# Measurement of Point Infusion Fluid Flow in Hydrogel Using Phase Contrast MRI

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## Introduction

Phase contrast (PC) MRI can capture fluid flow in real-time without the use of a contrast agent. In this study, we used this technique for the first time to capture the flow generated due to point infusion of a tracer into the hydrogel. This has implications for therapeutic drugs delivered directly into the tissue (e.g. brain) for treating diseases such as epilepsy [1]. In order to effectively administer such therapies, it is important to understand the underlying flow dynamics in tissue so that the drug could be concentrated in a targeted tissue. Further, the tracer distribution over time could be predicted by combining the convective velocity field vectors obtained using PC-MRI with mathematical models for drug transport [2].

## Experimental

MR experiments were performed on a Agilent 11.1 T magnet. In our measurement, the 3D velocity field resulting from the point infusion of Gd-Albumin at 0.5µL/min in 1% hydrogel was obtained using a Hadamard scheme [3] with a velocity encode value of 0.5 mm/s ($G_{bipolar}$ = 4 G/cm and $t_{bipolar}$ = 24 ms) chosen based on the infusion flow rate, cannula diameter and gel composition.

## Results and Discussion

The results indicate the flow was largely two-dimensional along phase-slice axis, with maximum velocity near the cannula tip, and a quadratic decay away from the infusion site, (see line plot in Fig. 1). These results seem to agree with the known physics of such flows. It is well known that the infusion into a porous media generates a cavity close to the needle tip from which the infusate is delivered [4]. The size and shape of the cavity depends largely on the properties of the porous media and needle type. Assuming a spherical cavity, the mass and momentum conservation equations could be solved simultaneously to show that velocity drops quadratically from the infusion site. The measured flow being largely 2D might suggest that the cavity created by this flow was not spherical due to backflow.

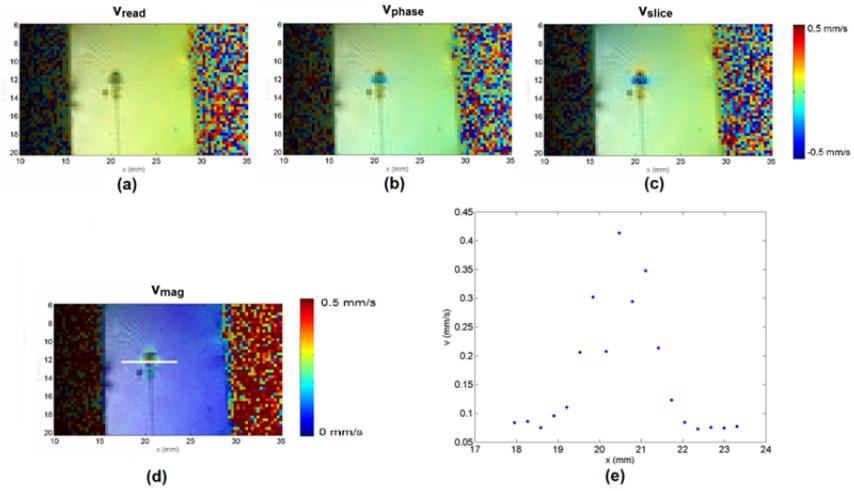


Figure 1: 3D velocity map with Venc= 0.5 mm/s during tracer infusion overlaid with the MR magnitude image to show the infusion cannula: Velocity components along (a) read (along the length of the hydrogel tube, 'y'), (b) phase (across the hydrogel tube, 'x'), and (c) slice (out of the screen, 'z') directions. Also shown are (d) velocity magnitude and (e) line plot of velocity magnitude for the horizontal white line shown in (d).

## Conclusions

The MR technique successfully captured the slow flows generated due to local infusion in hydrogel. In the future, the study would be further extended to flows in rat brain.

## Acknowledgements

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## References

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