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Diffusion-Weighted Magnetic Resonance Imaging of Organized Subdural Hematoma

—Case Report—

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Abstract

A 59-year-old male presented with a left organized subdural hematoma. The hematoma appeared as a homogeneous low density area on brain computed tomography and as hyperintense and isointense area on both fluid-attenuated inversion recovery and T_2-weighted magnetic resonance (MR) imaging. Echo-planar diffusion-weighted MR imaging showed a crescent hyperintense area under the dura mater and an irregular hypointense area over the brain surface in the left subdural space. The apparent diffusion coefficient (ADC) values of the solid and liquid hematoma were $0.86 \pm 0.32 \times 10^{-3}$ and $2.56 \pm 0.39 \times 10^{-3}$ mm²/sec, respectively. The ADC value of the solid hematoma was similar to acute subdural or intraparenchymal hematoma, and that of the liquid was similar to cerebrospinal fluid. Burr-hole surgery failed to remove all the hematoma, and he complained of persistent headache. The hematoma was removed through a craniotomy without further neurological deficits. Organized subdural hematoma often requires craniotomy for evacuation because of its solid content. Diffusion-weighted MR imaging and measurement of ADC values can differentiate solid from liquid hematoma, so are useful for selection of the surgical procedure.

Key words: organized subdural hematoma, diffusion-weighted imaging, apparent diffusion coefficient

Introduction

Burr-hole trepanation is now considered adequate for the treatment of chronic subdural hematoma and provides good postoperative outcomes.[1,12,13] However, craniotomy is often necessary for the evacuation of organized subdural hematoma. Therefore, the preoperative diagnosis is quite important. The combination of brain computed tomography (CT) and magnetic resonance (MR) imaging is useful to select the therapeutical strategy.[5] We recently reported that diffusion-weighted MR imaging can differentiate solid from liquid hematoma in the subacute stage.[9] Here, we discuss the usefulness of diffusion-weighted MR imaging and apparent diffusion coefficient (ADC) values of the organized subdural hematoma.

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Case Report

A 59-year-old male with a history of diabetes mellitus presented with headache, transient ischemic attack in the right upper limb, and motor aphasia occurring two times within 2 days. Brain CT showed a homogeneous low density area in the left subdural space with midline shift (Fig. 1 *left*). The lesion in the left subdural space was not enhanced by contrast medium, but the slightly enhanced rim over the left brain surface suggested the inner membrane of subdural hematoma (Fig. 1 *right*). The left subdural space was appeared as hyperintense and isointense associated with a trabecular structure on both fluid-attenuated inversion recovery (FLAIR) (repetition time [TR]/echo time [TE]/inversion recovery = 8000/108/2000 msec) and T_2-weighted MR imaging (TR/TE = 3000/99.7 msec) using a 1.5-T superconducting system (Fig. 2). Single-shot echo-planar diffusion-weighted MR imaging obtained in three orthogonal motion probing gradients (MPGs)

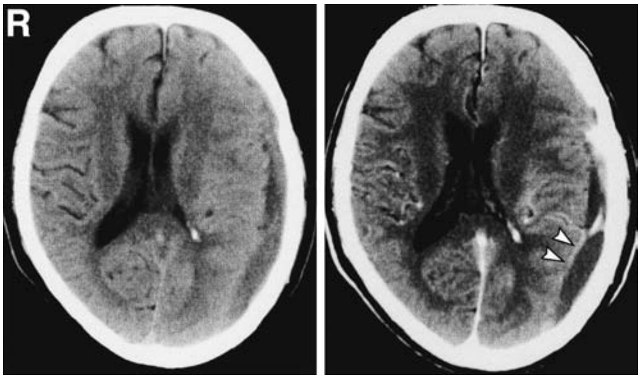

Fig. 1 **Brain computed tomography scan showing a homogeneous low density area in the left subdural space with midline shift (*left*). The lesion in the left subdural space was not enhanced by the contrast medium, but the enhanced rim over the left brain surface (*right*, *arrowheads*) suggests the inner membrane of subdural hematoma.**

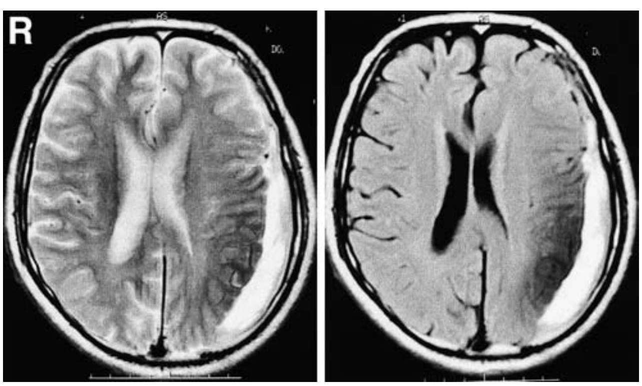

Fig. 2 **T_2-weighted (*left*) and fluid-attenuated inversion recovery magnetic resonance images (*right*) showing a homogeneous hyperintense and isointense area associated with a trabecular structure.**

