Quantitative Analysis of DCE-MRI Parameters K_{trans} and v_L in Intracranial Aneurysms

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Purpose The clinical significance of intracranial aneurysm (IA) wall permeability to contrast agent and the interobserver variability in measuring quantified k_{trans} and v_L metrics have not been explored. The purpose of this study was to determine whether dynamic contrast enhanced (DCE) MRI could quantify IA wall permeability, how it correlated with established metrics of rupture risk, and the reproducibility of measurements between two observers.

Methods Twenty-seven IAs in 24 patients were imaged with DCE-MRI, and wall permeability parameters (k_{Trans} and v_L using Tofts' Model (1)) were measured in regions adjacent to the aneurysm wall and healthy normal vessels by two independent reviewers. Interobserver strength of agreement was compared using intraclass correlation, Bland-Altman, and regression analysis. Aneurysms were sorted into ISUIA-determined, size-associated risk bins to assess correlation of k_{Trans} with size. A second risk paradigm used size-independent clinical criteria (progression to rupture, symptomatic presentation, dome irregularities) to sort and compare aneurysms. The two-sample t-test was used to compare mean k_{Trans} and v_L for each risk paradigm. Adjustments for multiple comparisons utilized Tukey's studentized range test.

Results Interobserver agreement was strong as shown in regression analysis (R^2=0.93), bland altman (mean bias = 0.005 min^{-1}), and intraclass correlation (0.93). In all IAs (Figure1a), there was a pronounced increase in wall permeability compared to a paired healthy normal vessel (k_{Trans} – 0.1778 vs. 0.0083 min^{-1}, p<0.001; v_L – 12.7 vs. 4.84%, p=0.0019). K_{Trans} was found to be significantly larger in progressively larger ISUIA-determined, size-based risk categories (Figure 1b-c). Furthermore, k_{Trans} was significantly larger in high risk versus low-risk IAs when risk was determined using a size-independent and clinically-based paradigm. Size did not show a statistically significant trend in this clinical risk assessment scheme.

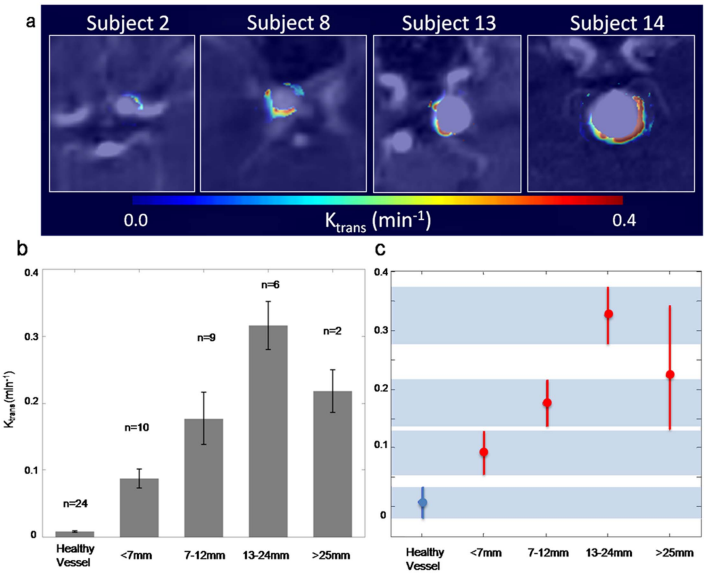

Figure 1 - **(a)** Aneurysms were found to have a broad range of wall permeability values. As this figure shows, k_{Trans} values varied from 0.1 to 0.5 min^{-1} over a 6-22 mm range of dome sizes in the subjects. K_{Trans} increases with larger ISUIA-determined size/risk bins as shown in the bar plot in **(b)**, with error bars representing standard errors. In **(c)** the mean for each group is shown as the filled circle with the Tukey adjusted confidence interval as the solid bar passing through the circle. The borders of the confidence intervals for each aneurysm size bin is visualized with the blue shaded regions.

Discussion/Conclusions

We found that quantitative permeability modeling of IAs is feasible and observer ROI measurements are repeatable. Increased wall-permeability in intracranial aneurysms correlates with size and clinical rupture risk metrics. DCE-MRI studies on IAs may provide useful clinical information especially for longitudinal study of patients.

References: 1) Tofts et al, MRM 1995 2) Tofts et al MRM 1989