Validation of a Standardization Technique for Brain Tumor rCBV Maps and Post-Contrast Anatomic Images

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Introduction Dynamic susceptibility contrast (DSC) magnetic resonance imaging (MRI), has demonstrated the potential to evaluate functional changes in rCBV (relative cerebral blood volume) caused by brain tumor angiogenesis. One of the main limitations faced in using (non-quantitative) rCBV measurements to evaluate primary brain tumors, is that the rCBV values for the same tissue type such as WM (white matter), GM (gray matter) or tumor can vary significantly across studies due to slight differences in system stability or contrast agent dose administered. As a result, most studies report rCBV values as normalized to WM or contralateral brain. Outlining regions of interest (ROI) for normalizing rCBV values is time consuming and subjective in nature thereby introducing variability. As a solution we have investigated application of a standardization method for rCBV and T1+C maps [1, 3]. In this study we attempt to validate the standardization technique. We test the hypothesis that standardization of rCBV maps and T1+C measurements accurately translates these values to a scale standard over tissue types, scanners and subjects without corrupting the informational content of the processed maps. This approach has tremendous potential to become part of the routine clinical workflow as it enables easy and accurate visual comparison without the need to draw ROIs for normalization. This is significant for the clinical longitudinal evaluation of perfusion studies.

Data Acquisition All MRI studies were performed on either a 1.5T GE Signa System fitted with a 12" local gradient coil and a quadrature transmit-receive birdcage RF coil (IGC-Medical Advances, Milwaukee, WI) or a 1.5T GE CV Scanner. A 0.10 mmole/kg dose of Gadodiamide (Omniscan; Nycomed Amersham, Princeton, NJ) was administered to diminish T1 effects that might result from agent extravasation. Next, GE EPI images were acquired for 1 minute before and 2 minutes after a 0.1 mmole/kg bolus injection. Twelve 5 mm thick slices were acquired with TE/TR = 30ms/1100ms, fat suppression ON and matrix size = 128x128. Finally, post-contrast T1 images were acquired (SE, TE/TR = 4.668ms/34ms, matrix = 256x256).

Data Analysis The rCBV maps were corrected for contrast agent leakage effects as previously described [2] and then normalized to normal appearing WM. The rCBV maps and T1+C images were also standardized using the previously reported routine [2, 3]. Previously, we have reported improved discrimination between and reduced coefficient of variation for WM-T1+_C and GM-T1+C images post standardization [1] and improved tumor grade classification with STDrCBV measurements in compared to NRMrCBV measurements [3]. In this study we validate our technique and explore it potential for use in the clinical settings.

Results and Discussion Figure 1 demonstrates a linear relationship (r = 0.99) between values for STDrCBV and NRMrCBV maps and also for T1+C and STD-T1+C maps for normal brain and tumor regions thus demonstrating that relationship between image voxel values is maintained with standardization. The images shown in Figures 2 and 3 show that the image content is not altered by standardization. However, as reported earlier [1], we observe improved delineation between WM and GM in T1+C images post-standardization. Table 1 and Figure 4. demonstrate that like normalization the standardized maps decrease variability across study dates in comparison to the original (non-normalized or standardized) rCBV maps. From these results we conclude that standardization technique not only produces better delineation between tissue types but also translates image values into a standard scale which accurately represents the original contrast, thus enabling objective visual comparison between patients and dates. From a clinical standpoint standardization will prove very helpful to the radiologists as it makes it unnecessary to subjectively change windowing and contrast on a per-case basis.

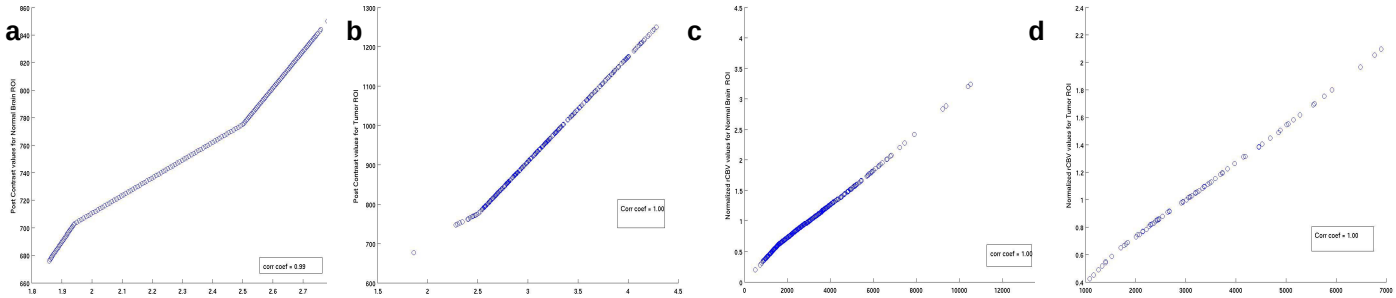

Figure 1. a) T1+C vs. STD-T1+C for normal brain region (r = 0.99) b) T1+C vs. STD-T1+C for tumor region (r = 1.00) c) NRM-rCBV vs. STD-rCBV for normal brain region (r = 1.00) d) NRM-rCBV vs. STD-rCBV for tumor region (r = 1.00)

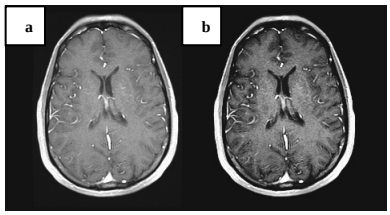

Figure 2. a) T1+C b) STD-T1+C

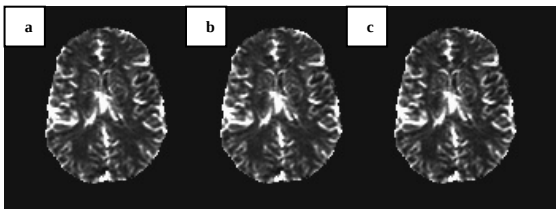

Figure 3. a) rCBV b) NRMrCBV c) STDrCBV

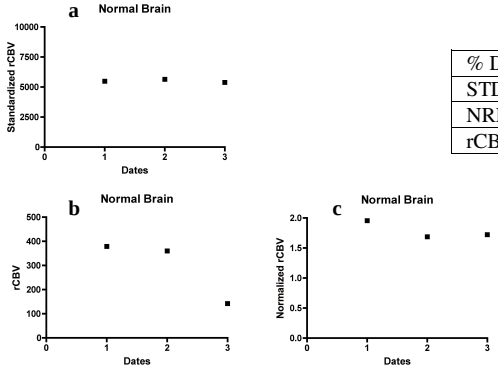

Figure 4. a) STD rCBV b) rCBV c) NRMrCBV values for Normal Brain (GM+WM) for a subject scanned over 3 dates.

% Difference	D2-D1	D3-D2
STDrCBV	2.73	-4.77
NRMrCBV	-15.89	2.08
rCBV	-5.25	-153.21

Table 1. Percentage difference in perfusion measurements between days

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[3] Bedekar D., Jensen T. R., Schmainda K. M., Standardization decreases interpatient differences in rCBV as a function of brain tumor grade, ISMRM 2007