ORIGINAL RESEARCH PAPER

Radiodiagnosis

MRI EVALUATION OF INTRACRANIAL COMPLICATIONS OF TUBERCULOSIS.

KEY WORDS: Basal Exudates, Hydrocephalus, Intracranial Tuberculosis, Mri, Meningitis, Tuberculoma.

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ABSTRACT

Tuberculosis of CNS accounts for approximately 5-10% of extra-pulmonary TB cases. Intracranial manifestations of CNS TB include tubercular meningitis, complications of tuberculous meningitis, pachymeningitis, parenchymal tuberculosis. The first choice of imaging in CNS TB is MRI because of its inherent sensitivity and specificity in the detection of early subtle lesions. Our Aim includes Detection & characterization of various MRI findings in Intracranial tuberculosis. MRI brain was done in 60 patients with signs and symptoms of CNS involvement. Out of which, 2 patients (3%) were found without any neuro-radiological abnormality and were excluded. In rest of patients (n=58; 97%) one or more than one finding was present in a single patient; Leptomeningeal enhancement (n= 37; 61%), Tuberculomas (n=32; 53%), Hydrocephalus (n=17; 28%), Infarcts (n=14; 23%), Basal exudates (n= 11; 18%) were more often present.

INTRODUCTION:

Tuberculosis is one of the oldest disease caused by Mycobacterium tuberculosis. Worldwide, TB is one of the top 10 causes of death and the leading cause of death from a single infectious agent (above HIV/AIDS). Millions of people continue to fall sick with TB each year. In 2017, TB caused an estimated 1.3 million deaths (range, 1.2–1.4 million) among HIV-negative people and there were an additional 300,000 deaths from TB (range: 266,000–335,000) among HIV-positive people. Globally, the best estimate is that 10.0 million people (range: 9.0–11.1 million) developed TB disease in 2017.' (Global tuberculosis report 2018)[1].

Tuberculosis of the central nervous system accounts for approximately 5-10% of extrapulmonary cases of TB[2]. Tuberculous meningitis (TBM) is the most life-threatening form of extrapulmonary tuberculosis and neuro-tuberculosis is the most common presentation[3]. It is common in young children but can also occur in HIV infected adults.

Mode of infection is due to the haematogenous spread of primary or post-primary pulmonary TB or rupture of subependymal tubercle into the subarachnoid space causing CSF dissemination of bacilli. In more than half of cases of central nervous system TB, chest radiograph shows presence of pulmonary lesions or miliary pattern.

Various manifestations occur in the central nervous system due to TB bacilli. The disease presents as a subtle headache and mental changes, fever, malaise, anorexia, and irritability. Acute presentation of tuberculous meningitis is with severe headache, confusion, lethargy, altered sensorium, and neck rigidity. The course of tuberculous meningitis is usually longer than that of bacterial meningitis[1].

Multiple intracranial manifestations of tuberculosis are:

1) Tubercular Meningitis (TBM)
2) Complications of tuberculous meningitis
- Hydrocephalus
- Vasculitic infarcts

3) Pachymeningitis
4) Parenchymal Tuberculosis
- Parenchymal Tuberculomas-Caseating granuloma with a solid centre, Caseating granuloma with liquid centre & Non-caseating granulomas (Miliary pattern).
- Tubercular abscesses
- Focal Tubercular Cerebritis
- Tubercular Encephalopathy

Early recognition of this treatable disease remains a challenge to clinicians and if effectively treated it can prevent neurologic damage and mortality. Thus, imaging studies are an important part of the diagnosis. The first choice of imaging modalities in patients with tuberculous meningitis is Magnetic resonance imaging (MRI). Magnetic resonance imaging (MRI) is more sensitive than Computed tomography (CT) for the detection of ischemic changes, basal meningeal inflammation, edema secondary to inflammation. Computed tomography can diagnose cerebral TB by identifying exudates in the basal cisterns and basal meningeal inflammation.

M Sobri*, J S Merican et al., (2007) proposed neuroimaging is one of the most important initial investigations in tubercular meningitis and the role of MRI in discovering subtle lesions. Neuroimaging features of tuberculous meningitis include hydrocephalus, meningeal enhancement, infarction, enhancing lesion, tuberculoma, abscess, cerebral edema and calcification. The two commonest neuroimaging features are hydrocephalus and meningeal enhancement [4].

