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Role of CT in the Evaluation of Meningitis in Correlation with Clinical and Laboratory Findings

Authors

Dr.Panil Kumar B E[1], Dr.Lalitha Kumari[2], Dr. Parthasarathi A[3]

[1]MD, Department of Radiodagnosis, Santhiram Medical College and General Hospital , NH 18 , Nandyal, Kurnool Dist, Andhra Pradesh, India 518501
[2]MD,Department of Radiodagnosis, Santhiram Medical College and General Hospital , NH 18 , Nandyal, Kurnool Dist, Andhra Pradesh, India 518501
[3]MD,Department of Radiodiagnosis, Rajarajeswari Medical College and Hospital, Mysore Road, Bangalore, Karnataka, India – 560074
E-mail: *panilkumarbe@yahoo.com,dr.pathu@gmail.com*
Work Should Be Attributed To:
Santhiram Medical College and General Hospital, National Highway 18, Nandyal, Kurnool Dist, Andhra Pradesh, India 518501
Corresponding Author
Dr. B. E. Panil Kumar
Associate Professor
Department of Radio-Diagnosis, Santhiram Medical College and General Hospital, NH 18 , Nandyal, Andhra Pradesh, India.518501
Email: *Panilkumarbe@Yahoo.Com*

ABSTRACT

The objective of our study was to evaluate the efficacy of computed tomography in the evaluation of meningitis in correlation with clinical and laboratory findings, to know the value of CT in determining the complications of meningitis and to differentiate between tubercular and pyogenic meningitis.

Keywords: *Meningitis, computed tomography, Hydrocephalus, pyogenic meningitis, tubercular meningitis.*

INTRODUTION

Meningitis is most common form of CNS infection in children[1]. Meningitis continues to be an important cause of hospital admissions, neurological disability and mortality in India.[2] Nowhere is the contribution of non-invasive imaging more appreciated than with CT (computed tomography) and now recently MRI which have clearly dominated the field of non-invasive neuroimaging in the diagnosis of meningitis and early detection of its complications. Meningitis is one of the most

dreadful diseases of mankind at all ages and is a major international health problem. Early diagnosis of the meningitis is important in introducing timely intervention in the form of specific therapy and thereby preventing mortality and morbidity.[3]

Early recognition of a lesion is thus of immense importance. CT is found to be helpful in early detection of meningitis and its complications, as well as in the evaluation of the extent of the lesion, facilitating early appropriate treatment, for indicating prognosis at its outset and for following up the response to treatment.[4] CT becomes the mainstay from the view point of safety and cost effectiveness. CT scan findings though nonspecific assume great diagnostic significance in meningitis, when considered in conjunction with clinical and laboratory findings.[5]

MATERIALS AND METHODS

This study evaluating the efficacy of CT in the diagnosis of meningitis and its complications was done on 50 cases. The study was performed in the Department of Radiodiagnosis, Santhiram Medical College and general hospital , Nandyal , Andhra Pradesh. All the cases were studied on a Siemens Somatom Emotion Duo computed Tomography system. Factors 130 Kv and 70 Ma were constant for all cases and factors of 110 Kv and 50 mA were used for infants.

Routine axial scans were performed on all the 50 cases, taking infraorbito-meatal line as the baseline. 5mm slices for posterior fossa with 5mm table increment and 8 mm slice for the supratentorial region with 8 mm table increment. Thin slices were done whenever necessary. Sagittal and coronal reconstructions were done whenever necessary.For contrast enhancement, a bolus injection of non-ionic contrast such as Iohexol were given in the dose of 300mg Iodine/kg of body weight.

INCLUSION CRITERIA

The patients who were subjected for study include clinically suspected cases of meningitis, clinically and laboratory diagnosed cases of meningitis with

1. Clinical evidence of increased ICP
2. Persistent or prolonged fever
3. Focal seizures
4. Persistent neurological dysfunction
5. Persistently abnormal CSF parameters
6. Diagnosed cases of meningitis, who are not improving on therapy.
7. To rule out complications of meningitis.

