Effects of cells and proteins on cerebrospinal fluid MRI FLAIR signal

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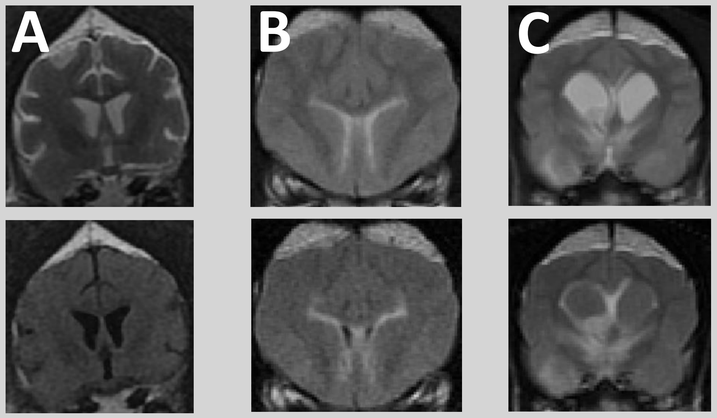
What is MRI FLAIR?



FLAIR MR images: T2 (top) and FLAIR (bottom) images. (A) Normal CSF nulls on FLAIR. (B) T2 periventricular hyperintensity, as in the case of edema, does not null on FLAIR. (C) Abnormal CSF does null on FLAIR.

- Fluid-attenuated inversion recovery (FLAIR) magnetic resonance imaging (MRI) nulls the signal from normal cerebrospinal fluid (CSF).
- CSF can become hyperintense during disease because of an increase in protein and/or other contaminants. To date, studies have focused on protein's effects on FLAIR signal[1,2].
- Our study is the first to examine the relationship between white blood cell concentration and FLAIR MRI signal.

Methods

In vitro study: prospective, experimental

- **Sample acquisition**:
  - Protein derived from bovine plasma
  - White blood cells (WBC) isolated from bovine whole blood using red cell lysis buffer
  - Commercially available bovine albumin and immunoglobulin used to assess individual protein effects.
- **Plate design**: full factorial design (below) with CSF analog as our diluent. We additionally filled plates with various concentrations of albumin and immunoglobulin. We took FLAIR MRI of the plates.

Factors	Levels
White blood cells (cells/µL)	**1, 10, 10^2, 10^3, 10^4**
Proteins (mg/dL)	**4.71, 23.5, 118, 588, 2940**

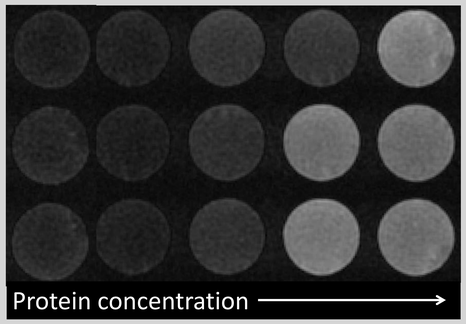
In vivo study: retrospective, observational

- **Data collection:** feline and canine patients; clinical diagnosis, CSF MRI FLAIR signal intensity, CSF analysis protein and WBC concentration

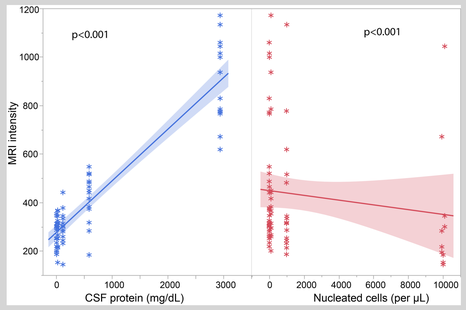
Statistics: ANOVA and Tukey's post-hoc test

Results: Protein but not cells affect signal

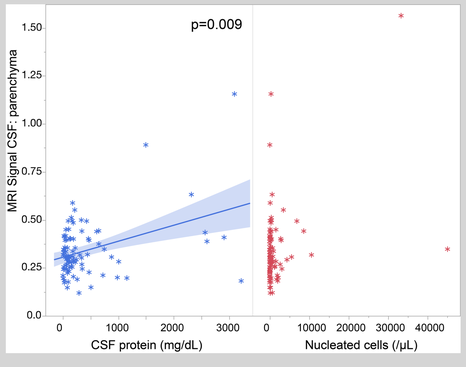
Plate MRI: FLAIR images of our plates showed increasing signal as protein concentration increased. Each well also contained various WBC concentrations.



