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Journal of Clinical Imaging 29 (2005) 86–93

CLINICAL IMAGING

Diffusion-weighted imaging with calculated apparent diffusion coefficient in intracranial hemorrhagic lesions

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Received 2 February 2004

Abstract

In the literature published so far, measurement of values of the apparent diffusion coefficient (ADC) using an echo-planar imaging (EPI) technique in intracranial hemorrhagic lesions show no uniform results. Furthermore, no data exist for bleedings into intracranial lesions. We investigated the ADCs of 18 intracranial hemorrhagic lesions of different stages using echo-planar diffusion-weighted imaging (DWI). The ADC values measured in the hemorrhagic lesions ranged from 1.42×10^{-3} to 0.22×10^{-3} mm^2/s. There were no significant differences between the ADC values in the hemorrhagic lesions and the contralateral white matter ($P=.39$). A differentiation between the lesions only with the ADC value was not possible as well. Using EPI DWI in intracranial hemorrhagic lesions of different stages, no reliable ADC values were found and a dependable differentiation between the lesions is not possible.

Keywords: Brain; Intracranial hemorrhage; Magnetic resonance imaging (MRI); Diffusion-weighted imaging (DWI); Apparent diffusion coefficient (ADC)

1. Introduction

For detection of acute hemorrhage, computed tomography (CT) is still the usual method. Magnetic resonance imaging (MRI) has become the technique of choice for assessing the age of an intracranial hemorrhage and demonstrating its causal relationships.

Diffusion-weighted MR imaging (DWI) is commonly used as the initial imaging examination for the detection of acute cerebral infarction [1]. DWI also provides unique information about other cerebral diseases, including neoplasms, intracranial infections, and traumatic brain injury [2]. The first studies that investigated intracranial hematomas with DWI did not show uniform results. Especially when echo-planar imaging (EPI) was used, different results were presented concerning the measured apparent diffusion coefficient (ADC) values of intraaxial hematomas during different phases [3]. There are, however, publications about increased ADC values in the late subacute phase [4], the lack of different values during hyperacute, acute, and early subacute phase [5], and decreased ADC values in all phases except the chronic phase [6]. In addition, different values were seen in in vivo and in vitro measurements [7]. Here, increasing ADC values were found in the acute and early subacute stage in blood clots.

To the best of our knowledge, in the literature no published data exist about the ADC of bleedings into other lesions such as cavernomas, subdural hematomas, hemorrhagic venous infarction, or bleedings caused by a vasculitis. We found only one case report about a bleeding into a metastasis, where DWI with calculated ADC values was performed [8].

Therefore, the purpose of our study was twofold: (1) to test whether extra- and intraaxial intracranial hemorrhagic lesions of different origins show different ADC values and

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doi:10.1016/j.clinimag.2004.04.005

Table 1
Investigated patients, arranged according to the stage of hemorrhage and the size, location, and etiology of the hematoma

Patient no./ stage of hemorrhage	Time from ictus to MRI	Size of lesion (cm)	Location	Etiology of hematoma
Acute				
1	1 day	2×2	Temporoparietal	Thrombosis, superior sagittal sinus
2	2 days	3×2	Basal ganglia	Hypertensive
3	2 days	4×4	Cerebellar	Subdural hematoma
4	3 days	1×1	Frontal	Metastasis
4	3 days	1×1	Central	Metastasis
5	3 days	1×1	Frontal	Metastasis
6	3 days	1.5×1.5	Pons	Cavernoma
7	2 days	4×2	Parietal	Epidural hematoma
Early subacute				
8	8 days	5×2	Temporal	Subdural hematoma
9	4 days	2×1	Cerebellar peduncle	Tumor (postoperative)
10	5 days	2×1	Frontal	Cavernoma
11	5 days	2×1	Temporal	Thrombosis of Trolard's vein
12	8 days	1×0.5	Frontal	Metastasis
Late subacute				
13	4 weeks	2×1	Parietal	Vasculitis
14	3 weeks	1×1.5	Occipital	Unknown
Chronic				
8	>1 year	1×1	Basal ganglia	Cavernoma
13	8 weeks	1×1	Thalamus	Vasculitis
15	9 weeks	3×2	Frontal	Hypertensive

Table 2
Investigated patients, arranged according to the stage of hemorrhage, signal characteristics in the sequences, and measured ADC values

Patient no./ stage of hemorrhage	T1	T2	Gradient echo	Diffusion-weighted image	Contralateral white matter	ADC ($\times 10^{-3}$ mm^2/s)
Acute						
1	→	↓	↓	Hypointense	0.71	0.82±0.09
2	→	↓	–	Hypointense	0.79	0.69±0.04
3 (top)	(↑)	↑	↑	Hyperintense	0.81	2.66±0.01
sediment (down)	→	→	↓	Hypointense	0.75	1.42±0.08
4	→	↓	↓	Hypointense	0.69	0.67±0.04
4	→	↓	↓	Hypointense	0.72	0.78±0.01
5	→	↓	↓	Hypointense	0.80	0.56±0.01
6	→	↓	↓	Hypointense	0.69	0.64±0.05
7	→	↓	↓	Hypointense	0.74	0.23±0.02
Early subacute						
8 (rim) and	↑	↑	↑	Hyperintense	0.72	2.50±0.03
(center)	↑	↓	↓	Hypointense	0.71	1.95±0.05
9	↑	↑/↓	↑/↓	Hyperintense/ hypointense	0.80	0.52±0.09
10	↑	↑	↑/↓	Hypointense	0.75	0.98±0.01
11	↑	↓	↓	Hypointense	0.74	0.60±0.01
12	↑	↑/↓	–	Hypointense	0.71	0.40±0.01
Late subacute						
13	↑	↓	–	Hypointense	0.83	0.41±0.04
14	↑	↓	–	Hypointense	0.74	0.22±0.09
Chronic						
8	→	↓	↓	Hypointense	0.70	0.67±0.03
13	→	↓	–	Hypointense	0.74	0.67±0.03
15 (center)	→	↓	–	Hyperintense	0.82	1.64±0.04
(rim)	↑	↓	–	Hypointense		0.40±0.04

↓ Hypointense, → isointense, ↑ hyperintense signal.