A detailed history along with complete clinical examination and laboratory investigations was done before the CT examination.

STATISTICAL ANALYSIS

All the data were expressed in percentages. Chi square test was used for comparison of CT findings in TBM and PM and p value was calculated using MINITAB (USA 13.1) program.

HISTORICAL REVIEW OF MENINGITIS

Though meningitis as such was not mentioned in the historic era, it is an age old disease.

Meningitis was mentioned as cerebrospinal fever by willis in 1684. The term “meningitis” was coined by French Army Surgeon Herpin in 1803.

The first definite account of cerebrospinal fever was given by Gaspard vieusseux of Geneva in 1805 following an epidemic of the disease in that city. Elisha North of Goshen, Connecticut in 1811, published the first book on cerebrospinal meningitis ("Spotted fever"). The cerebrospinal fluid examination was greatly facilitated by the introduction of the minor operation of lumbar puncture by Heinrich Quincke in 1895.

The term Tubercular meningitis was coined by P.H. Green, a Physician who wrote a fairly complete study of the disease in the Lancet in 1836, 50 years before Koch's discovery of bacillus and almost 100 years before Rich and Mccor dock's presently accepted theory of pathogenesis.[6]

Zimmerman et al in 1976 has first emphasized that CT is an important modality in both diagnosis and management of cerebral infections.[7.] Hilton et al has concluded in 1976 that CT is helpful in assessing the degree of hydrocephalus and in evaluating the effectiveness of antituberculous therapy.[8]

Claveria et al in 1976 has emphasized that most important contribution of computed axial tomography (CAT) is in the diagnosis and localization of cerebral abscess and they also showed that CAT provides not only information of the nature of the lesion but also the number of loculi and the presence of multiple lesions; it is the investigation of choice for follow-up of patients with cerebral abscess treated either by operation or conservatively.[9] Bilaniuk et al (1978) has concluded that CT is an effective method of demonstrating the complications of meningitis and also emphasized that information provided by CT has both therapeutic and prognostic significance.[10]

DEFINITION

Meningitis is defined as inflammation of the meninges, the two membranes (pia and arachnoid mater) that surround the brain and spinal cord to form the subarachoid space. This space is filled by cerebrospinal fluid (CSF). A hallmark of meningitis is the spillover of cells into the CSF to produce an increased cell count. Meningitis is the major infectious syndrome of the CNS. When meningitis is accompanied by obvious parenchymal involvement, it is more properly referred to as meningoencephalitis.[1]

Meningitis is the fifth most common cause of death in children between the ages of 1 and 4 years, with reported mortality rates of 5-15% and significant neurologic deficits may be present in 10-25% of meningitis survivors.[4]It is important to identify those patients with complications early in an attempt to decrease the likelihood of permanent neurologic squeal. If irreparable damage has occurred, the extent of the lesion must be evaluated.[4]

INFECTIOUS MENINGITIS IS DIVIDED INTO THE FOLLOWING GENERAL CATEGORIES:

1. Acute pyogenic meningitis
2. Acute lymphocytic meningitis
3. Chronic meningitis (classical example is tuberculous meningitis).

ACUTE PYOGENIC MENINGITIS

In newborns upto 3 months of age , Group B Streptococci and E .Coli are common.Older children and in adults more commonly affected by Neisseria Meningitidis and Streptococcus pneumonia.

The diagnosis of meningitis is established by history, physical examination and laboratory evaluation.[11] CT has been shown to be both sensitive and accurate in detecting characterizing and delineating the purulent bacterial infectious process. It is reliable, repeatable and non-invasive technique which enables earlier diagnosis of potentially fatal but treatable complications of acute meningitis.[12]

Of the available neuroimaging procedures, CT provides the best information with a minimum of inconvenience, risk or discomfort to the patients. CT manifestations of purulent bacterial infection of the leptomininges correlate well with neuropathological findings.[7]