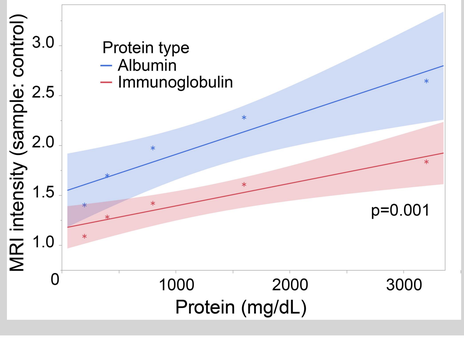
***In vitro* results**: Protein and WBC concentration had a significant correlation with FLAIR signal. Protein concentration had a positive correlation with signal, whereas WBC concentration had a negative correlation.

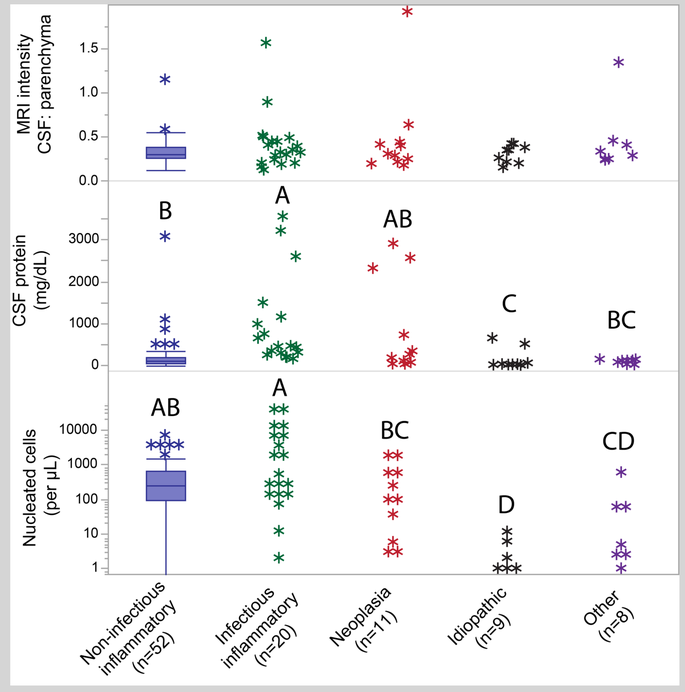


***In vivo* results**: Protein concentration had a significant positive correlation with FLAIR signal intensity. However, we did not find that WBC concentrations were significantly correlated with our response variable (p=0.611).



Protein type results: Albumin and immunoglobulin were statistically different from each other, with albumin having an overall higher FLAIR signal intensity than immunoglobulin.





Disease categories: CSF protein concentrations (p<0.001) and CSF WBC concentrations (p<0.001) differed among disease categories. However, CSF FLAIR MRI signal did not differ among disease categories (p=0.652).

Conclusions

- MRI FLAIR does not differentiate diseases.
- When MRI FLAIR CSF hyperintensity is seen clinically, increasing protein is the more likely contributor than increasing cell count.
- Even though albumin had a greater effect on signal intensity than immunoglobulin, the difference may not be clinically relevant.
- Cell concentration may have had a negative effect on FLAIR signal because of hemoglobin contamination. Hemoglobin is known to strongly shorten T2 relaxation times, decreasing overall signal[1].

Acknowledgements

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References

1. Melhem, E.R., H. Jara, and S. Eustace, *Fluid-attenuated inversion recovery MR imaging: identification of protein concentration thresholds for CSF hyperintensity.* AJR Am J Roentgenol, 1997. **169**(3): p. 859-62.
2. Stuckey, S.L., et al., *Hyperintensity in the subarachnoid space on FLAIR MRI.* AJR Am J Roentgenol, 2007. **189**(4): p. 913-21.