Purpose: Dynamic contrast-enhanced (DCE) and dynamic susceptibility-contrast (DSC) MRI have their own advantages and limitations in the assessment of tumor physiology (1, 2). Few studies of intra-operative MRI for more precise brain tumor resection have employed the DCE (iDCE) and DSC (iDSC) techniques (2). With the nature of this two techniques, one may expect that DSC provides better SNR in mapping cerebral blood volume (CBV) while DCE offers additional information on vessel permeability. Another consideration specific to intra-operative MRI is that the operation-associated blood and trapped air may cause susceptibility artifacts that distort the iDSC results. Such problem may be mitigated by the T1-weighted image acquisition in iDCE. Our goal is to perform qualitative and quantitative comparisons between the two techniques as applied in brain tumors.

Materials and Methods: Three patients sustained intra-axial brain tumors underwent intra-operative MRI studies shortly after surgical resection. The MRI scans were applied with a 1.5 T Magnetom Espree scanner (Siemens, Erlangen, Germany) in the operation room. To obtain the baseline T1 maps, a 3D-FLASH sequence with varied flip angles was applied before the contrast injection, with TR/TE = 4.5/1.96 ms, flip angle = 2, 5, 10, 20, 30 degrees, field-of-view (FOV) = 256 mm x 256 mm, matrix size = 256 x 128 or 128 x 128. The same sequence and parameters with a fixed flip angle of 30 degrees, was used for the T1-weighted DCE-MRI. Sixty dynamic phases were acquired during a total acquisition time of 5 min, with a sampling interval of 5 s.

The mTK model was used to quantify the volume transfer constant ($K_{trans}$), the volume fractions of the blood ($V_p$) and the extravascular extracellular space ($V_e$), where

$$C_1(t) = V_p C_p(t) + K_{trans} \int C_2(t) e^{-\frac{t}{\tau}} dt$$

The arterial input function, $C_p$, was measured from the internal carotid artery. For each scan, a bolus of 0.1 mm/kg Gd-DTPA (Magnevist, Schering, Berlin, Germany) was injected through an antecubital vein of the patients using a power injector with an injection rate of 4mL/s. Post-contrast T1-weighted images were acquired between the two dynamic scans using a conventional spin-echo sequence. The DSC-MRI was applied using a dynamic single-shot gradient-echo EPI sequence with TR/TE/FA = 1500 ms/40 ms/90°; acquisition matrix = 128 x 128, and FOV = 230 mm × 230 mm. Sixty phases were acquired with a total acquisition time of 90 seconds. Considering possible leakage of contrast agent, the Weisskoff model (4) was applied to the DSC-MRI data analysis:

$$\Delta R_1^*(t) = K_2 \Delta R_1(t) + K_2 \int \Delta R_1(t) dt$$

where $\Delta R_1(t)$ is the mean normal tissue time curve, and $K_2$ is a permeability-related parameter. The corrected $\Delta R_{2,cor}^*(t)$ was defined by:

$$\Delta R_{2,cor}^*(t) = K_2 \Delta C_1(t) + K_2 \int \Delta R_1(t) dt$$

which used to calculate the relative CBV. The $V_p$ and CBV normalized to a white matter ROI ($nV_p$ and $nCBV$), $K_{trans}$ and $K_2$ values were determined for normal tissue and tumor regions for comparisons of the two techniques.

Results: Figure 1 demonstrated that regions with distortions in iDSC-MRI-derived nCBV map (c) were significantly improved by iDCE-MRI. iDCE-MRI provided blood volume map (b) with similar contrast but nosier appearance than the iDSC(c). For quantitative comparisons, Table 1 shows no statistical difference between the mean $nV_p$ and nCBV in the three regions of normal brain tissues. Figure 2 illustrated that iDCE-MRI derived $K_{trans}$ map was more representative of permeability and correlated better with the extent of enhancement pattern seen on post-contrast T1-weighted image, whereas $K_2$ map reflected the mixed edema change and permeability, presumably related to the artifact inevitably present in the intra-operative MRI.

Conclusion: The findings of the better representative of permeability by $K_{trans}$ map and less image distortions are arguably for iDCE-MRI to be more valuable for the clinical need of intra-operative assessment of sufficiency of tumor resection. In addition, that no discrepancy between the $nV_p$ and nCBV values is suggestive of the comparative capability of the parameters derived from DCE-MRI in terms of assessing the tumor physiology, long biased on DSC-MRI results.