Introduction to Project 5: MRI Measurements of Perfusion

Quantitative and Functional Imaging

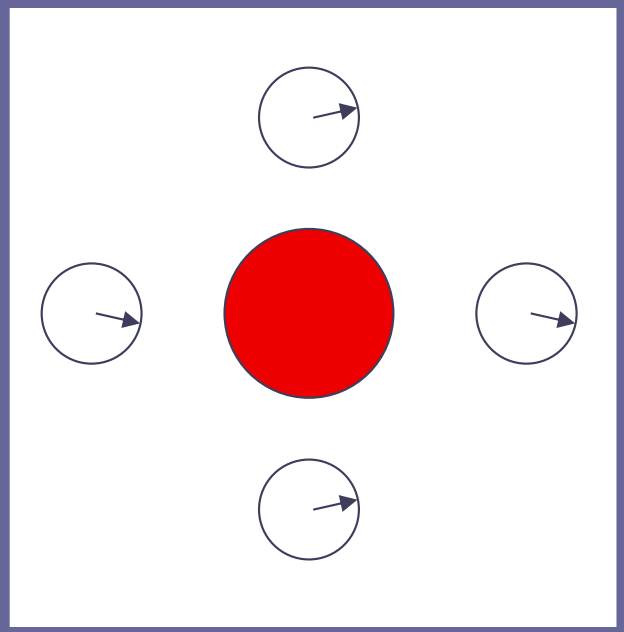
BME 4420/7450

Fall 2022

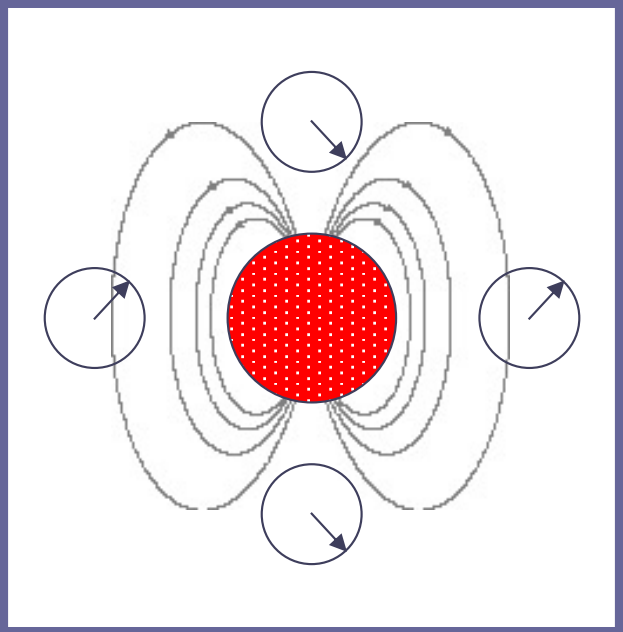
Review: magnetic susceptibility contrast agents

- Large magnetic moment
  - Gadolinium (7 unpaired electrons)
- Increase relaxation rate of neighboring water molecules
  - T_1 relaxation (M_z)
  - T_2 relaxation (M_{xy})
- When confined to vessels, concentrated magnetic moments shift the field around the vessels

Magnetic field surrounding a vessel



B_0



Normal blood

Blood with contrast agent

Capillary networks

Buxton, 2002

Dependence of relaxation rate on tissue contrast agent concentration

- Relaxation rate is the inverse of the time constant

$$R_2^* = \frac{1}{T_2^*}$$

$$R_2^*(\text{with contrast}) = R_2^*(\text{without contrast}) + \Delta R_2^*$$

- Tissue relaxation due to contrast agent

$$\Delta R_2^* = k \cdot C_T(t)$$

- Signal intensity prior to contrast agent injection

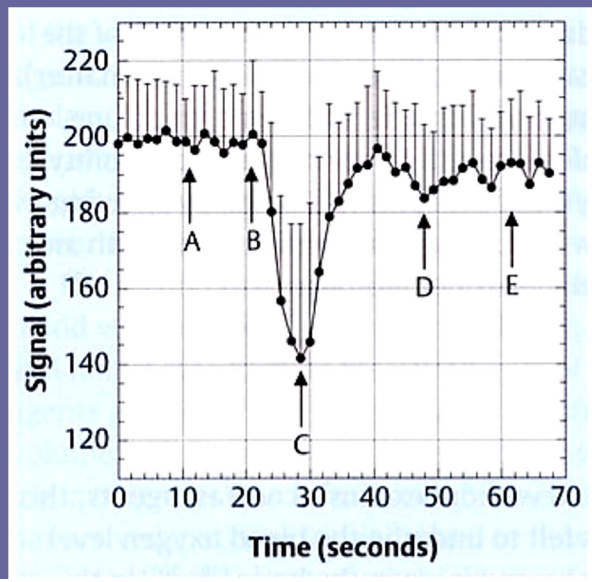
$$S_0 = A \cdot e^{-T_E \cdot R_2^*(\text{no contrast})}$$

