ADC measurements in the evaluation of lymph nodes in patients with non-Hodgkin lymphoma

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Introduction

Non-Hodgkin lymphomas (NHLs) comprise approximately 4% to 5% of all malignancies and are the fourth to fifth most frequently occurring type of cancer in the United States [1]. Once a NHL has been diagnosed histologically, extent of disease has to be assessed, because this determines prognosis and treatment planning [2, 3]. Recently, whole-body diffusion-weighted magnetic resonance imaging (DWI) was introduced as a new imaging modality for staging malignant lymphoma [4, 5]. However, detection of lymphomatous lymph nodes at DWI still depends on size criteria which are regarded as imperfect [6]. On the other hand, DWI allows quantifying diffusion in lymph nodes by means of apparent diffusion coefficient (ADC) measurements, and this may aid in the characterization of lymph nodes. Of note, 40% of indolent lymphomas eventually transform into aggressive lymphomas, which have a worse prognosis and require prompt treatment [2, 3]. ADC measurements may potentially also be used as a noninvasive predictor of malignancy grade in the follow-up of patients with NHL, which may reduce the number of biopsies and associated patient morbidity. The purposes of this study were therefore to investigate whether ADC measurements allow discriminating normal lymph nodes from lymphomatous lymph nodes, and indolent lymphomas from aggressive lymphomas in patients with NHL.

Subjects and Methods

Eighteen healthy volunteers and twenty-two patients with newly diagnosed NHL (indolent: n=9; aggressive: n=13) prospectively underwent DWI of the head/neck, chest (patients only), abdomen (patients only), and pelvis, at 1.5 T and using a 4-element phased-array receiver coil. The following parameters were applied for DWI: slice thickness/gap of 4/0 mm, field of view of 450×360 mm^2, partial fourier factor of 0.651, parallel acquisition factor of 2, echo-planar imaging factor of 43, b-values of 0 and 1000 s/mm^2, acquired voxel size of 3.52 × 4.50 × 4.00 mm^3. ADC maps were created without using any image registration. ADCs of the largest normal lymph nodes in the volunteers were measured and compared to those of the largest lymphomatous lymph nodes in the patients (this approach was chosen to avoid selection and clustering bias), and ADCs of indolent lymphomas were measured and compared to those of aggressive lymphomas, using unpaired *t* tests. Receiver Operating Characteristic (ROC) analysis was performed when ADCs were significantly different between two of aforementioned groups. All analyses were two-tailed. *P* values less than 0.05 were considered significant.

Results

All diffusion-weighted images and corresponding ADC maps were of diagnostic quality, without any disturbing (susceptibility or motion) artifacts (Figure 1). Mean region of interest size of normal lymph nodes was 56 ±19 mm^2, and that of lymphomatous lymph nodes was 1144 ± 855 mm^2. ADCs (in 10^{-3} mm^2/s) of lymphomatous lymph nodes (mean ± SD, 0.72 ± 0.23) were significantly lower (*P*=0.0001) than those of normal lymph nodes (mean ± SD, 1.00 ± 0.15). Area under the ROC curve was 0.848 (95% CI: 0.700-0.942). Sensitivity was 77.3% (95% CI: 54.6-92.1%) and specificity was 100% (95% CI: 81.3-100%) when using an optimal cut-off ADC value of 0.78. On the other hand, ADCs of indolent lymphomas (mean ± SD, 0.65 ± 0.21) were not significantly different (*P*=0.2997) from those of aggressive lymphomas (mean ± SD, 0.76 ± 0.25). Scatterplots and ROC curve are displayed in Figures 2-4.

Figure 1. *Axial diffusion-weighted image (a) and corresponding ADC map (b) showing para-aortic lymphomatous nodes with region of interest in the largest lymph node.*

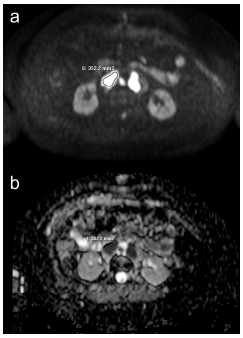


Figure 2. *Scatterplot with ADCs according to nodal status (normal vs. lymphomatous) and 95% CIs for the mean ADC of each group. ADCs of lymphomatous lymph nodes were significantly lower (P=0.0001) than those of normal lymph nodes.*

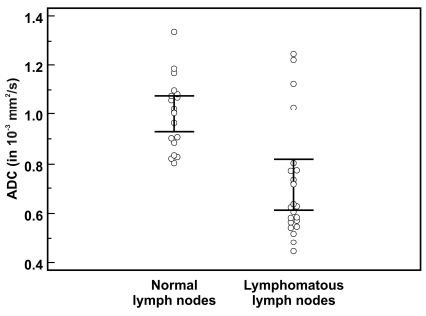


Figure 3. *ROC curve for ADC measurements for the determination of nodal status (normal vs. lymphomatous). Area under the ROC curve was 0.848 (95% CI: 0.700-0.942).*

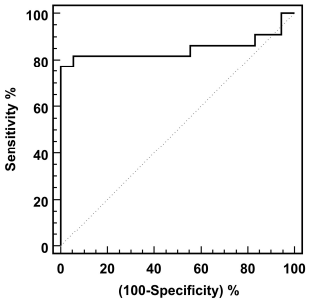
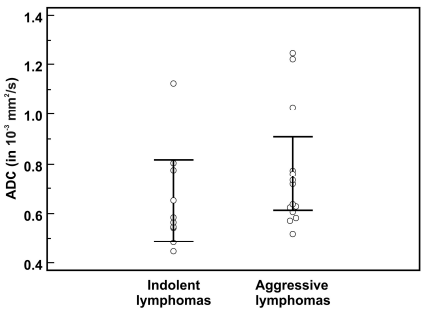


Figure 4. *Scatterplot with ADCs according to lymphoma type (indolent vs. aggressive) and 95% CIs for the mean ADC of each group. ADCs of indolent lymphomas were not significantly different (P=0.2997) from those of aggressive lymphomas.*



Conclusions

This study is the first to show that ADC measurements show promise as a highly specific method for discriminating normal lymph nodes from lymphomatous lymph nodes in the staging work-up of patients with NHL. However, ADC measurements appear to be of no utility in differentiating indolent from aggressive lymphomas.

References

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