Introduction: Recent years have seen increased concern about using multiple doses of contrast agent in clinical research studies. This concern has had an impact on stroke clinical trials. The ideal MRI assessment for stroke trials would involve two contrast enhanced studies. One contrast agent administration would be used for contrast enhanced MRA (vascular assessment). The second would be performed as part of a DSC assessment of microvascular perfusion and permeability. Concerns related to gadolinium exposure have generated renewed interest in the feasibility of lowered dose DSC microvascular assessment. While early DSC studies were typically performed with double or triple doses of a contrast agent, it is now more common to use a single (0.1 mmol/kg) contrast agent dose for DSC. We hypothesized that it is possible to acquire a DSC perfusion study for stroke assessment using half the normal dose of contrast agent (0.05 mmol/kg). As a preliminary investigation to support the study of lowered dose DSC studies in patients, we evaluated feasibility of half dose DSC in six normal adult subjects. We also used software to simulate realistic bolus passage data over the entire range of normal and pathophysiological CBV and CBF for normal and half dose conditions.

Methods: Six normal adult subjects underwent a half dose and a normal dose DSC study during a single imaging session. Gadopentate dimeglumine was used as a contrast agent. DSC imaging was performed with a 1.5 T Siemens Vision scanner. A gradient echo planar pulse sequence was used to acquire a dynamic series of T2*-weighted images (slice thickness 7 mm, time resolution 2.0 sec, TE 45). DSC data were processed by custom-written software. Dynamic image intensity was converted to dynamic concentration in the customary fashion. Arterial input functions (AIFs) and venous outflow functions (VOFs) were selected manually using morphological and dynamic signal characteristic criteria. The VOF was used to correct the AIF for partial volume effect. The corrected AIF was inverted using truncated singular values decomposition (filter of 0.15). The dynamic concentration data and the inverted AIF were used to compute a series parametric images which included CBV and CBF. CBF was calculated as the initial value of the deconvolved residue function. Custom-written DSC simulation software simulated bolus passage over the entire range of CBV and CBF values that are typically seen in normal subjects and stroke patients. The normal human data were used to obtain representative values of arterial inputs for both contrast agent doses. The simulation software produced a time series of simulated images which were then analyzed using the same software used to analyze the human data.

Results: The CBF images (Figure 1) illustrate that half dose protocols produce CBF data nearly equivalent to normal dose protocols, although there is a small bias toward lower CBF readings for the half dose studies. The half dose CBF images also have slightly worse noise characteristics. Arterial passages (Figure 2) had virtually identical mean full widths at half maximum (FWHM) values (half dose: 7.3 ± 1.6 sec v. normal dose: 7.2 ± 1.6 sec) for the two dose protocols. CBF images derived from simulated bolus passage (Figure 3) were used to assess feasibility of half dose for slowed (penumbral) flow associated with stroke. These results show the half and normal dose passages give similar penumbral CBF readings but the half dose results have modestly increased variance (due to noise).

Conclusions: The potential for half dose (0.05 mmole/kg) DSC studies appears to be quite realistic for stroke imaging. The principal limitation is noise that is most pronounced at low CBF and CBV. These studies were done under relatively conservation conditions (1.5 T and modest dynamic time resolution). Performance in more modern 3 T scanners is anticipated to be better.