Diffusion-weighted MRI of normal sized pelvic lymph nodes: how to delineate an ideal region of interest?

D. G. Chong[1], G. Petralia[1,2], M. Ith[1], J. M. Froehlich[1,3], and H. Thoeny[1]
[1]Dept. of Diagnostic, Interventional and Pediatric Radiology (DIPR), Inselspital, Bern, Switzerland, [2]Division of Radiology, European Institute of Oncology, Milan, Italy, [3]Guerbet AG, Zurich, Switzerland

Introduction: Typically, normal lymph nodes are substantially smaller than 1cm in diameter, and might appear even smaller on single MRI cross-section slices. Therefore, on low-resolution image modality like diffusion-weighted MRI (DW-MRI), lymph nodes typically cover only a few pixels with significant partial volume effect [Fig 1]. When a clinician needs to delineate regions of interest (ROIs) on an isolated lymph node for any type of quantitative assessment (signal, ADC-value), delineation gets difficult on non-interpolated images. Therefore, ROIs are drawn on interpolated images and values are calculated with the underlying pixels [1]. In the presented study, instead of using the interpolated images purely as visual aid, they are also used for quantitative analysis. Interpolation offers no gain of information but is more comfortable for delineation, however the hypothesis is that it could introduce a systematic error. The aim of this study was to assess whether interpolated data correspond to original data for the quantitative analysis (ADC) of small structures such as lymph nodes.

Materials and Methods: Pelvic DW-MR images were acquired as part of a large lymph node staging study followed by lymphadenectomy. Partial data of 37 lymph nodes from 13 randomly selected study patients were used to perform this study. DW-MR images were scaled by a factor of 8 with bi-cubic interpolation using ImageJ software (National Institutes of Health, USA) from 128x128 up to 1024x1024 pixels. DW-MR images have been acquired with an EPI-DW pulse sequence (3T, TRIO Siemens HC, Erlangen) including b factors of 0, 10, 20, 50, 130, 270, 500 and 900 sec/mm^2. A ROI was placed by a reader on single lymph nodes on interpolated images to acquire quantitative data (diffusion parameters including ADC_{tot} from mono-exponential fit and perfusion fraction F_p as well as the true diffusion coefficient ADC_D and the pseudo-perfusion ADC_p from bi-exponential fit) and values from original pixels were compared. Original pixels were selected when coverage of the interpolated ROI exceeded 25%. Pixel values within the ROI were summed up before performing mono- and bi-exponential fitting. Statistical analysis was performed with one-way ANOVA. When the diffusion parameters (ADC_{tot}, F_P, ADC_D and ADC_p) of the lymph nodes were equal to zero, they were excluded from further analysis.

Results & Discussion: Table 1 shows the comparison of various diffusion parameters calculated by mono- and bi-exponential fit deriving either from interpolated or equivalent original pixels. They do not differ statistically (p>0.73). Moreover, figure 2 shows that ADC values are independent of lymph node size (p = 0.79, R^2 = 0.012), and the median original pixel count per lymph node is 4 (0.266cm^2; range: 1-16, 0.067-1.065cm^2). Only 19 out of 37 lymph nodes could be evaluated for bi-exponential fitting, and 36 out of 37 for mono-exponential fitting after adoption of exclusion criterion mentioned in methods.

Conclusion: For the quantitative analysis of diffusion-weighted MRI of lymph nodes there is no significant difference between calculated diffusion parameters using interpolated image or original image pixel data in lymph nodes. ADC values were size independent. Apparently interpolation improves ROI definition in case of such small structures of interest without influencing DW-MRI quantification allowing its application in clinical practice.

References:

1. Mir et al. J Med Imaging Radiat Oncol (2010).

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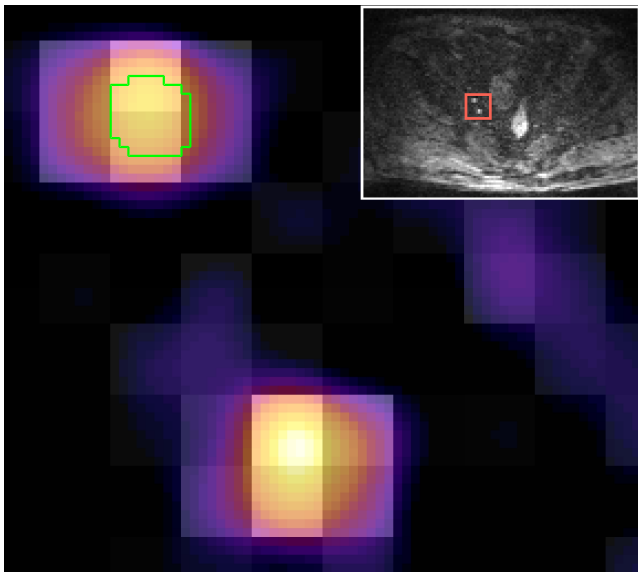

Figure 1 Two adjacent lymph nodes on interpolated image (fire color map, small pixel) overlaid with original b=900 sec/mm^2 image (gray scale color map, large pixel 2.58mm width). Green line is a region of interest (ROI) drawn on this particular lymph node. Both lymph nodes cover six pixels, but only larger portions are within 2 to 4 pixels. Insert shows with red box with the location of depicted lymph nodes on a DW-MRI on a b=900sec/mm^2 image.

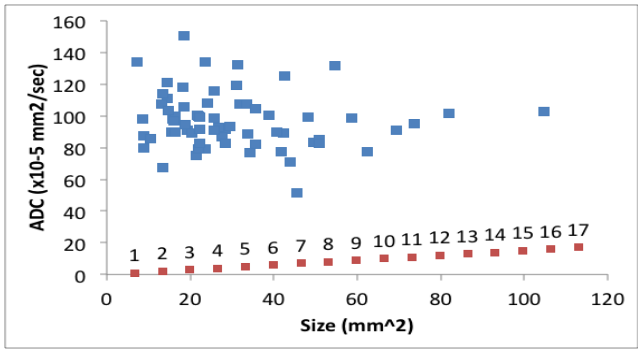

Figure 2: ADC_{tot} values of pelvic lymph nodes with respect to interpolated pixel size in mm^2. Red dots with increasing number indicate the number of original pixels. No size relevant shifting of ADC_{tot} is observed.

Diffusion Parameters	Median Difference	p values
ADC_{tot}	1.4%	0.9158
F_p	3.7%	0.7322
ADC_D	2.8%	0.9521
ADC_p	5.8%	0.8654

Table 1: Median difference between fitted values using ROI from interpolated and raw pixel values. (p-values are calculated from 1-way ANOVA test)