# Assessment of bowel inflammation in Crohn's disease by using quantitative dynamic contrast enhanced MRI

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**Introduction:** Crohn`s disease is a chronic inflammatory disease of unknown origin affecting the entire gastrointestinal tract with a remitting and relapsing course. Quantitative analysis of dynamic contrast enhanced MRI (DCE-MRI) is a widely accepted reliable technique for evaluating vasculature and vascular changes during therapy. The purpose of this study was to evaluate the feasibility of quantitative analysis of DCE-MRI in detection of bowel inflammation in patients with Crohn`s disease and compare the results of quantitative analysis based on two-compartmental model (TCM) [1] with semi-quantitative analysis parameters and the results of an empirical mathematical model (EMM) [2].

**Material and Methods:** Eleven patients who had undergone MR enterography (including DCE-MRI) for known or suspected Crohn`s disease and had colonoscopy or surgery within 4 weeks of MR examination were recruited. DCE-MRI data were acquired using a 1.5T scanner with temporal resolution of 5 - 12 sec for approximately 5 min after contrast imjection. The data were fit using the two compartment model to obtain the volume transfer constant ($K^{trans}$) and extravascular extracellular space per unit volume of tissue ($v_e$). The same DCE-MRI data was also analyzed by using an empirical mathematical model (EMM) and semi-quantitative parameters - initial area under the curve (IAUC, @ 1 min), Initial enhancement slope ($slope_{ini}$), and time to peak ($T_{peak}$), were derived from the EMM fitted data. Endoscopy, surgery and pathology results served as the gold standard for evaluation of MRI data. Receiver operating characteristic (ROC) analysis was performed to compare the diagnostic utility of the parameters.

**Results:** 51 bowel segments (19 with inflammation, 32 normal) were included in the analyses. **Fig. 1** shows plots of contrast media concentration as a function of time for a typical normal and Inflamed bowel. The curves fitted with the TCM (red line) and the EMM (green line). The average values for the TCM, EMM and derived parameters for normal and inflamed bowel were calculated and summarized in **Table 1**. The inflamed bowel segments were characterized by fast volume transfer rate ($K^{trans}$), large EES volume ($v_e$), high contrast uptake (*A*), a large value of the IAUC, and steep enhancement slope compared to normal bowel ($p < 0.05$ by t-test). The Az values from ROC analysis (**Fig. 2**) for the parameters $K^{trans}$, $v_e$, *A*, $slope_{ini}$, and **IAUC** were 0.71, 0.80, 0.82, 0.86 and 0.86 respectively.

**Discussion:** The results demonstrate that several parameters derived from DCE-MRI data for normal and inflamed bowels were significantly different by t-test. However, there was substantial overlap in kinetic parameters for normal and inflamed bowels. This overlap may be reduced if contrast media washout is sampled for a longer time after injection. Both the TCM and the EMM provided adequate fits to the contrast concentration curves, but EMM fits were somewhat more accurate (see Table 1). Without the EMM fits to experimental data, semi-quantitative parameters could not be accurately obtained due motion and noise in the data. The Az values for initial slope and IAUC were fairly high, suggesting that these parameters have clinical utility. The present results come from a small number of patients, and a much larger clinical study is required to evaluate the clinical utility of DCE-MRI for evaluation of Crohn's disease.

[1] Fan et al. MRM 2004;
[2] Tofts JMRI 1997.

**Figure 1**



**Figure 2**
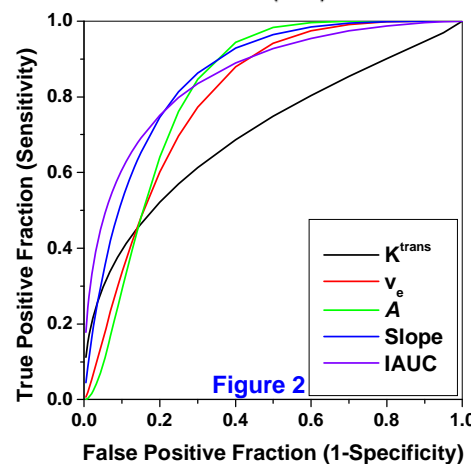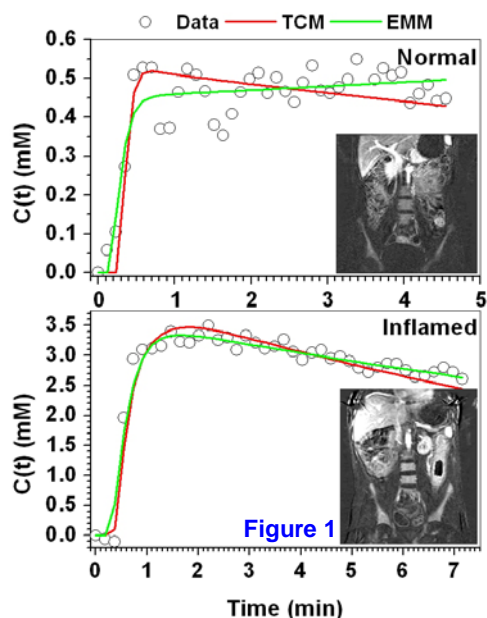
| Table 1 | $K^{trans}$ (min$^{-1}$) | $v_e$ | $R^2_{TCM}$ | A (mM) | q | α (min$^{-1}$) | β (min$^{-1}$) | $R^2_{EMM}$ | IAUC (mM·min) | $T_{peak}$ (min) | $Slope_{ini}$ (mM/min) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Normal** | 0.50 | 0.25 | 0.76 | 1.69 | 2.5 | 3.51 | 0.034 | 0.80 | 0.85 | 3.0 | 1.32 |
| **inflamed** | 0.81 | 0.36 | 0.80 | 3.21 | 1.6 | 3.33 | 0.026 | 0.89 | 1.70 | 3.9 | 2.56 |
| **p-value** | 0.05 | 10$^{-3}$ | 0.46 | 4×10$^{-3}$ | 0.07 | 0.81 | 0.77 | 0.02 | 0.0002 | 0.18 | 0.001 |