According to Rakesh K Gupta et al., (2009) most severe form of tuberculosis is the involvement of the central nervous system (CNS). It is associated with high mortality and morbidity. Noninvasive imaging modalities such as computed tomography (CT) scan and magnetic resonance imaging (MRI) are routinely used in the diagnosis of neurotu berculosis, with MRI offering greater inherent sensitivity and specificity than CT scan [5].

Kadriye Yasar, et al., (2012) suggested that neuroimaging techniques are useful parameters in the early diagnosis of TBM. Hydrocephalus is a common complication of TBM. In particular, MRI provides specific findings for defining TBM, such as tuberculoma, basal meningitis or hydrocephalus[6].

According to Vandana et al., (2013) CNS TB is a major cause of morbidity and mortality in patients with tuberculosis and MR imaging plays a crucial role in diagnosis because of its

inherent sensitivity and specificity in detecting CNS lesions earlier than CT [7].

Sumaira Nabi, et al., (2014) proposed Neuroimaging techni ques are a handy tool in the early diagnosis of TBM. MRI in particular helpful in defining findings, such as hydrocephalus, tuberculomas, leptomeningeal involvement, or infarcts. Tuberculomas were almost always multiple involving both the supra-cortical and infra-cortical regions [8].

AIMS AND OBJECTIVES:

- Detection & characterization of various intracranial MRI findings in tuberculosis patients.

MATERIALS AND METHODS:

- This is an observational study carried out in 60 Patients from December 2017 to December 2018 for 12 months, who were referred to the Department of Radiodiagnosis IMS & SUM Hospital, Bhubaneswar for MRI Brain.
- Approval from the ethical committee and informed consent of all patients were taken for this study.
- Equipment used: 1.5 Tesla GE – Signa Hdxt MRI machine with Head coil.

PROTOCOL FOR MRI BRAIN (PLAIN AND CONTRAST) STUDY

1. FOV: 22x26
2. Matrix: 512x512

- MRI brain plain and contrast studies were done in Axial, Sagittal and Coronal planes.
- Gadolinium- DTPA was used as the contrast media with 0.1mmol/kg (0.2mg/kg) as standard dose.
- Sedation was given in paediatric and patients with altered sensorium.

3. Recommended sequences:

The MR examination primarily consisted of the following sequences,

- Diffusion-weighted image(DWI),
- Apparent diffusion coefficient (ADC),
- T1W Axial image, T2W Axial image.
- Fluid attenuated inversion recovery sequence (T2-FLAIR).
- GRE: Gradient Recalled Echo
- Post Contrast T1W- Axial /Sagittal / Coronal images.
- MR Spectroscopy in required cases.
- MR Angiography and MR Venography when required.

INCLUSION CRITERIA:

- 60 patients of all age groups and irrespective of sex.
- Patients those diagnosed to have tuberculosis and presenting with clinical features of CNS involvement like fever, seizures, headache, vomiting, neck rigidity, altered sensorium, weakness in limbs etc and referred for MRI were included in this study.

EXCLUSION CRITERIA:

- Patients having any non-MR compatible metal implants, cardiac pacemakers, prosthetic heart valves and cochlear implants.
- All patients with a history of adverse reaction to contrast agents used.
- All patients who do not consent to be a part of the study.
- Claustrophobic patients.

OBSERVATIONS AND RESULTS:

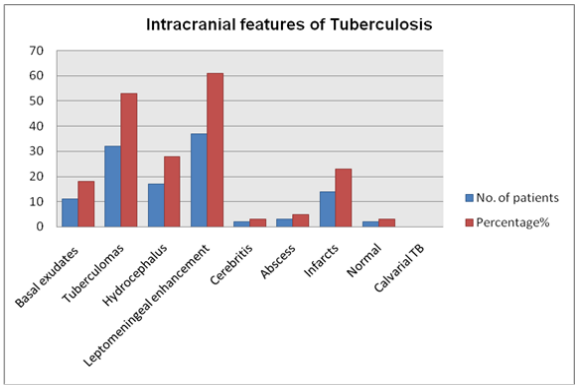
60 known tuberculosis patients with signs and symptoms of central nervous system involvement were included in our study, out of these patients 2 patients were found without any neuro-radiological abnormality on MRI that constitutes 3% of the total.