CT is useful in early detection of complications of leptomeningeal infections as well as in the evaluation of the extent of lesions.[4]. The information provided by CT has both therapeutic and prognostic significance.[10] Neuroimaging may also provide information regarding infective processes in the paranasal sinuses or mastoids, which could be a source of intracranial infection.[13]

Uncomplicated Pyogenic Meningitis

In early meningitis and in successfully treated cases, CT findings are normal. Mild ventricular dilatation and subarachnoid space enlargement are early abnormalities on NECT scans. Enhancement of the basilar or convexity cisterns (FIG 1) by inflammatory exudates can be seen in some cases. Occasionally, some enhancement of the meninges will be seen on post contrast scans. [14]

FIG 1 - CECT axial section of a 30 year old male with pyogenic meningitis (PM) reveals peripheral meningeal enhancement and cerebral edema

Complications of pyogenic meningitis which are well detected on CT are as follows – Hydrocephalus, Ventriculitis/ependymitis , Cerebritis/abscess (FIG 2) (FIG 3), Venous thrombosis (FIG 4) , arterial infarcts ,Subdural effusion and Cerebral edema

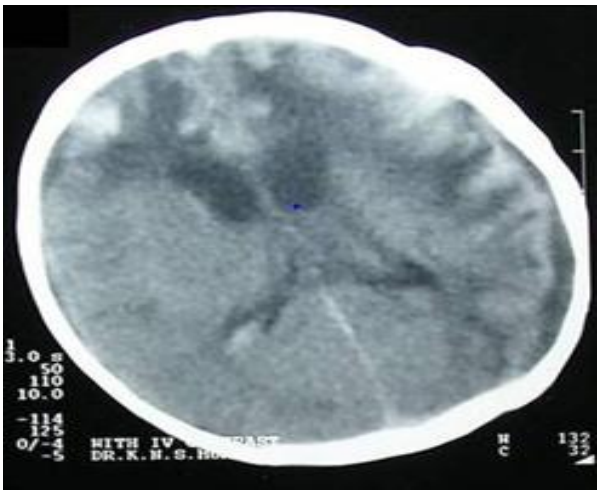

FIG 2 - CECT axial section of a 2 month old male child with PM reveals cerebritis, bilateral subdural collections and mild hydrocpehalus

FIG 3 - Axial CECT section in a 11 year old male with PM shows peripheral meningeal enhancement , left frontal cerebral abscess with perilesional edema and mass effect.

FIG 4 - Axial CECT section in a 8 month old child with PM reveals bilateral subduraleffusion (more on left side) and superior sagittal sinus thrombosis.

ASEPTIC MENINGITIS

Most viral meningitides are benign and self-limited.

Etiology

1. Enteroviruses (echo viruses, coxsackie viruses) - are responsible for 50 to 80% of viral meningitidis.
2. Mumps virus
3. Arbo virus.
4. Herpes simplex virus I and II

CHRONIC MENINGITIS (TUBERCULOUS MENINGITIS, TBM)

Tuberculous meningitis refers to the numerous manifestations that follow infection of the meningeal membranes with the tubercle bacillus. The disease can occur at any age, but is uncommon under the age of 6 months. Highest incidence is in the 1 to 5 years of life.[2]The incidence in adults has increased in recent years, partly because of incomplete therapy of existing cases and also because of the increase in the immunodeficiency states from various causes, including organ transplantation, treatment of certain malignant diseases and AIDS.

Pathological lesions visualized on CT are as follows - Basal exudates(FIG 5) ,hydrocephalus (FIG 6), infarcts(FIG 7), tuberculoma, tuberculous abscess ,cerebral edema, Ventriculitis, Subdural collection, Cerebral atrophy(FIG 8) , Calcifications and encephalomalacia

