tuberculous (TB) is still a health problem throughout the world. TB meningitis is the most common manifestation of central nervous system (CNS) TB with an incidence of 3% - 5% of the total incidence of extrapulmonary TB. A total of 3,179 cases were reported in 2002 - 2011 in Europe and 100 cases in 2014 in the United States.¹ Although rare, TB infection in the CNS is a very dangerous disease and is associated with increased mortality and morbidity.²

Duramater has a good supply and blood flow and acts as a protective barrier with its connective tissue composition. Various mechanisms such as direct displacement or hematogenous spread are associated with the pathogenesis of the occurrence of TB in meninges. Severe local inflammation of the bones and related structures such as the temporal muscles, paranasal sinuses and orbit can be a source of infection that can move directly and invade meninges.³ The formed tubercle will form an aggregation of fibrotic tissue that attaches to the dura or can rupture into

the subarachnoid space and form a subependymal or subpial granuloma commonly called Rich Focus⁴.

Symptoms of TB meningitis are generally non-specific and can cause death if not treated. Children with TB meningitis will generally be restless, unwilling to eat, and will lose weight, while adults will easily feel tired, decrease appetite, and sweat at night. These prodromal symptoms can appear several days to several weeks before the main symptoms of TB meningitis appear such as headaches, fever, and neck stiffness. If the patient is not treated immediately, a few days later will fall into a coma and as many as 50% will experience a neurological deficit, such as cranial nerve paresis (generally III and VI nerves) or hemiplegia.⁵

CSF examination is very important in patients with TB meningitis and usually shows, the increase in the number of leukocyte is dominated by neutrophils and lymphocytes (50 - 1,000 cells / mm³), increased protein levels (1.5 - 5 gr / L), CSF comparison ratio and plasma glucose <50%. High levels of adenosine deaminase in CSF and the presence of acid-resistant bacilli on CSF smear are the initial indicators, but the gold standard of the examination is the culture of *Mycobacterium tuberculosis*.²

HYDROCEPHALUS IN TUBERCULOUS MENINGITIS

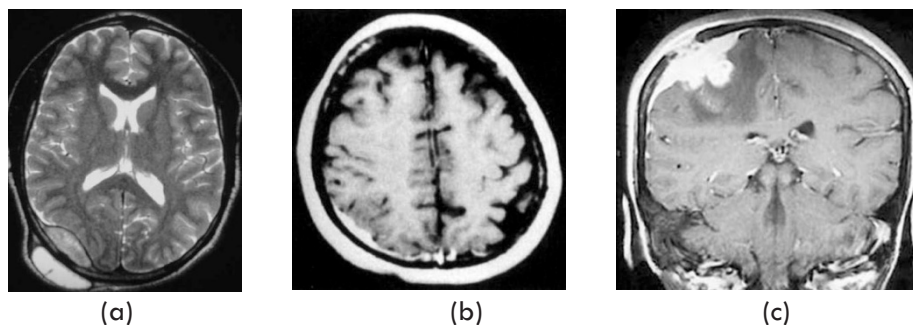
Hydrocephalus is a common complication of TB meningitis, and almost always appears at week 4 - 6 after the patient has TB meningitis. Its incidence is higher in children than the adult population and can appear in the early phase of the infection process. Schoeman et al. reported the incidence of hydrocephalus in patients with TB meningitis approaching 83% based on evaluation of CT scans. Hydrocephalus in TB meningitis can be communicating or obstructive; between them, communicative hydrocephalus occurs more frequently.⁶

TB meningitis occurs due to rupture of Rich focus in subcortical or subependymal regions. This condition results in the formation of an exudate at the basal subarachnoid space, and the exudate will spread to the optic

Table 1. Clinical evaluation of patients with untreated TB meningitis

Time (weeks)		0	1	2	3	4	5	Mortality
Symptoms	Easily tired	+	++	++	++	++	++	
	Fever	+ / -	+	+	+	+	+	
	Headache	+ / -	+	++	++	++	++	
	Loss of consciousness							
	Focal symptoms			+	++	++	++	
	MRC degree	I	I	II	II/III	III	III	
CSF	Leukocytes							
	Protein							
	Glucose							
	Lactate							
	Bacteria		+	+	+	++	++	
Radiology	Hydrocephalus		+	++	+++	+++	+++	
	Ischemia / Infarction			+	++	++	++	
	Tuberculoma				+	+	++	
Mortality		5%	10%	20%	30%	50%	80%	
Time (weeks)		0	1	2	3	4	5	