Intracranial tuberculosis has multiple manifestations in the form of meningeal and parenchymal involvement with complications.

Table 1: Intracranial features of Tuberculosis on MRI brain.

MRI Brain findings	No. of patients	Percentage (%)
Leptomeningeal enhancement	37	61
Tuberculomas	32	53
Hydrocephalus	17	28
Basal exudates	11	18
Cerebritis	2	3
Abscess	3	5
Infarcts	14	23
Normal	2	3
Calvarial TB	0	0

Chart 1: Intracranial features of Tuberculosis on MRI brain.



COMMENTS:

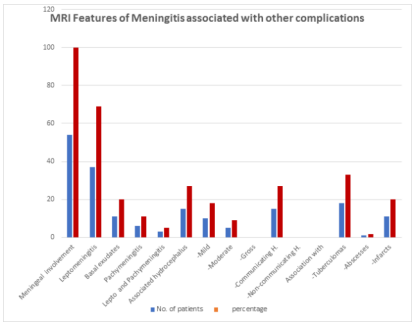
The number of findings noted in our study were 118 and the total number of patients studied were 60, this suggests that more than one finding was present in a single patient, hence overlapping features were noted.

Out of 60 patients included in our study, 58(97%) shows some form of abnormality in the brain on MRI study. The maximum number of patients, 37 shows leptomeningeal enhancement on contrast study suggestive of leptomeningitis which constitutes 61% and forms the most common CNS manifestation. Followed by this next maximum number of patients 32(53%) were having tuberculomas. 17(28%) patients were having hydrocephalus. Infarcts were noted as second after hydrocephalus in TBM patients.

Table 2: MRI Features of Meningitis associated with other complications.

Sr. No	Types of meningitis	No. of patients	%age
1	Meningeal involvement	54	100
2	Leptomeningitis	37	69
3	Basal exudates	11	20
4	Pachymeningitis	6	11
5	Lepto and Pachymeningitis	3	5
6	Associated hydrocephalus	15	27
	-Mild	10	18
	-Moderate	5	9
	-Gross	0	0
	-Communicating H.	15	27
	-Non-communicating H.	0	0
7	Association with		
	-Tuberculomas	18	33
	-Abscesses	1	1.8
	-Infarcts	11	20

Chart 2: MRI Features of Meningitis associated with other complications.



COMMENTS:

Out of 54 patients having meningitis most common form of involvement was leptomeningitis seen in 69% cases. Communicating hydrocephalus was associated with meningitis in 27% cases, Tuberculoma in 33% cases and infarcts in 20% cases.

DISCUSSION:

Multiple intracranial manifestations of tuberculosis as described below.

1) Tubercular Meningitis(TBM)
2) Complications of tuberculous meningitis
- Hydrocephalus
- Vasculitic infarcts
3) Pachymeningitis
4) Parenchymal Tuberculosis
- Parenchymal Tuberculomas-Caseating granuloma with a solid centre, Caseating granuloma with liquid centre & Non-caseating granulomas (Miliary pattern).
- Tubercular abscesses
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1. TUBERCULAR MENINGITIS (FIGURE-1)

Meningitis found to be the commonest manifestation of tuberculosis involving 37(61%) of patients in our study. A study conducted in North India by **'H.K. Anuradha et al[9]** on 100 patients of age range from 14–85 years and suggest that meningeal enhancement was the most common finding. Another study by **Indrajit et al [10]** on 18 patients with clinical findings and positive cerebrospinal fluid analyses for TB, in 11(61%) patients meningitis were detected. MRI of the brain often demonstrates a characteristic pattern of abnormal meningeal enhancement after the administration of intravenous gadolinium, typically at basal cisterns. Basal exudates are best appreciated on FLAIR sequences. In our study the most common association seen with meningitis is Tuberculoma in 33% cases, communicating hydrocephalus in 27% cases and infarcts in 20% cases.