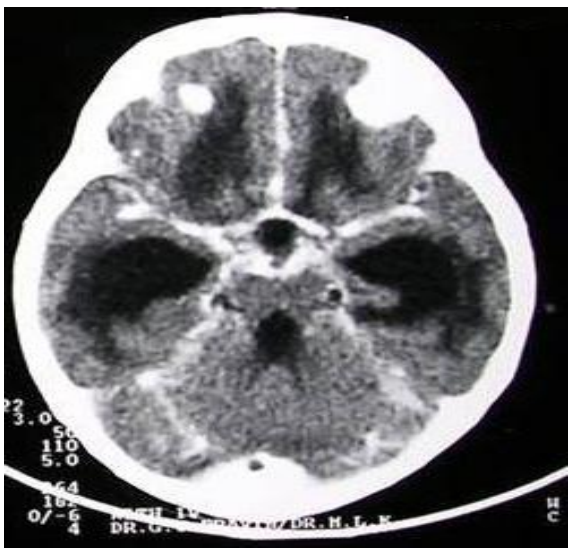

FIG 5 - Axial CECT section of a brain in a 18 months old female child with TBM demonstrates severe enhancing basal exudates and moderate communicating hydrocephalus.

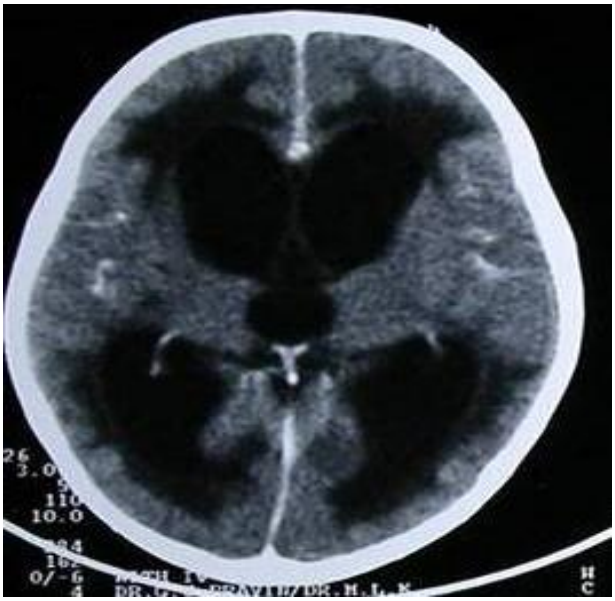

FIG 6 - CECT axial section in a 18 months old female child with TBM shows moderate communicating ydrocephalus with periventricular lucencies representing interstitial oedema.

FIG 7- CECT axial section in a 50 years old male with TBM demonstrates moderate communicating hydrocephalus with periventricular lucencies and infarcts in the left MCA territory.

FIG 8 - CECT axial section of a 11 month old male child with TBM shows mild communicating hydrocephalus and mild cerebral atrophy.

DISCUSSION

Meningitis continues to be an important cause of hospital admissions, neurological disability and mortality. Meningitis is one of the most common causes of central nervous system infection. Meningitis is a frequent problem in children with dreadful complications.

Our study comprised of 50 cases which includes 26 cases of TBM and 24 cases of PM.

The study group had male predominance in both TBM (73%) and PM (70.8%). In our study TBM was commonly noted in patients below the age of 5 years (65.4%), whereas PM was noted more commonly in patients between 12 to 40 years (37.5%).

Most of the patients with TBM presented to the hospital after duration of 15 days of illness whereas most of the patients with PM were admitted before 7 days of duration of illness. Fever, neck stiffness, altered sensorium, vomiting

and convulsions were common presenting features in both TBM and PM.

The appearance of CSF in most of the cases of TBM and PM was clear, however few cases of TBM showed cobweb formation (on allowing the CSF to stand) and few cases of PM showed turbidity. The predominant cell type in cases of TBM was lymphocytes and polymorphonuclear leucocytes in case of PM. Elevated protein level and decreased sugar level in CSF were noted in both TBM and PM.

However, culture and staining technique did not demonstrate growth/organism in the majority of cases in our study. But, the confirmatory diagnosis of both TBM and PM is by demonstration of organism in the CSF, which was demonstrated in only in 2 cases of PM and none in TBM. This may be due to partial treatment of the patients with antibiotics before CSF analysis. Hence one cannot rely solely on laboratory investigation for the final diagnosis, but needs to correlate clinically and radiologically for the same.

