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Magnetic Resonance Imaging Feature of Bacterial Meningitis in a Neonate Hanwoo Calf

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Abstract : A 1-week-old, male Korean native calf with acute clinical signs of depression, mild diarrhea, ataxia, recumbency and tremor was referred to Chonbuk Veterinary Medical Center of Chonbuk National University. Vision loss and cornea edema were also observed on physical examination. The patient had been deteriorated with nystagumus, strabisumus and opisthtonus. Blood cell count test and blood biochemistry test revealed remarkable leukocytosis, and hypoalbuminemia and increased blood urea nitrogen. No remarkable findings were observed on radiography. On magnetic resonance imaging study, there were enlarge lateral, third, and forth ventricles. The cortical grey and subcortical white matter of left temporal lobe showed hypointense on T1-weighted images and hyperintense on T2- weighted images, and slightly enhanced on contrast-enhanced T1-weighted images. *Escherichia coli* strain was identified from cerebrospinal fluid sample. Palliative treatment was attempted but the neonatal calve was expired three days after admission. Severe multifocal fibrino-suppurative meningitis with *Escherichia coli* infection was confirmed histopathologically.

Key words **:** *Escherichia coli*, Hanwoo calf, magnetic resonance image, meningitis.

Introduction

In neonatal calves, bacterial meningitis is the most common central nervous system (CNS) disease and it develops secondary to septicemia and bacteremia associated with failure of passive transfer of colostral antibodies (6). *Escherichia* (*E.*) *coli* was the organism most frequently isolated from the CNS (6). Bacterial meningitis usually has rapidly progressing clinical signs, and the disease is often grave (2). The major clinical signs of CNS disturbance were lethargy, recumbency, anorexia, loss of suckle reflex, and coma. Diagnosis is aided by cerebrospinal fluid (CSF) analysis but should be performed with caution. Because the intracranial alterations may result in an intracranial pressure and resultant brain herniation (2). Computed tomography and magnetic resonance imaging (MRI) of intracranial inflammatory lesions in animals have been described (5,10,20) but to our knowledge there are few reports of magnetic resonance imaging changes of meningitis in calves. We describe the MR findings in a neonatal Hanwoo calf with histopathologically confirmed bacterial meningitis.

Case

A 1-week-old, male Korean native calf (weighing 20 kg), with acute clinical signs of depression, mild diarrhea, ataxia, recumbency and tremor was referred to Chonbuk Animal Medical Center (CAMC) of Chonbuk National University. According to medical history obtained from the referring veterinarian, no abnormalities were observed since birth. There was no history of trauma. The calf showed neurologic sings such as ataxia, recumbency and tremor suddenly on the seventh day after birth. Symptomatic treatment with intravenous corticosteroid and antibiotics was attempted by private veterinarian but the calf did not improve at all. On careful physical examination, lack of suckle reflex, vision loss and cornea edema (both eyes) were found. Complete blood count and biochemistry test showed severe leukocytosis 54.3×10^3 μl (reference range, 4-12 × $X10^3$ μl), with neutrophilia and lymphopenia. The serum chemistry profiles revealed hypoalbuminemia 0.9 g/dl (reference range, 2.7-4.1 g/dl), and elevated blood urea nitrogen 45 mg/dl (reference range, 10-20 mg/dl). Antibiotics, mannitol, MPSS and fluid were administered but the calf did not progress with medication. No remarkable findings were observed on survey radiographs. The second day of admission, the patient was deteriorated with left eye jerk nystagmus and right eye dorso-lateral strabisumus and opisthtonus. Based on those clinical signs and test results, intracranial inflammation was suspected. On the following day MR scanning was performed. T1 weighted image (T1WI, TR, TE; 500 ms, 26 ms) and T2 weighted image (T2WI, TR, TE; 3500 ms/90 ms) with 3 mm thick and 0.3 mm interslice gap were obtained in transverse and sagittal