2. HYDROCEPHALUS (FIGURE-1)

In our study out of 60 patients 28% of patients had hydroce phalus.in a study by **Omer Etlik et al [11]** on 16 patients with TBM suggested that MR imaging should be performed as the first choice of imaging modality in patients with suspected tuberculosis. Hydrocephalus was noted in 25% of patients in the same study. Hydrocephalus occurs due to obstruction to CSF flow by thick gelatinous inflammatory exudates within the basal cisterns. Communicating hydrocephalus can also result from the exudates blocking the arachnoid granulations which prevent the absorption of cerebrospinal fluid. The presence of hydrocephalus is frequently related to poor prognosis, particularly in children. On MRI imaging study, a dilated ventricular system with periventricular hyperintensity on T2W images is due to the seepage of the CSF into the white matter and suggests hydrocephalus under pressure. Hydrocephalous can be of two types, commu nicating which is more common (27% cases in our study) and non-communicating less common.

3. FOCAL OR DIFFUSE PACHYMENINGITIS

The normal dura mater shows only thin, linear and discontinuous enhancement after the administration of gadolinium-based contrast material. Pachymeningitis appears isointense on T1W images, isointense to hypointense on T2W images and enhanced on post-contrast MR images. Diffuse involvement may appear hyperintense on T2W images. In our study 6(11%) patients have Pachymeningitis.

4. INTRACRANIAL TUBERCULOMAS (FIGURE-2 & FIGURE-3)

Tuberculous granuloma or tuberculoma is the most common form of the parenchymal tubercular lesion. In our study, 53% of patients show tuberculomas. **Sumaira Nabi et al (8)** a study of 100 patients diagnosed with TBM, tuberculomas were noted in 53%.

The radiological presentation depends on whether the granuloma is non-caseating, caseating with a solid centre or caseating with a liquid centre. The degree of surrounding edema is variable and is thought to be inversely proportional to the maturity of the lesion. Non-caseating granulomas appear hyperintense on T2W images and slightly hypoin tense on T1W images with homogeneous post-contrast enhancement. Solid caseating granulomas appear hypo to isointense on both T1W and T2W images with an iso to hyperintense rim on T2W images. The rim is inseparable on T2W images in presence of an edema. They show rim enhancement on post contrast T1W images. Caseating granulomas with liquid centre appear hyperintense on T2W images with surrounding hypointensity and post-contrast images show rim enhancement.

5. MILIARY TUBERCULOMAS (FIGURE-4)

Multiple small granulomas (<2 mm) scattered diffusely in brain parenchyma. The usual location is at the cortico-medullary junction and along the distribution of perforating vessels because the dissemination is haematogenous. On MRI the lesions are tiny (2-3mm in diameter) scattered lesions that may be invisible on non-contrast MR sequences. Post-contrast T1-weighted MR images show numerous, round, small, homogeneous, enhancing lesions (non-caseating type). They appear hyperintense on T2W images and slightly hypointense on T1W images with homogeneous post-contrast enhancement [9,10].

6. VASCULITIS (INFARCT) (FIGURE-5)

Vasculitis is a complication of cranial tubercular meningitis. In our study, prevalence of cerebral infarction was 23% and 20% associated with meningitis. **Chan KH et al [12]** studied 40 TBM patients. Out of 40 patients, 12 (30%) had cerebral infarct. In a study conducted by **H.K. Anuradha et al [9]** in north India, 30% of tuberculous meningitis patients developed ischemic stroke. The most frequent locations of infarction were internal capsule and basal ganglia. Infarct on magnetic resonance imaging (MRI) was defined as an area of abnormal signal intensity in a vascular distribution without any evidence of a mass effect. Diffusion weighted images (DWI) are the gold standard for the diagnosis of acute infarction, which appears bright on DWI and shows decrease signal on corresponding apparent diffusion coefficient (ADC) map. Areas of prolonged T1 and T2 relaxation on MR images. **Anderson et al [13]** total of 104 patients of TB meningitis was studied. Out of 104 patients, 34 patients (33%) had vasculitic infarcts.

7. TUBERCULAR ABSCESS (FIGURE-6)

In our study out of 60 patients, we found three cases (5%) with intracerebral abscesses. Out of these three patients, 2 cases show solitary abscess and one case multiple abscesses. MRI pictures of a tuberculous abscess show a granuloma with a liquid centre however, they are much larger and frequently

multiloculated and with marked surrounding oedema. On post-contrast images it shows smooth peripheral thin rim enhancement. Brain abscesses were found in tuberculosis patients. In a study by **K.Yasar et al [14]** on 134 patients of TB meningitis, 5 patients showed brain abscess which constitutes (3.7%).