In few cases, the condition of the patient (signs of raised intracranial pressure), contraindicated the procedure of lumbar puncture and hence were directly, subjected to CT scan, which helped to arrive at the diagnosis. Hence, there is a great need for the role of CT scan for the final diagnosis of meningitis and its complication and for further proper management.

CT Evaluation of PM

In the present study of 24 cases with PM. 20.8% of cases were normal on CT which were similar to the study by Kumar et al[16] (26.9%).

In our study 41.7% of cases with PM showed peripheral meningeal enhancement, which was 17.3% in the study conducted by Kumar et al.[16]

Basal exudates were noted in 12.5% of cases in the present study,however no case were recorded in the study by Kumar et al.[16]

In our study 16.7% of cases had hydrocephalus which was 44.2% in the study conducted by Kumar et al.[16]

Infarct was seen in only one (4.2%) case of PM in the present study but was observed in 7.7% of cases in the study by Kumar et al.[16]

Cerebral edema was noticed in 41.7% of cases in the present study. Other rare complications encountered were abscess (20.8%), periventricular lucencies (4.2%), cerebritis (4.2%), ventriculitis (12.5%), subdural effusion (8.3%), cerebral atrophy (4.2%) and superior sagittal sinus thrombosis (4.2%).

CT Evaluation of TBM

Our study showed basal exudates in majority (84.6%) of cases which is similar to the study by Kumar et al[16] (82.7%), Bhargava et al[17] (81.66%) and Bullock et al[18] (64.2%). Majority of these patients were children.

In our study 96.2% of cases with TBM showed hydrocephalus on CT. Bhargavaet al[17] showed hydrocephalus was common and accounted for 83.05% of cases. Similarly Bullock et al[18] in their study, reported that hydrocephalus was present in 76% of cases. Kumar et al[16] study showed 80.6% cases of TBM had ventriculomegaly.

Hydrocephalus is more frequent in children less than 5 years of age. Moderate and severe degree

of hydrocephalus is also more frequent in children than adults.

Majority of our cases showed communicating type of hydrocephalus except for two cases which had obstructive hydrocephalus. However the cause of obstructive hydrocephalus was due to pressure over the fourth ventricle by cerebellar tuberculous abscess in one case and multiple cerebellar tuberculomas in the other. The communicating hydrocephalus was due to blockage of CSF circulation by exudates in the basal cisterns.

Our study showed periventricular lucencies in 61.5% of cases, similar to the study conducted by Bullock et al[18] (64.7% of cases). Most of the moderate and severe grade of hydrocephalus had periventricular lucencies.

The infarcts seen in the present study were more (50%) when compared to the study done by Bhargavaet al[17] (28.33%), Bullock et al[18] (32.3%) and Kumar et al[16] (19.3%). Infarcts are most commonly noted in the middle cerebral artery territory. The common areas of involvement in middle cerebral artery region were basal ganglia and internal capsule. Most of the infarcts are noted in the clinical stage II and stage III of TBM.

In present study tuberculoma was noted in 7.7% of cases (2 out of total 26 cases). Bhargavaet al[17] study showed tuberculoma in 10% of cases. Bullock et al[18] study did not show tuberculoma in any patient. Multiple tuberculomas were seen in two cases of our study, One case was noted in the supratentorial region and the other in infratentorial region.

Cerebellar tuberculous abscess was noted in the one case (4.2%)of TBM.

Cerebral edema was noted in 7.7% of cases of TBM.

Rare complications like cerebral atrophy and cerebritis were noted in 7.7% of cases.

Comparison of CT findings in TBM and PM:

Features	Kumar et al[16] p value	Present study p value
Basal exudates	0.000	0.000
Ventriculomegaly	0.000	0.000
Infarction	0.06	0.000

P value of basal exudates and ventriculomegaly in the above studies was highly significant.However p value of infarction which was highly significant in the present study was not significant in the study by Kumar et al[16].