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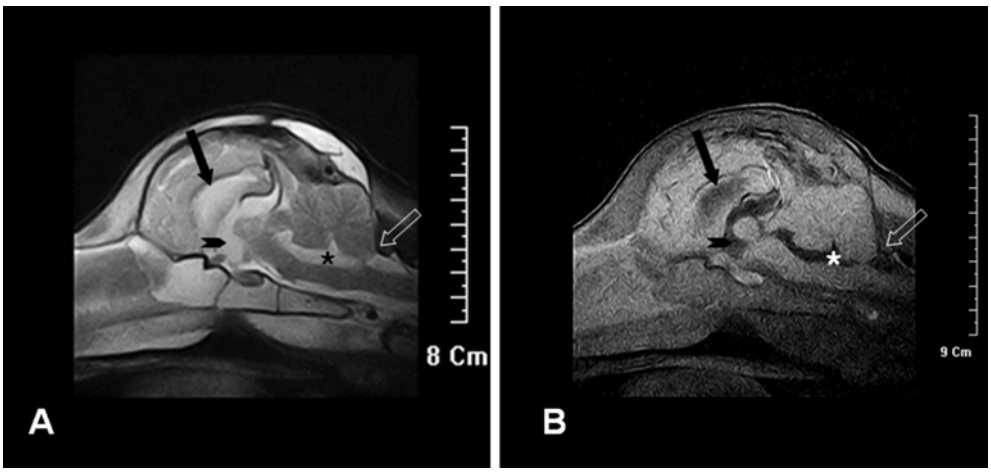

Fig 1. Midsaggital T2WI and T1WI of a calf brain. Enlarged lateral ventricle (arrow), third ventricle (arrowhead), and forth ventricle (asterisk) and slighted herniated cerebellar (empty arrow).

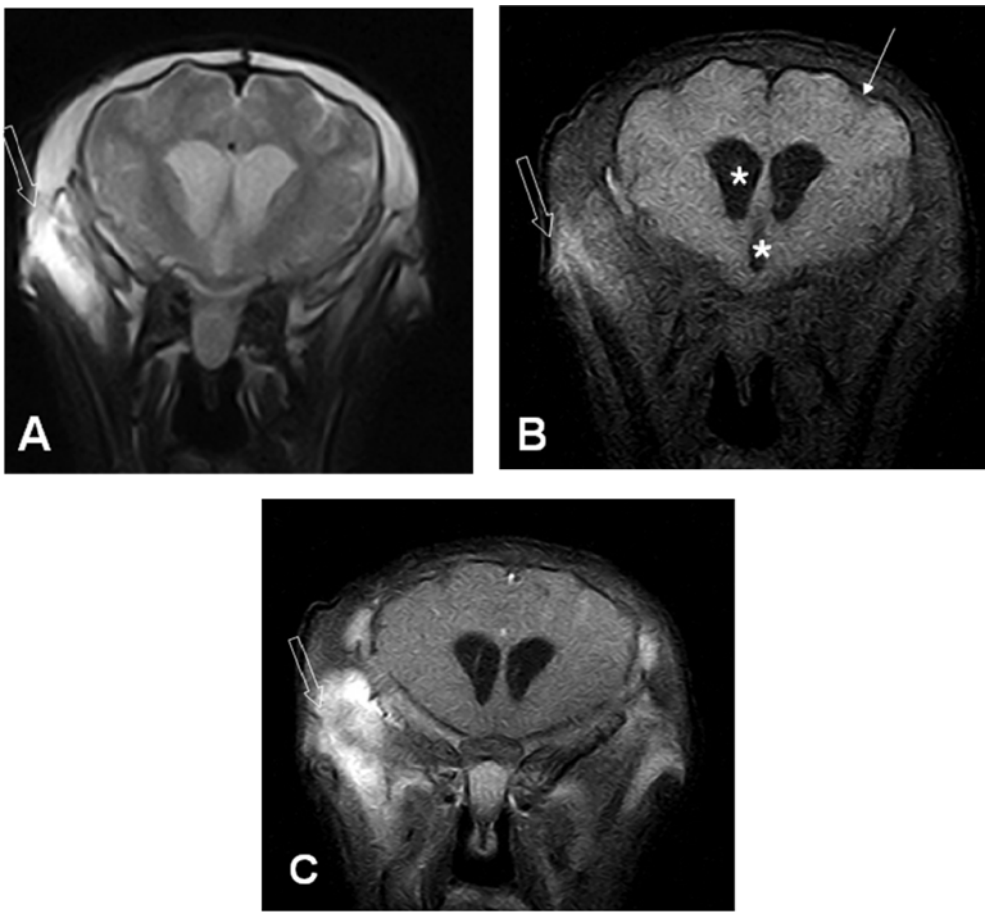

Fig 2. Transverse T2WI (A), T1WI (B), and enhanced T1WI (C) of a calf brain. Enlarged lateral ventricle, third ventricle (arrows). Hypointensity on T1WI and hyperintensity on T2WI on cerebral cortex of temporal lobe (arrows) with faint enhancement on other meningeal region (arrowhead). Hyperintense lesion on T2WI, T1WI and enhanced T1WI is observed (empty arrow).