Magnetic resonance imaging (MRI) with gadolinium is the most widely used and superior radiology modality compared to Computed Tomography (CT) scan to evaluate all forms of TB in the CNS. In general, epidural tuberculoma and empyema show a hypointense of T1-weighted MRI with peripherally hyperintense. T2-weighted MRI will show a hyperintense lesion.



Picture 1. TB meningitis on MRI examination using gadolinium: (a) T1-weighted MRI axial view show the Dural tuberculoma plaque in the parietal region; (b) T1-weighted MRI coronal view show epidural tuberculomas in the right parietal region accompanied by osteolytic lesions; (c) T2-weighted MRI axial view show epidural TB abscess in the right occipital region with bone and subcutaneous involvement.⁴

nerve, optic chiasm and circle of Willis. Furthermore, this exudate will clog the subarachnoid space or ventricular flow. A thick exudate will block the basal cisterna and cause communicating hydrocephalus in the early stages of the disease.. Another cause

of communicant hydrocephalus is the formation of arachnoid granulation which inhibits CSF absorption, excessive CSF production because the coronary plexus and the ependyma are inflamed, and scar tissue is formed in the subarachnoid space in the advanced

phase.

Obstructive hydrocephalus occurs due to the blockade of aqueduct due to subependymal tuberculoma or the formation of scars in the brain stem. Other causes are obstruction of ventricle 4 by exudate or scar tissue.

CLINICAL SYMPTOMS AND DIAGNOSIS

Hydrocephalus must be suspected in all TB meningitis patients who experience changes in sensorium. Symptoms related to increased intracranial pressure (ICP) such as headache, vomiting, blurred vision and papillary edema can or do not occur. Symptoms of tuberculosis and hydrocephalus can be not specific, therefore, various diagnostic modalities such as CSF analysis and radiology are needed to diagnose this disease. The results of the CSF examination will show lymphocytosis, increased protein levels and decreased glucose. Sometimes acid fast bacteria can also be found in CSS staining.⁶

Contrast CT scan is generally the diagnostic choice in patients who are unstable. This modality is better than MRI because the process is faster and does not require sedation or anesthesia especially in patients with loss of consciousness. Contrast CT scan will provide information such as ventricular size, exudate accumulation, patches in the periventricular area, cerebral ischemia or infarction and tuberculoma. Repeat the examination for comparison and assess therapeutic response. CSF blockade cannot always be evaluated from CT scan because when the entire ventricle is dilated, it is difficult to distinguish communicative or non-communicable hydrocephalus due to fourth ventricular obstruction. As a solution, it is necessary to do air encephalography, but this procedure is very invasive.⁶

CLASSIFICATION

Determination of the classification or severity of patients with TB meningitis needs to be done to determine the prognosis and treatment plan. Some classification commonly used are Bhagwati grading, modified Vellore grading and MRC staging.⁶

Table 2. Bhagwati grading in patient with TB meningitis.⁷

Grade	Description
I	Full awareness, there is no neurological deficit
II	Full awareness, there is a neurological deficit
III	Drowsiness with neurological deficits
IV	Semicomatous
V	Coma with deserebrasi

Table 3. MRC staging in patient with TB meningitis.⁸

Grade	Description
1	Full awareness, no paresis
2	Decreased consciousness, local pain
3	Coma ± severe paresis

Table 4. Modified Vellore grading in hydrocephalus patient with TB Meningitis⁹

Grade	Description
I	GCS 15 Headache, vomiting, fever ± stiff neck Neurological deficit: (-)
II	GCS 15 Neurological deficit: (+)
III	GCS 9 – 14 Neurological deficit: (+) / (-)
IV	GCS 3 – 8 Neurological deficit: (+) / (-)

