ON-LINE APPENDIX: MATERIALS AND METHODS

Ungated QISS-MRA

Unlike the conventional QISS sequence of the lower extremities that applies a balanced steady-state free precession readout and fat saturation,[1] no fat saturation RF pulse was used with ungated QISS FLASH, in part because uniform fat suppression is difficult to obtain in the neck region. Moreover, a spatially nonselective fat-saturation pulse is undesirable because it may inadvertently saturate inflowing arterial spins due to the substantial B_0 inhomogeneity in the upper chest. Frequency offset corrected inversion (FOCI) RF pulses were used for both in-plane and tracking venous saturation.[2-4] Compared with standard sinc RF pulses, FOCI pulses provide a more uniform slice profile and are less sensitive to RF field (B_1) inhomogeneity. The QISS sequence was also outfitted with a short-duration 2D image navigator before image acquisition that detected and suppressed the appearance of swallowing artifacts. The navigator, which was acquired in a sagittal orientation through the midline using a low-flip angle, low-resolution (~1 cm) FLASH readout, detected swallowing motion in the neck on the basis of correspondence with prior navigator images. If motion was detected, radial views from the succeeding QISS shot were rejected and reacquired.

To maximize coverage efficiency, we tilted ungated QISS slices about 45° between the axial and coronal planes, with the anterior slice edges located cranial to the posterior edges. Compared with axial slices, tilted slices increase cranial-caudal coverage by a factor of $\sqrt{2}$, thereby reducing scan time by about 40%.[4]

The breath-hold first-pass CE-MRA was performed after ungated QISS-MRA in all subjects with the administration of 0.1 mmol/kg body weight of gadolinium-based contrast agent (Gadovist, 1.0 mmol/mL, gadobutrol; Bayer Pharma AG, Berlin, Germany) in an antecubital vein at a rate of 2 mL/s. The imaging parameters for 3D-CE-MRA are summarized in Table 1. After CE-MRA examination, the CE-MRA images were subtracted from a native MRA image (mask), which was acquired with the same parameters before contrast agent injection.

Statistical Analysis

Median and range are reported as summary statistics for all variables due to the severe skewness of the respective distributions. Interrater agreement on the scoring of an image was assessed by quadratic weighted concordance.[5] A Wilcoxon signed rank test was used to identify scoring differences between the ungated QISS-MRA and the CE-MRA sequences. All P values were reported with a precision of 10^{-5}. A P value $< .01$ was considered statistically significant. Statistical analysis of the data was performed with R statistical and computing software, Version 3.5.1 (http://www.r-project.org/). Concordance was calculated with the raters package (CRAN raters; https://cran.r-project.org/web/packages/raters/raters.pdf). The conventional interpretation of an agreement is as follows: <0.00 indicates poor agreement, 0.00–0.20 indicates slight agreement, 0.21–0.40 indicates fair agreement, 0.41–0.60 indicates moderate agreement, 0.61–0.80 indicates substantial agreement, and 0.81–1.00 indicates almost perfect agreement.[6] Sensitivity and specificity were calculated considering CE-MRA as a reference standard and are presented with exact 95% confidence intervals derived from the binomial distribution. A stenosis grade of <50% was considered as not clinically relevant and a stenosis grade of ≥50% was interpreted as clinically relevant.

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