using a 0.2 T magnet. (E-scan, ESAOTE, Genova, Italy). Contrast-enhanced T1WI was gained immediately after an intravenous bolus of gadopentetate dimegluminew of 0.1 mmol/kg. In T2WI, an irregular hyperintensity of the focal left cortical gray matter and subcortical white matter was present (Fig 1A, 2A). All these lesions appeared hypointense on T1WI (Fig 1B, 2B). Slight peripheral enhancement after contrast medium administration could be

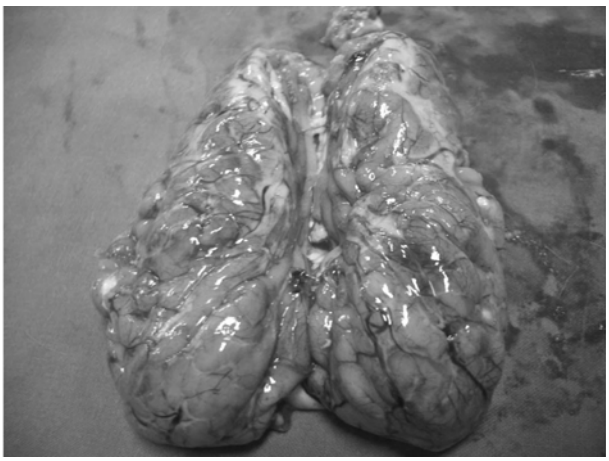

Fig 3. Photograph of brain. Note the suppurative meninges diffusely with congestive cerebral cortex. Overall the gyri are flattened, indicating brain swelling and compression.

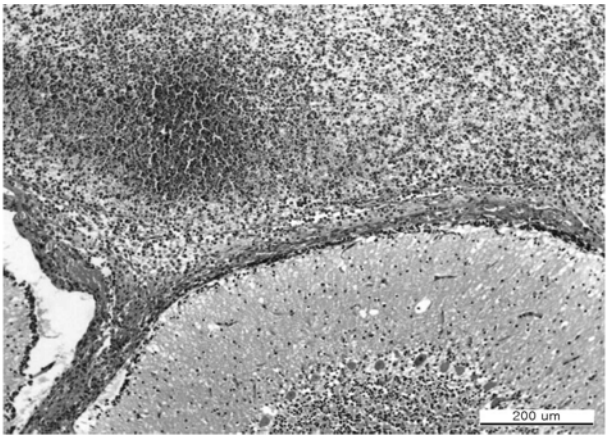

Fig 4. Cerebellum. Severe suppurative meningitis in a calf. (H&E stain; Bar = 200 μm).

seen, which was compatible with the hypointense lesion on T1WI (Fig 2C). Enlarged lateral ventricles, third ventricle and fourth ventricle compressing forebrain craniodorsally and cerebellum dorsally were noticeable (Fig 1, 2). Additionally, slightly herniated cerebellum was observed (Fig 1A, B). Hyperintense lesion on T2WI, T1WI, and enhanced T1WI is considered inflammatory change (Fig 2 A, B, C)).

CSF analysis revealed a mild monocytic pleocytic pleocytosis of six nucleated cells per microliter (reference rage ≤ 5μl) with a protein concentration of 0.33 g/l (reference rage ≤ 0.25 g/l). *Escherichia coli* strain was confirmed from cerebrospinal fluid. The calf was deteriorated severely with dyspnea and expired 3 days after admission regardless of medication with antibiotics and corticosteroid.