SURGICAL PROCEDURES

When ventriculomegaly has occurred, surgical drainage is the most effective procedure for reducing intracranial pressure. Previously, the surgical method used for the management of hydrocephalus in patients with TB meningitis was ventricles through burr holes, sub occipital decompression, third and lateral ventriculostomy and ventriculosubarachnoid shunts.¹⁰ At Recently, the choice of surgical procedures change to:

1. Ventricular tab
2. Ventricular shunt
3. Endoscopic third ventriculostomy (ETV)

All TB meningitis patients who have obstructive hydrocephalus must undergo an operative procedure. Non surgical therapy can be given to communicant hydrocephalus patients but with various risks such as the occurrence of worsening conditions and the outcomes is poor if the surgical procedure is delayed. Kemaloglu et al. Proved that the shunting procedure which is immediately done in mild and moderate hydrocephalus has a better outcome. Therefore, patients in grade I and II (modified Vellore grade) must be operated immediately. Even more, patients who are given medical treatment need ongoing monitoring at the hospital which will extend the treatment period and increase the burden of medical expenses.⁶

SURGICAL PROCEDURE :VENTRICULAR TAB

The ventricular tab is an emergency procedure, performed on patients who do not allow to undergo an immediate shunting procedure because of limited operating facilities, suffering from pyogenic infections or general unstable conditions. This procedure not only reduces CSF pressure but is also useful for taking CSF for diagnostic. Within 6 to 8 hours after the procedure, clinical symptoms will improve. Patients who have very high levels of CSF protein need a repeat ventricular tab procedure, so that an external ventricular drainage (EVD) catheter can be installed, but it cannot be used for a long time because it can cause infection.⁶

SURGICAL PROCEDURE:VENTRICULAR SHUNT

The ventricular shunt is a procedure performed to drain CSF from the ventricles to the body. Ventriculoperitoneal (VP) shunt is one of the most widely used ventricular shunt procedures. Previously, the ventriculoatrial (VA) shunt was a method commonly used for the management of hydrocephalus. But, in 1980 this method began to be abandoned because it was often reported to cause various complications and contribute to the spread of the disease.¹¹

Before performing the procedure, a neurosurgeon needs to evaluate the following clinical and radiological criteria:

Clinical: persistent ICT improvement (headache,

vomiting, papilledema) or symptoms of decreased consciousness, gait ataxia, progressive, deserebration or decortication neurological deficits.

Radiology: CT scan or MRI shows ventriculomegaly with periventricular edema.

CSSF examination: the lymphocyte cell count should ideally be less than 5 cells/cm³.