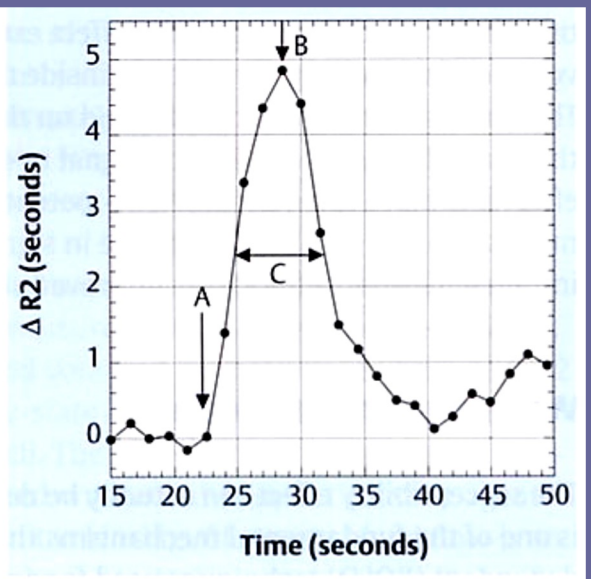
- Signal intensity with contrast agent

$$\begin{aligned} S &= A \cdot e^{-T_E \cdot R_2^*(\text{contrast})} \\ &= A \cdot e^{-T_E \cdot R_2^*(\text{no contrast})} \cdot e^{-T_E \cdot \Delta R_2^*} \\ &= S_0 \cdot e^{-T_E \cdot \Delta R_2^*} \end{aligned}$$

Image analysis

- Find signal time course in a region of interest (ROI)
- Identify the baseline (pre-contrast R_2^*)
- Convert signal changes to R_2^* changes





$$\Delta R_2^* = -\frac{\ln(S/S_0)}{TE}$$

Sorensen, 2000

Image analysis

- Find signal time course in a region of interest (ROI)
- Convert signal changes to R_2^* changes
- Identify the baseline (pre-contrast R_2^*)
- Integrate the changes in R_2^*

$$CBV = \frac{\int_0^\infty C_T(t)dt}{\int_0^\infty C_A(t)dt} = c \cdot \int \Delta R_2^*(t)dt$$

Same for all voxels

Project 5 Goals

- Measure image intensity changes in an ischemic region of interest (ROI) in the brain of a stroke patient
- Estimate the mean cerebral blood volume (relative CBV= rCBV) in the ROI

$$\Delta R_2^* = -\frac{\ln(S/S_0)}{TE}$$

$$rCBV = \int \Delta R_2^*(t)dt$$

  - Is this significantly different from healthy tissue?

Problem #1: data visualization

- How good are the data?
  - Contrast
  - Noise
  - Artifacts
- Check the image time course visually
- Show images in a movie

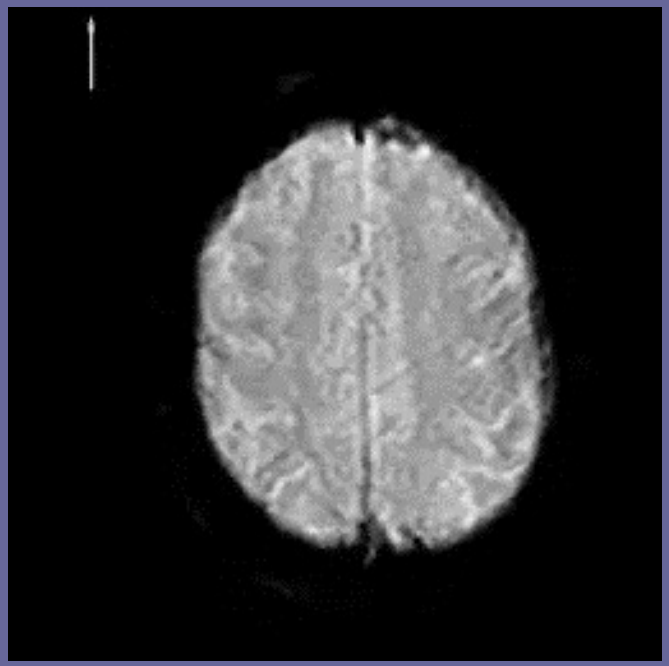
Making movies

- Assemble images into a movie:

```
for j = 1:n
        <display image>
        F(j) = getframe;
end
movie(F)
```

Problem #2: what is a normal rCBV?

- We need to compare rCBV in the stroke region to a normal rCBV
  - Where can we get this?



Sorensen, 2000

Problem #2: what is a normal rCBV?

- We need to compare rCBV in the stroke region to a normal rCBV
  - Where can we get this?
- Compare to a similar region in the opposite hemisphere