Our study results indicate that CT findings in TBM are more distinct and specific than in PM. Basal exudates, hydrocephalus, tuberculoma and infarcts were the important findings in TBM. However peripheral meningeal enhancement, cerebral edema, ventriculitis and subdural effusion were commonly noted in PM when compared with TBM.

CONCLUSION

CT is a valuable tool with a high diagnostic sensitivity and prognostic accuracy in the evaluation of meningitis.

- CT is an effective method of demonstrating the complications of meningitis and the information provided by CT has both therapeutic and prognostic significance.
- In meningitis, when clinical condition of the patient deteriorates, it may be difficult to determine on the basis of clinical findings alone what type of complications has occurred. Computed tomography is an invaluable tool in management of these patients, for it provides information necessary for institution of proper treatment.
- CT scan be used to effectively distinguish TBM and PM and provides useful additional information.
- In the armamentorium of noninvasive techniques, CT becomes the mainstay of investigation from the view point of accuracy, safety and cost-effectiveness.

To conclude, CT scan findings assume great diagnostic significance in meningitis, when considered in conjunction with clinical and laboratory findings

OBSERVATION AND RESULTS

Table 1: Showing the Sex incidence in Tuberculous and Pyogenic Meningitis

Sex	TBM		PM	
	No. of patients	Percentage	No. of patients	Percentage
Male	19	73	17	70.8
Female	7	27	7	29.2
Total	26	100	24	100

The incidence of both tuberculous and pyogenic meningitis was more common in males compared to females.

In TBM, males (19) outnumbered females (7) with Male: Female ratio of 2.7:1

In PM also males (17) outnumbered females (7) with Male: Female ratio of 2.4:1.

Table 2: Showing Age incidence in TBM and PM

Age in years	TBM		PM	
	No. of patients	Percentage	No. of patients	Percentage
0 – 1	10	38.5	2	8.3
1 – 5	7	26.9	6	25
5 – 12	3	11.5	6	25
12 – 40	4	15.4	9	37.5
> 40	2	7.7	1	4.2
Total	26	100	24	100

The majority of patients with TBM were in the age group of 0-1 years (38.5%) followed by 1-5 years (26.9%).The majority of patients with PM were in the age group of 12-40 years (37.5%) followed by 1-5years (25%) and 5-12 years (25%).

Table 3: Showing duration of illness prior to hospitalization in TBM and PM

No. of days	TBM		PM	
	No. of patients	Percentage	No. of patients	Percentage
< 2	-	-	5	20.8
3 – 7	4	15.4	12	50
8 – 14	3	11.5	3	12.5
15 – 28	10	38.5	4	16.7
> 29	9	34.6	-	-
Total	26	100	24	100

Majority (38.5%) of patients with TBM presented to the hospital between 15-28 days of illness followed by 34.6% of cases who presented beyond 29 days.

Majority of patients (50%) with PM presented to the hospital between 3-7 days of illness followed by 20.8% of cases who presented within 2 days.

Table 4: Showing the spectrum of Clinical Features in TBM and PM

Clinical features	TBM (n=26)		PM (n=24)	
	No. of patients	Percentage	No. of patients	Percentage
Fever	26	100	24	100
Headache	6	23	12	50
Vomiting	14	53.8	17	70.8
Cough	4	15.4	1	4.2
Altered sensorium	12	46.2	19	79.2
Unconsciousness	10	38.5	5	20.8
Convulsions	16	61.5	12	50
Signs of meningeal irritation	20	76.9	21	87.5
Cranial nerve involvement	2	7.7	1	4.2
Hemiparesis	6	23.1	1	4.2

The common presenting clinical features in both TBM and PM in the present study was fever followed by signs of meningeal irritation, altered sensorium, vomiting and convulsions.

The incidence of hemiparesis, convulsions and loss of consciousness was high in TBM as compared to PM.

The incidence of headache, vomiting and altered sensorium was higher in PM as compared to TBM.

