Contrast dose optimization in MR angiography (MRA) of the carotids.

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Purpose:

Various dose recommendations ranging from fixed volumes to weight adapted dosing with single- and double dose are being used clinically for MR-angiography (MRA) of the carotids. Pulse sequence acquisition times, contrast flow-rate and injection duration are important factors which influence the needed volumes. In MRA imaging time is limited due to the short time window between optimal arterial filling and venous return, hampering image quality. Rapid imaging acquisition is thus one of the most important prerequisites which on the other hand limits spatial resolution and image quality. Due to the shortening of acquisition time dosing of contrast is getting less critical as often several dynamic sequences are acquired sequentially allowing to choose the optimal coverage. Nevertheless, due to cost and quality assurance factors an optimization of the contrast volume is certainly recommended.

The aim of the study was to compare the contrast-enhanced MRA of the carotid arteries with single- versus double-dose gadolinium. Besides the assessment of various qualitative variables, signal-to-noise and contrast-to-noise ratios were evaluated as quantitative indicators for image quality and correlated to the injected volume.

Material and Methods:

A total of 120 patients (mean age 64,8; range 23 to 98y) were included according to clinical criteria and underwent a contrast-enhanced carotid MRA. Randomization was done according to the referral: single-dose in cases of MRI of the brain, double-dose in case of a suspected vascular pathology of the extracranial arteries. MR Imaging was performed on a Siemens Sonata 1.5T with head/neck/spine array coils. T1-w 3D-GRE coronal images covering the arteries from the arch to the skull base were acquired within 19s acquisition time (linear K-space sampling, voxel size=1.2x0.8x0.9mm^3). The contrast administration was performed according to a standardized protocol (delay time with CARE-bolus) with patients receiving i.v. either a single-dose (n=57; 0,1 mmol/kg BW) or a double-dose (n=63; 0,2 mmol/kg BW) of 0.5 molar Gd-DOTA (Dotarem®, Guerbet, Roissy, France) followed by 30ml saline flush (flow-rate=2-3ml/s). Grade of stenoses were staged on single-slices, MIP-images or AVI-movies. Regions of interest for the evaluation of SNR or CNR were standardized with 0.25cm^2 for the muscle, noise and carotid artery itself. MR image quality scored on a five-point scale and diagnostic accuracy were compared for both dose groups. This prospective, clinical study had been approved by the ethical committee of our institution.

Results:

Both dose groups didn't differ significantly regarding descriptive statistics (sex p=0.27; age p=0.09 and weight p= 0.39). All MRA studies were diagnostic and covered dose-independently the area of interest (Fig. 1). Image quality, rated as good or excellent in all cases, didn't differ significantly between single- and double-doses. Overall, the mean CNR for the single-dose group resulted in 68.98 (± 19.7 SD) whereas for the double-dose group it was 63.89 (± 20.5 SD), which corresponds to no significant difference using t-test (p=0.81). The 95% confidence interval lies between -8 to +6. Multiple regression analysis of the weight dependant dose in relation to the resulting CNR demonstrates a significant lower CNR for patients with a higher weight for both dose groups (Fig. 2). CNR measurements at different localizations of the carotid arteries showed higher values in the internal carotid arteries compared to the origin of the common carotid artery. Results of MRA revealed significant stenoses (> 70%) in 29/120 patients which correlated well with duplex sonography (k=0.77).

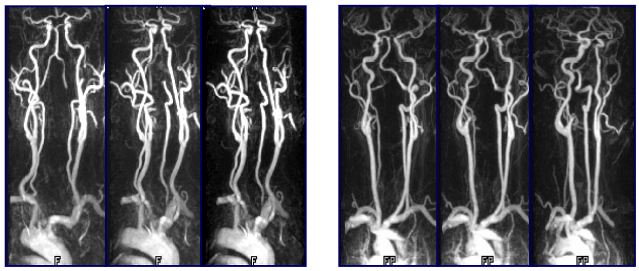

Fig. 1: Non-pathologic contrast-enhanced carotid MRA performed with single dose (left) and achieved with double dose (right). No significant difference of image quality could be seen.

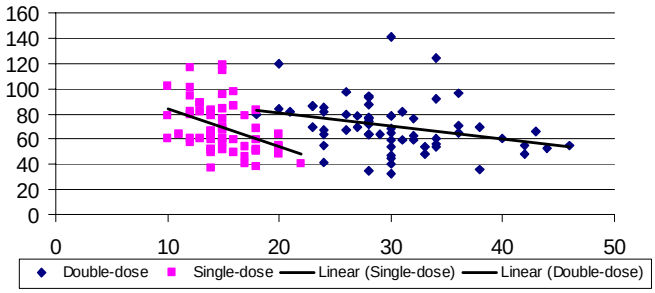

Fig. 2: Intraarterial CNR values for single- and double-dose CE-MRA of the carotids (n=120)

Discussion:

In our series overall qualitative and quantitative image parameters did not differ significantly between both dose groups, even though the mean values of CNR were slightly higher for the double-dose group, especially if one compares the subgroup with higher weight. As both dose-groups had the same injection rate (3ml/s), one might conclude, that the prolongation of injection time in case of double-dose didn't influence the measured parameters. The question if higher flow-rates, especially in case of double-dose lead to higher CNR's remains to be assessed clinically. Unexpectedly even though heavier patients receive higher gadolinium volumes compared to patients with lower body weight, CNR is still significantly reduced within both dose-groups. This could reduce diagnostic quality. Apparently the CNR influencing factors like extravascular diffusion during the pulmonar first-pass, cardiac output and hemodynamic factors have a weight dependant relationship, which is insufficiently corrected in linear dose-curves.

Conclusion:

Diagnostic performance and all image quality parameters of single-dose carotid MRAs are comparable with double-dose. Nevertheless, CNR as a quantitative parameter is significantly lower in heavier patients for both dose-groups. Therefore the only subgroup which could potentially benefit from higher dosing are patients with higher body weight, which still must be confirmed clinically.