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Clinico-radiological features of subarachnoid hyperintensity on diffusion-weighted images in patients with meningitis

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AIM: To investigate the clinical and radiological features of meningitis with subarachnoid diffusion-weighted imaging (DWI) hyperintensity.

MATERIALS AND METHODS: The clinical features, laboratory data, and radiological findings, including the number and distribution of subarachnoid DWI hyperintense lesions and other radiological abnormalities, of 18 patients seen at five institutions were evaluated.

RESULTS: The patients consisted of eight males and 10 females, whose ages ranged from 4 months to 82 years (median 65 years). Causative organisms were bacteria in 15 patients, including *Haemophilus influenzae*, *Streptococcus pneumoniae*, *Streptococcus agalactiae*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Listeria monocytogenes*. The remaining three were fungal meningitis caused by *Cryptococcus neoformans*. Subarachnoid DWI hyperintense lesions were multiple in 16 of the 18 cases (89%) and predominantly distributed around the frontal lobe in 16 of the 18 cases (89%). In addition to subarachnoid abnormality, subdural empyema, cerebral infarction, and intraventricular empyema were found in 50, 39, and 39%, respectively. Compared with paediatric patients, adult patients with bacterial meningitis tended to have poor prognoses (7/10 versus 1/5; $p = 0.1$).

CONCLUSION: Both bacterial and fungal meningitis could cause subarachnoid hyperintensity on DWI, predominantly around the frontal lobe. This finding is often associated with poor prognosis in adult bacterial meningitis.

Introduction

Meningitis occasionally affects the central nervous system and can cause significant sequelae, such as hearing loss, paresis, epilepsy, hydrocephalus, and psychomotor retardation.[1] More subtle deficits including behavioural and academic difficulties are more prevalent among children

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who had meningitis in infancy.[1] Therefore, prevention and proper management of complications are crucial to improve outcome. Neuroimaging examinations play an important role in the management of meningitis. Although computed tomography (CT), which readily available in emergencies, is the most widely used examination, it might fail to demonstrate subtle pathological changes.[2] Compared with CT, magnetic resonance imaging (MRI) can more clearly demonstrate not only meningeal, but also parenchymal lesions resulting from meningoencephalitis or vasculitic complications.[3] In particular, diffusion-weighted imaging (DWI) is superior to other conventional sequences, such as T2-weighted imaging (T2WI) and fluid-attenuated inversion recovery (FLAIR) imaging in the diagnosis of acute ischaemic changes, cerebral abscess, intraventricular, and subdural empyema, and encephalitis.[3–6]

In spite of previous reports evaluating various intracranial infections on DWI, meningitis with subarachnoid hyperintensity on DWI has rarely been reported, with only a limited number of patients in the literature.[7,8] The purpose of this study was to investigate the clinical and radiological features of meningitis with subarachnoid DWI hyperintensity.

Materials and methods

Patients

This was a retrospective study evaluating characteristic subarachnoid DWI hyperintensity in meningitis from the data sources of five institutions. The privacy of patients was completely protected. Approval by an institutional review board was not necessary for this type of study. First, diagnostic reports of MRI taken between June 1999 and May 2010 were searched using the keywords DWI, hyperintensity, and meningitis, and their images were collected. Then, two neuroradiologists (T.K. and K.S.) evaluated the chosen images to investigate whether or not DWI hyperintense lesions were present in the subarachnoid space without reference to clinical information. When the finding was not judged as subarachnoid hyperintensity on DWI, the cases were excluded from the present study. Patients who were not diagnosed as having meningitis were also excluded. Diagnosis of meningitis was based on detection of infectious organisms by microscopic examination of Gram-stained or India-ink-stained smear and/or a positive result of cerebrospinal fluid (CSF) culture testing, or on CSF pleocytosis and clinical information, including their symptoms and laboratory data (e.g., white blood count and C-reactive protein). Finally, 18 patients with clinically diagnosed meningitis showing subarachnoid hyperintensity on DWI were identified. The clinical information, including age, gender, primary causative organism, clinical symptoms, and laboratory data, was reviewed from the hospital medical records. Since the study period was relatively long, only limited clinical information was available in a number of patients.

MRI protocol

Brain MRI was performed using a 1.5 T MRI system (Gyroscan Intera, Philips Medical Systems, Best, The Netherlands; Signa HDe, Signa Horizon or Signa Excite HDxt, GE Medical Systems, Milwaukee, WI, USA), or a 1 T MRI system

Table 1
Clinical features of patients.

Patient no.	Age	Sex	Clinical symptoms	Laboratory findings				Causative organism	Prognosis
				Blood		CSF			
				WBC (/μl)	CRP (mg/dl)	Cell count (/μl)	L/N		
1	4 mo	F	Fever	8100	24.5	559	NP	Bacterium (H. i)	Good
2	9 mo	F	Fever, seizure	20,100	6.2	62,464	NA	Bacterium (H. i)	Good
3	10 mo	M	Fever, seizure	6200	27.2	7968	NA	Bacterium (H. i)	Poor
4	9 mo	F	Fever	7100	22.1	6432	NP	Bacterium (H. i)	Good
5	3 y	F	Fever, headache	NA	NA	NA	NA	Bacterium (H. i)	Good
6	52 y	F	Fever, headache	19,700	31.2	316	NP	Bacterium (S. p)	Poor
7	77 y	M	Fever, delirium	6900	31.0	58	NP	Bacterium (S. p)	Poor[a]
8	72 y	M	Fever, cons dist	23,800	18.1	NA	NA	Bacterium (S. p)	Poor
9	64 y	M	Fever, delirium	31,400	28.7	NA	NA	Bacterium (S. p)	Good
10	63 y	F	Cons dist	NA	NA	NA	NA	Bacterium (S. p)	Poor[a]
11	69y	F	Fever, cons dist	NA	NA	16,133	NP	Bacterium (S. p)	Good
12	77 y	F	Fever, cons dist	3500	32.15	9	NP	Bacterium (S. ag)	Poor[a]
13	66 y	F	Cons dist	NA	NA	215	LP	Bacterium (S. au)	Poor
14	79 y	F	Fever, cons dist	122,00	14.3	NA	NA	Bacterium (K. p)	Poor
15	82 y	M	Fever, cons dist	NA	NA	669	LP	Bacterium (L. m)	Good
16	71 y	M	Dementia, headache	4900	0.4	7	LP	Fungus (C. n)	Poor
17	77 y	M	Dementia, headache	9500	4.0	21	LP	Fungus (C. n)	Poor
18	64 y	M	Fever, dysbasia	6700	1.1	45	LP	Fungus (C. n)	Good

mo, Months; y, years; M, male; F, female; WBC, white blood cell count; CRP, C-reactive protein; L/N, lymphocyte/neutrophil ratio; LP, lymphocyte predominance; NP, neutrophil predominance; NA, not applicable; cons dist, conscious disturbance; H. I, *Haemophilus influenza*; S. p, *Streptococcus pneumoniae*; S. ag, *Streptococcus agalactiae*; S. au, *Staphyococcus aureus*; K. p, *Klebsiella pneumoniae*; L. m, *Listeria monocytogenes*; C. n, *Cryptococcus neoformans*; Good, recovery with no detectable disabilities; Poor, recovery with neurological sequelae or death.

[a] Patient died.