Table 5: Showing CSF analysis in TBM and PM

CSF	TBM		PM	
	No. of patients (n = 25)	Percentage	No. of patients (n = 22)	Percentage
Clear	19	76	13	59.1
Cobweb	6	24	-	-
Turbid	-	-	9	40.9
Cell count (> 10cells /cumm)	25	100	22	100
Lymphocyte predominant cell type	24	96	2	9.1
Polymorphonuclear leucotyes predominant type	1	4	20	90.9
Protein (≥ 50mg/dl)	23	92	22	100
Sugar (≤ 50mg/dl)	21	84	15	68.2

Note: In 3 cases of suspected meningitis in our study ,lumbar puncture could not be done as the patients presented with signs of raised intracranial pressure(fundoscopy showed papilloedema).

In a total of 25 patients with TBM, the CSF analysis demonstrated a clear appearance in 76% of cases, cobweb appearance in 24% of cases, the predominant cell type (≥ 10cells/cumm) being lymphocytes in 96% of cases. Proteins ≥ 50mg/dl and sugar ≤ 50mg/dl were noted in 92% and 84% of cases respectively.

In a total of 22 patients with PM, the CSF analysis demonstrated a clear appearance in 59.1% of patients, turbid appearance in 40.9% of cases, the predominant cell type (≥ 10 cells/cumm) being polymorphonuclear leucocytes in 90.9% of cases.Proteins ≥ 50mg/dl and sugar ≤ 50mg/dl were noted in 100% and 68.2% of cases respectively.

Note:

None of the cases of TBM who underwent CSF analysis showed culture/Z-N stain positivity.

Only two cases (9.1%)of PM in our study who underwent CSF analysis showed Gram's stain positivity

Table 6: Showing CT findings in Pyogenic Meningitis

CT findings	No. of cases	Percentage
Normal	5	20.8
Basal enhancement	3	12.5
Meningeal enhancement (peripheral)	10	41.7
Hydrocephalus	4	16.7
Peiventricularlucencies	1	4.2
Infarct	1	4.2
Cerebral edema	10	41.7
Cerebritis	1	4.2
Ventriculitis	3	12.5
Subdural effusion	2	8.3

Abscess	5	20.8
Cerebral atrophy	1	4.2
Superior sagittal sinus thrombosis	1	4.2

Out of 24 cases of PM subjected to CT scan about 5 cases (20.8%) were normal. The commonest CT finding encountered was peripheral meningeal enhancement and cerebral edema (41.7% each). This was followed by abscess (20.8%), hydrocephalus (16.7%), ventriculitis (12.5%) and subdural effusion (8.3%). The remaining findings which were less often encountered were periventricular lucencies, infarct, cerebritis, cerebral atrophy and superior sagittal sinus thrombosis (4.2% each).

Table 7: Shows comparison of CT findings in TBM and PM

CT Findings	TBM		PM		*p value
	No. of patients	Percentage	No. of patients	Percentage	
Normal	-	-	5	20.8	-
Basal enhancement	22	84.6	3	12.5	0.000
Meningeal enhancement (peripheral)	4	15.4	10	41.7	0.05
Hydrocephalus	25	96.2	4	16.4	0.000
Periventricular lucencies	16	61.5	1	4.2	0.000
Infarct	13	50	1	4.2	0.000
Tuberculoma	2	7.7	-	-	-
Cerebral edema	2	7.7	10	41.7	0.005
Cerebral atrophy	2	7.7	1	4.2	-
Abscess	1	3.8	5	20.8	-
Vetriculitis	-	-	3	12.5	-
Cerebritis	2	7.7	1	4.2	-
Superior sagittal sinus thrombosis	-	-	1	4.2	-
Subdural effusion	-	-	2	8.3	-

* $p>0.05$ not significant, $p < 0.05$ significant, $p < 0.001$ highly significant

On comparing CT findings of TBM and PM, basal enhancement, hydrocephalus, periventricular lucencies and infarcts are higher in TBM cases. However meningeal enhancement ,cerebral edema, abscess and ventriculitis were more common in PM.

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