Temporal change of bloody fluid with apparent diffusion coefficient and T1-/ T2-relaxation time in a phantom study.

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TARGET AUDIENCE: Radiologists and technologists of diffusion weighted imaging.

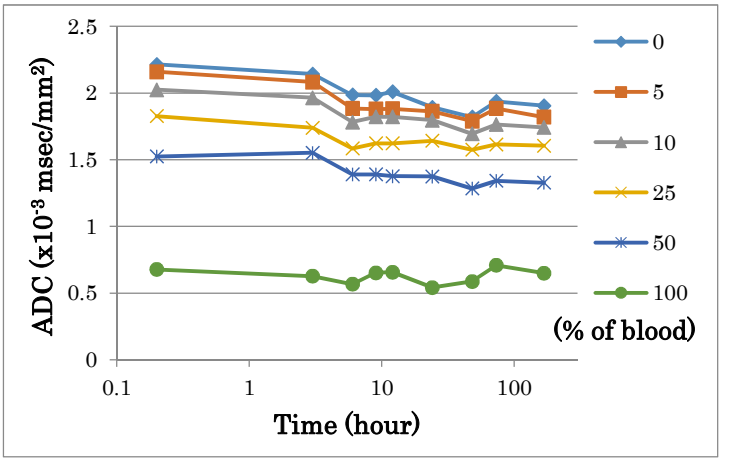
PURPOSE: Hemorrhagic cysts (i.e. endometrial cysts) exhibiting varying percentages of hemorrhage tend to display a wide range of signal behavior. High intensity in the lesion on T1-weighted images is attributed to paramagnetic effects from methemoglobin[1], and varying intensity on T2-weighted images may be due to red blood cell lysis[2]. Although both T1-/T2-relaxation time and apparent diffusion coefficients (ADCs) were largely affected by blood concentration, ADC was almost independent of blood oxidation and red blood cell lysis related diminution of magnetic inhomogeneity[3]. However, the relationship between T1-/T2-relaxation time and ADC in connection with blood concentration has not been evaluated. Hence, this study was undertaken to determine whether blood concentration-related changes of ADCs were similar to ones of T1-/T2-relaxation time in a phantom study.

METHODS: Twenty ml of blood was obtained from a healthy human volunteer (hematocrit, 43%) and heparinized (100 U/ml). Blood phantoms were gradually diluted (100, 50, 25, 10, 5 and 0% of the whole blood contents) with saline. MR measurements were performed at 0.2 hour, 4 hours, 6 hours, 12 hours, 1 day, 2 days, 3 days and 7 days after the collecting blood. MR measurements were performed at each of these concentrations with T1 (saturation recovery)/ T2 (multi TE spin echo) calculations and ADCs at 24°C. Diffusion-weighted imaging was performed using a TR/TE of 2100/60ms, a b value of 0 and 800 s/mm^2 at 3T whole-body MR imager (Achieva TX; Philips Medical Systems, Best, Netherland) with head coil.

RESULTS: T1-/T2-relaxation times and ADC values as a function of time from the generation of the blood phantom are shown in figures. T1-relaxation time cumulatively increased until 12 hours and slightly decreased. T2-relaxation time increased until 4 hours, and then decreased. ADC value changed little, and slightly decreased during whole times. T1-relaxation time and ADC value was almost proportional decreased as blood concentration decreased. T2-relaxation time was almost inversely proportional decreased as blood concentration increased.

DISCUSSION: In spite of markedly varied T1-/T2-relaxation time of the blood phantom, ADC value was little changed. These results reveal that the ADC value is almost unaffected by both the methemoglobin related paramagnetic effect and the diminution of magnetic inhomogeneity by gradual red blood cell lysis[1, 2]. In our study, diffusion value was a nearly linear function of blood concentration, which is almost the same result as reported for protein solution[4]. The ADC value obtained for protein solution is considered to be mainly dependent on the free water fraction, since water bound to protein has little effect on ADC values.

CONCLUSION: Temporary change of ADC value in bloody fluid was poorly correlated with that of T1-/T2-relaxation time. ADC value is almost linearly dependent on blood concentration and almost independent of blood oxidation and red blood cell lysis that affect T1-/T2-relaxation times.



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