8. TUBERCULOUS CEREBRITIS (FIGURE-7)

Focal cerebritis on MR imaging appears hypointense on T1, hyperintense on T2W images and patchy enhancement on post-contrast images. Focal tuberculous cerebritis is rare. 3% of our patients showed cerebritis.

CONCLUSION:

- This observational study was carried out on 60 tuberc ulosis patients with signs and symptoms of central nervous system involvement in Department of Radiodi agnosis IMS & SUM Hospital Bhubaneswar a tertiary care centre.
- Main CNS manifestation of tuberculosis was meningitis (61%) followed by Tuberculomas (53%).
- Meningitis was the overall most common imaging finding observed in 61% of patients.
- Devastating complications like hydrocephalus, abscess and infarcts were also observed.
- Communicating hydrocephalus was the most common cerebrovascular complication followed by multiple vasculitic infarcts.
- In this study, 60 patients were studied and a total 118 findings were detected, suggesting multiple features present in a single patient at a time.
- Multiple other manifestations like focal cerebritis, brain abscess, edema, haemorrhage, calcification, venous sinus thrombosis etc. were also observed.
- We did not find any neurological abnormality on imaging in 3% of patients with CNS symptoms.
- MRI also plays an important role in detection, localization and characterization of the lesions because of its multiplanar imaging and better inherent soft tissue contrast imaging ability.
- Post-contrast MRI is better in lesion detection along with MR spectroscopy.

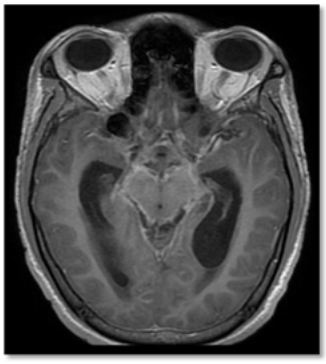
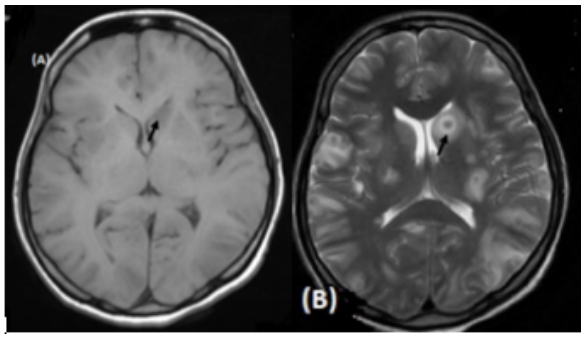


Figure-1-Axial T1WI showing enhancing basal exudates and mild hydrocephalus.



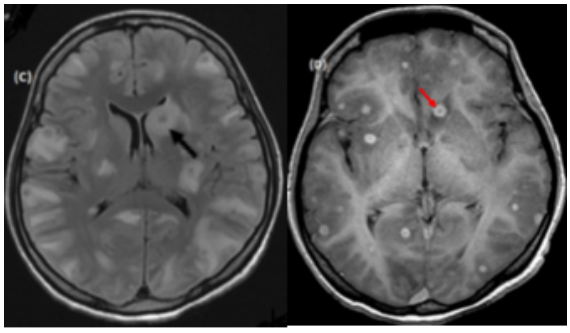


Figure 2: A) Axial T1W image shows isointense lesions (arrow) with edema. B, C) Axial T2W & FLAIR images showing multiple lesions with hypointense centre & hyperintense rim (arrow) .D) Axial post-contrast image showing multiple tiny ring & disc enhancing lesions (red arrow), s/o caseating tubercular granulomas with a solid centre.

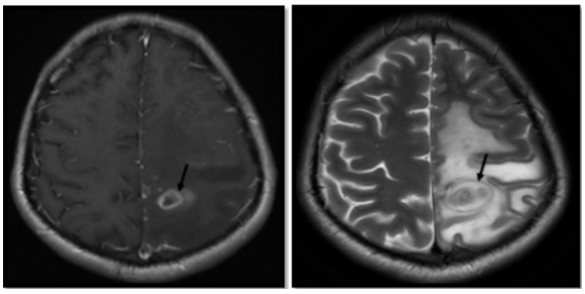


Figure 3: Axial T2W and post-contrast T1W images showing hypointense lesion with central hyperintensity on T2WI and peripheral enhancement on post-contrast images s/o caseating granuloma with central necrosis (black arrow).