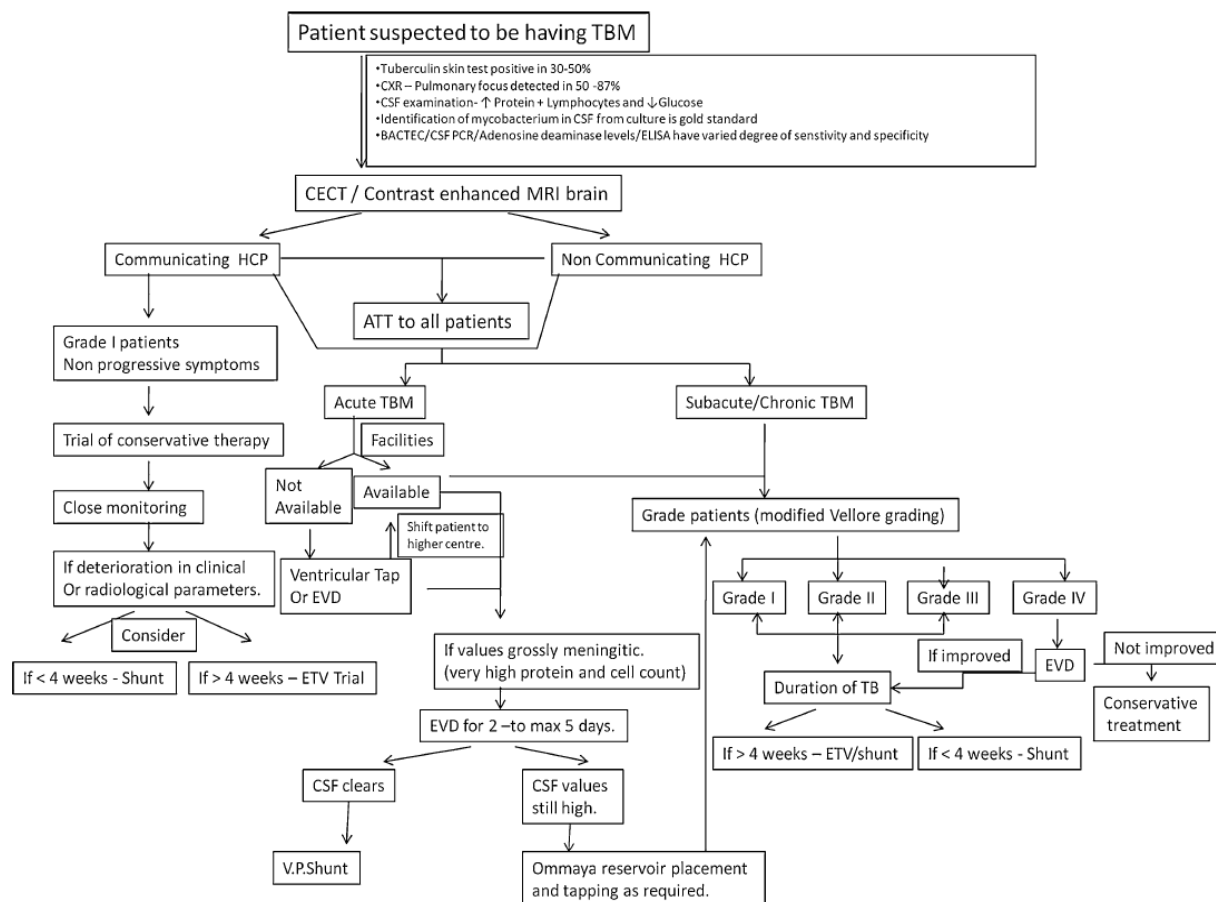
Ventricular tab: after a ventricular tab procedure, there is a decrease in ICT and improvement of clinical symptoms.⁶

VP shunt catheter insertion can cause various complications such as catheter tip blocking, changes in catheter position, subdural hematoma, ventricular syndrome due to excessive drainage, formation of peritoneal cysts, peritonitis and shunt infection. Terlebih lagi, pemasangan shunt dapat mempengaruhi dinamika CSS, seperti halnya pasien kehilangan kemampuan absorpsi CSS di celah subaraknoid karena penggunaan sistem drainase alternatif jangka panjang menggunakan shunt.⁶

SURGICAL PROCEDURES: ENDOSCOPIC THIRD VENTRICULOSTOMY

Endoscopic third ventriculostomy (ETV) is one of the surgical modalities for obstructive hydrocephalus with a success rate of 60-85% in various reports. Various studies have reported the effectiveness of ETV in communicant hydrocephalus patients. This procedure helps circulate CSF which previously cannot be absorbed because the formation of exudates can be absorbed normally. In addition, ETV can also reduce the tranventricular pressure gradient and demyelination in the periventricular area of the brain parenchyma, which contributes to various symptoms in hydrocephalus patients. A good flow of CSF will then contribute to the good work of drugs therapy.⁶

ETV efficacy depends on the severity of the disease. Performing this procedure after TB meningitis has its own challenges and sometimes cannot be done due to thickening of the base of the third ventricular membrane. The thickening of the membrane will block the visualization of the third ventricle and block the identification of mammillary bodies.⁷ The most



Picture 2. The hydrocephalus management algorithm with TB meningitis uses the modified Vellore grading system, TBM, tubercular meningitis; HCP, hydrocephalus; EVD, external ventricular drainage, CSF, cerebrospinal fluid; ETV, endoscopic third ventriculostomy. ⁶

frequently reported ETV procedure complications are ETV failure, CSS leakage and bleeding. The risk of injury to the basilar artery and its branches is more likely to occur in patients with TB meningitis due to thickening of the base of the third ventricle.¹²

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