A necropsy and histopathologic examination was performed. Grossly the principal lesions were confined to the CNS. There was an increased amount of turbid yellowish CSF along with dilation of the ventricles. The meninges of the brain and spinal cord were congested, and massive yellowish fibrin

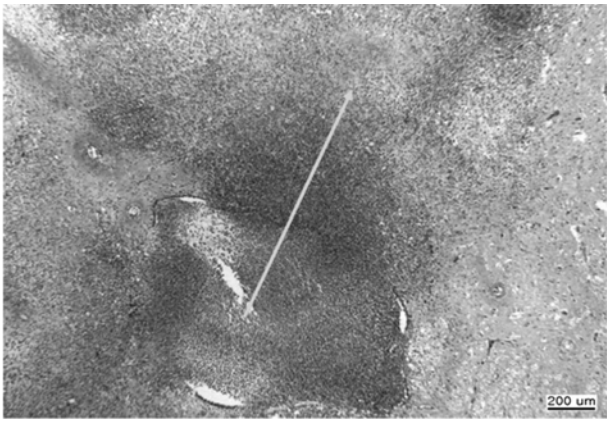

Fig 5. Spinal cord. Severe inflammation in central canal extended into gray matter of spinal cord (arrow). (H&E stain; Bar = 200 μm).

plague covered brain especially over the sulci and vermis (Fig 3). Overall the gyri are flattened, indicating brain swelling and compression. On histopathologic examination, severe diffuse fibrinopurulent inflammation extended along the meninges from the cerebrum to the spinal cord (Fig 4). The major changes composed of congestion, perivascular hemorrhage, fibrinous exudates, and infiltration of neutrophils and macrophages. Multifocal neutrophils infiltrations around blood vessels and micro-abscesses also presented in the brain parenchyma such as cerecrum, cerebellum and brain stem. There were severe fibrinopurulent meningitis and neutrophil infiltration at central canal in the spinal cord. Because of the extension of inflammatory process from central canal, tremendous meylomalacia was observed in the gray matter of spinal cord (Fig 5). Fibrinopurulent exudate was also found in the dorsal or ventral root ganglia. Based on those results, severe suppurative meningitis was identified in a neonate calf.

Discussion

Although, meningitis in neonatal calves with has been reported well previously (4,6,15-17), the magnetic resonance imaging (MRI) features of calf brain disease was not studied yet. Only the comprehensive description of normal calf brain in MRI scan was introduced for diagnostic imaging and neuromorphological research recently (13). In human medicine, even serial MR images revealed the progress of multiple brain abscesses over a month (7).

Meningitis, inflammation of the meninges, is most frequently caused by bacteria such as *E. coli* and *Streptococcus* spp. that pass through to the leptomeninges and subarachnoid space hematogenously in animals generally (6,21). Especially acute meningitis (leptomeningitis) which are suppurative and fibrinous is commonly caused by systemic bacterial infections in neonates, and the onset is usually within a few days of birth up to 2 weeks (21). In this case, the neonate calf showed systemic infection including nervous and gastrointestinal tract disorder caused by *E. coli* was observed at 7 days old. Bacte-

rial infection can spread to the meninges by direct extension and leukocytic trafficking. (21). The infection route can be oral, intrauterine, umbilical, surgical, via postsurgical procedures such as castration and ear notching, or via the respiratory, but the bacteria ultimately invade into the central nervous system hematogenously (21). And it is known that neonatal infections and sepsis happen most commonly in calves with failure of passive transfer. If the invading bacteria are not rapidly controlled, they can set up focal infections, such as in growth plates, joints, or meninges, or generalized sepsis may occur. If not successfully treated, sepsis can lead to a systemic inflammatory response, multiple organ dysfunction syndromes, septic shock, and death (4). Thought the exact infection course was not determined in this case, the meningitis with systemic infection could be originated from lack of passive transfer and/or oral infection in this case presumably.

The MRI findings have been well established in dogs and cats (9,10). Meanwhile bacterial meningitis in dogs and cats is rare (11) and usually has fast progressing clinical signs and the disease is often lethal (3). In MR images of dogs with meningoencephalitis, there may be hypointense foci in T1-weighted images, hyperintense foci in T2-weighted images (8-10,14,18) and focal parenchymal or meningeal enhancement after administration of gadolinium (10,14,18). In this neonatal calf, the MRI findings showed that low signal on T1WI and high signal on T2WI, and faint enhanced on contrast-enhanced T1WI at cerebella focally compatible with the possible meningioenchephalitis. The enhancement effect was slight enough failure to notice on enhanced T1WI. It was reported that meningeal enhancement is an insensitive and relatively non-specific sign in dogs with inflammatory CSF because it was only identified in some cases (10).