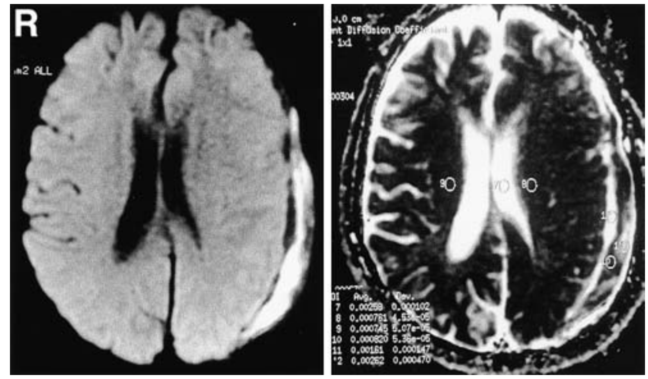

Fig. 3 **Diffusion-weighted magnetic resonance image (*left*) showing a crescent hyperintense area under the dura mater and an irregular hypointense area over the brain surface in the left subdural space. The hyperintense and hypointense areas corresponded to the hypointense and hyperintense areas on the apparent diffusion coefficient (ADC) mapping image (*right*). The ADC values of the hyperintense and hypointense areas in the subdural hematoma, corona radiata, and lateral ventricle were measured respectively. Circles (30 mm²) indicate the regions of interest.**

(TR/TE = 4800/83.3 msec, field of view 200 × 200 mm, slice thickness 8.0 mm with a 2.0 mm gap, matrix 128 × 128 mm, MPG of 14 mT/m, and maximum b_1-factor of 1000 sec/cm² and minimum b_0-factor of 0 sec/cm²) showed a crescent hyperintense area under the dura mater and an irregular hypointense area over the brain surface in the left subdural space (Fig. 3 *left*). The ADC value was calculated based on the Stejskal and Tanner equation, $ADC = \ln(SI_1/SI_0)/(b_0 - b_1)$, where SI_0 and SI_1 are the pixel signal intensities acquired from the diffusion-weighted MR imaging with b_0 and b_1, respectively.[15] The ADC mapping image was created by this calculation on a pixel-by-pixel basis. The average ADC values of the areas (30 mm²) appearing as hyperintense and hypointense on the diffusion-weighted MR imaging in the hematoma were $0.86 \pm 0.32 \times 10^{-3}$ (mean ± standard deviation) and $2.56 \pm 0.39 \times 10^{-3}$ mm²/sec, respectively (Signa Horizon Infinity EXCITE; General Electric Medical Systems, Tokyo) (Fig. 3 *right*).

Burr-hole surgery was performed but only about 20 ml of dark brown fluid was aspirated on the day after admission. The presence of organized tissues in the left subdural space was confirmed through the burr hole, so no measurement of intracranial pressure or subdural drainage was performed. Although he had no further ischemic neurological deficits, he complained of persistent headache after the burr-hole surgery. Therefore, osteoplastic left frontoparietotemporal craniotomy was performed 17 days after the admission. The dura mater could easily be separated from the outer membrane. The outer membrane was oozy and about 3 to 5 mm in thickness (Fig. 4 *left*). Gray or yellow-greenish paste-like materials including some yellowish fluid were found under the outer membrane (Fig. 4 *right*). The paste-like materials and yellowish fluid were totally evacuated, revealing the thin inner membrane and