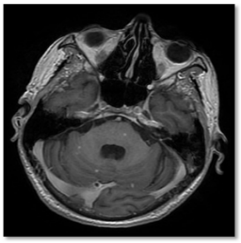
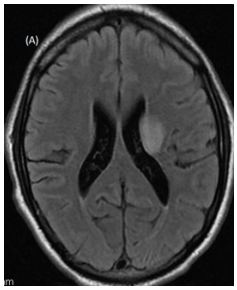
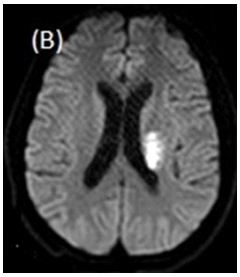


Figure 4- Post-contrast T1WI showing nodular enhancing lesions in cerebellum and pons s/o non-caseating granulomas (Miliary pattern)





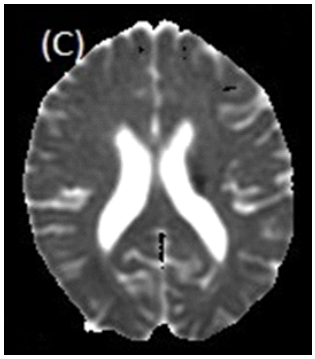


Figure 5: Vasculitic infarct, A) Axial FLAIR image showing hyperintensity in the left basal ganglia region B, C) DWI & ADC map showing restricted diffusion in the left basal ganglia region suggestive of acute infarct.

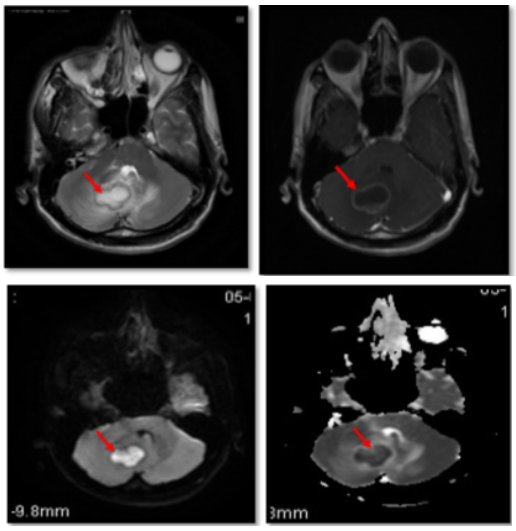


Figure 6: Axial T2W image showing well defined hyperintense lesion with hypointense rim (capsule) in the right cerebellar hemisphere with peripheral enhancement on post-contrast T1W images and shows restricted diffusion on DWI images, s/o brain abscess (Red arrow)

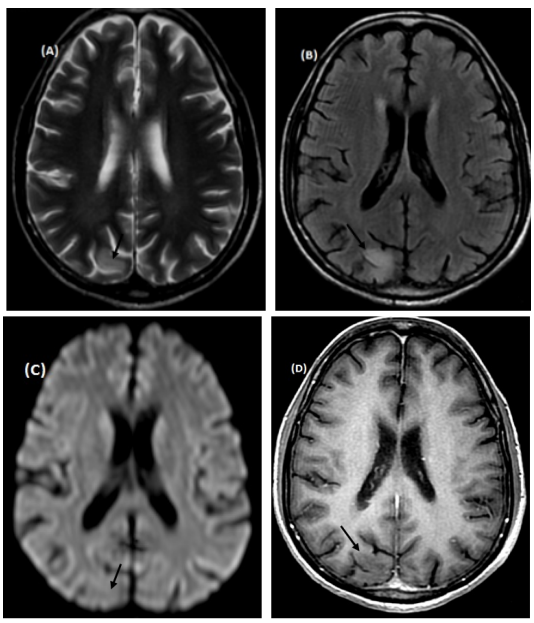


Figure 7: A, B) Axial T2W & FLAIR images showing hyperi ntensity involving the right occipital cortex. C) DWI image showing no restricted diffusion. D) Axial post-contrast image showing no enhancement, s/o focal cerebritis.

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