Diagnosis is usually aided by CSF analysis. CSF collection, however, should be performed with caution, since the related intracranial alterations associated with fulminant bacterial encephalitis may result in an increased intracranial pressure and resultant brain herniation (2). As usual, MRI was carried out first, and CSF analysis was followed for more precise decision for the CNS disease and treatment plan.

Analysis of cerebrospinal fluid (CSF) is the most useful diagnostic test for intracranial inflammatory situation. In canine patients, increased CSF protein or white cells are observed in approximately 90% (19). The highest protein concentrations and white cell counts are found in dogs with steroid-responsive meningitis-arteritis or bacterial meningitis (12,19). In this calf, the CSF analysis also showed noticeable alterations indicating bacterial meningitis.

At necropsy, the respiratory and gastrointestinal tracts which were known the most commonly damaged lesions were affected merely (1). The respiratory and gastrointestinal systems were most commonly affected. Few of the calves had umbilical infections. The survival rate was poor (< 12%) (1). And the neonatal calf developed nervous symptoms followed by light diarrhea (16). In this case, failure of colostrum management or oral entry of the contagious agent seems to contribute cause the meningitis and death in this case. The clinical onset was acute and no noticeable abnormalities such as omphalitis, diarrhea or respiratory distress indicating systemic infection were observed.

On histopathologic examnination, pale yellow thick exudate in the sulci and subarachnoid space, and flattened overall gyri were identified. Moreover, histopathologic examination confirmed the severely damaged evidence in cerebellum, spinal cord and brainstem as well in cerebrum. Interestingly, no remarkable intensity changes were observed on cerebellum, brain stem, and spinal cord.

The discrepancy between the MR findings and histopathologic findings might be contributed by the early stage process of the CNS inflammation or lack of pathologic changes enough to be imaged in MR or enhance MR scan. After all, MR images in this calf could not reveal the severe damage of spinal cord and brain stem at all. Therefore careful caution must be paid to interpret the MR images of meningitis and myelitis in neonate calve as well in other animals.

It is known that meningitis may be accompanied by infection of the underlying parenchyma of the spinal cord (myelitis) (2). The spinal cord was also severely affected as well as brain stem confirmed by histopathologic examination in this case.

Usually treatment with trimethoprimsulfadiazine, clindamycin, doxycycline, and corticosteroids is frequently started before final diagnosis (2). In this calve the initial treatment prior to make definitive diagnosis did not work effectively. The severe infection might be the cause of non responsive circumstances.

MR imaging along with CSF analysis can be considered in industrial animal such as calf and other large animal to reveal CNS alterations affected by infection or inflammation resulting in precise judgment for efficient treatment plan in terms of economical aspect as well life itself. Absolutely, further studies to make obvious more the MR signs in calves with histologically confirmed meningitis are necessary.

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한우 송아지에서 세균성 뇌막염의 자기공명영상

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요 약 : 일주령 20 kg 한우 송아지가 급성으로 침울, 보행실조, 횡와위 그리고 진전을 보여 전북대학교 전북동물의료센터로 내원하였다. 시력소실과 각막부종도 관찰되었다. 안구진탕과 사시 그리고 후궁반장까지 보이는 등 점점 증상은 악화되었다. 혈액검사 결과 뚜렷한 백혈구 증가증 및 저알부민혈증과 BUN증가를 관찰하였다. 단순방사선검사에서는 특이소견이 관찰되지 않았다. 자기공명영상 검사 결과 측뇌실, 제3뇌실 그리고 제4뇌실의 확장을 관찰하였으며 대뇌 좌측 측두엽의 피질과 백질 부위에 국소적으로 T1강조영상에서 저신호로 T2강조영상에서 고신호로 그리고 조영T1강조영상에서 미약하지만 조영증강효과가 관찰되었다. 뇌척수액 검사결과 대장균 감염이 확인되었다. 환자는 치료에 반응하지 않고 입원 3일 후 폐사하였다. 조직병리학적 검사에서 대장균 감염에 의한 심각한 다발성 섬유-화농성 뇌막염으로 확진되었다.

주요어 : 자기공명영상, 뇌막염, 대장균, 한우송아지.