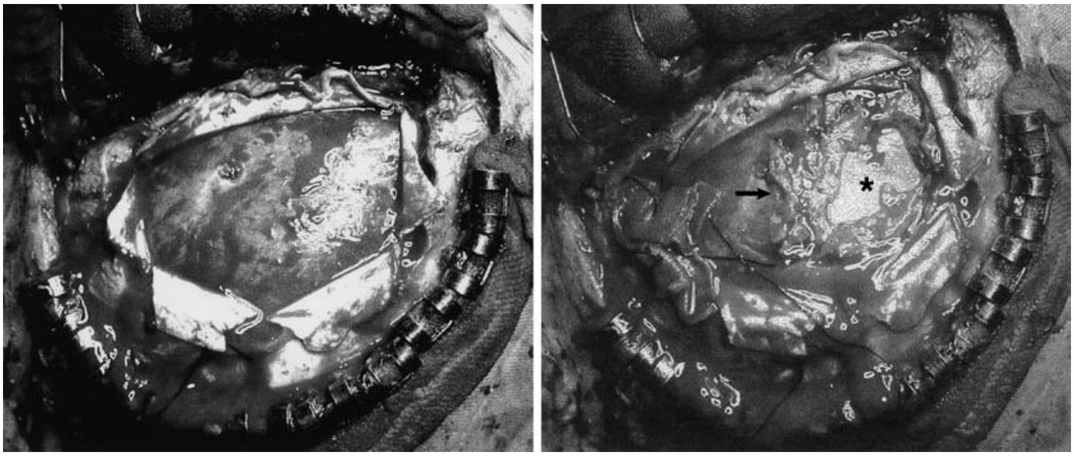

Fig. 4 Operative photographs showing the hematoma was composed of gray or yellow-greenish paste-like materials including some yellowish fluid (*right*, *arrow*) underneath a thick, oozy outer membrane (*left*). There was a thin inner membrane (*right*, *asterisk*), and the brain surface was intact.

normal brain surface.

The postoperative course was uneventful and his headache disappeared.

Discussion

The MR imaging appearance of chronic subdural hematoma is usually described as a short T_1 and long T_2 pattern, since the extracellular methemoglobin induces marked shortening of the T_1 relaxation time and prolongation of the T_2 relaxation time.[4,14] If the concentration of free methemoglobin is decreased by dilution, absorption, or degradation, the subdural hematoma is usually slightly hypointense to isointense relative to the gray matter on the short TR/TE images.[2]

Organized or partially calcified hematomas appear as mixed lesions consisting of slightly hypointense and hyperintense areas on T_1-weighted MR imaging, with heterogeneous web- or net-like appearances in the hematoma cavities. T_2-weighted MR imaging shows the calcification as characteristic heterogeneous structures in the hematoma cavity.[5] T_1- and T_2-weighted MR imaging of the muddy component shows hyperintense areas caused by the presence of free methemoglobin.[3] On the other hand, CT shows organized or partially calcified hematomas as heterogeneous moderate high density,[5] mixed density with high density inner margins,[3] or inhomogeneous density without a niveau.[6]

In our case, the subdural hematoma appeared as a homogeneous low density area on CT and as a hyperintense and isointense area associated with a trabecular structure on both FLAIR and T_2-weighted MR imaging. Unfortunately we did not perform T_1-weighted MR imaging, and so we could not make an initial preoperative diagnosis of organized subdural hematoma. The craniotomy subsequent to the initial burr-hole surgery confirmed that the hematoma consisted of liquid and solid components.

Retrospectively, preoperative diffusion-weighted MR imaging and measurement of the ADC value in the subdural hematoma were useful for discriminating the solid and liquid hematoma in the subdural space. The gray or yellow-greenish paste-like materials appeared as hyperintense with an ADC value of $0.86 \pm 0.32 \times 10^{-3}$ mm²/sec, which is similar to those of acute subdural hematoma ($0.71 \pm 0.21 \times 10^{-3}$ mm²/sec, $n = 3$), acute intracerebral hematoma ($0.58 \pm 0.16 \times 10^{-3}$ mm²/sec),[7] and normal internal capsule and corona radiata ($0.60 \pm 0.10 \times 10^{-3}$ mm²/sec).[8] Diffusion-weighted MR imaging is sensitive to the movement of water molecules, so any changes in diffusion reflect changes in the environment of the water molecules.[10,11] Organized hematoma is generally composed of thick, fibrous, collagenous neomembrane and old thrombosis-like clot consisting of a large amount of fibrin. Deposits of calcium, hemosiderin, and cholesterin are present in the neomembranes and trabeculae.[5] Therefore, the low ADC value of the gray or yellow-greenish paste-like materials and thick neomembrane may be due to the heavily impeded water mobility caused by the high viscosity and cellularity of the hematoma, rather than any paramagnetic effect. In contrast, the yellowish fluid appeared as hypointense on diffusion-weighted MR imaging with an ADC value of $2.56 \pm 0.39 \times 10^{-3}$ mm²/sec, which is similar to that of normal cerebrospinal fluid ($2.87 \pm 0.38 \times 10^{-3}$ mm^2/sec, n = 10). The high ADC value in the yellowish fluid reflects the random translational motion of the water molecule, or so-called Brownian motion.[10,11]

Craniotomy is required for the evacuation of organized and/or calcified chronic subdural hematoma.[3,5,6,13] Therefore, the preoperative diagnosis of organized chronic subdural hematoma is important for planning the therapeutical strategy. The combination of diffusion-weighted MR imaging and measurement of the ADC value can differentiate solid from liquid components, so may be useful for the selection of the proper surgical procedure in cases of chronic subdural hematoma.

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