# DC MEG Indicators of Tumor Growth and Chemotherapy in Rat Model

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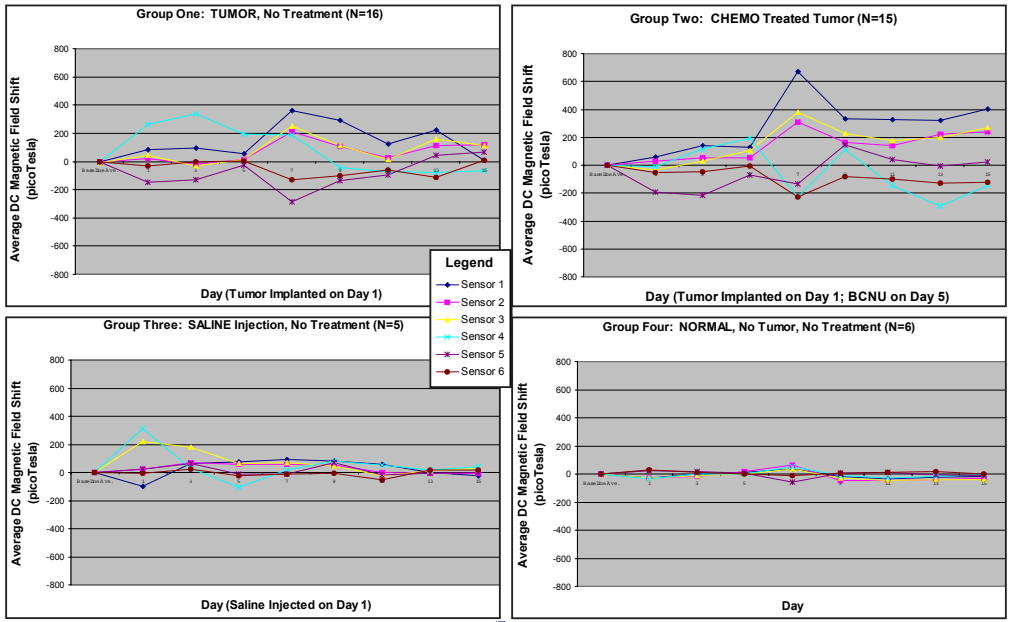
**Objective:** The objective of this longitudinal study was to determine if DC MEG can detect injury currents from tumor growth and chemotherapy in an animal model.

## Background

Injury currents arise from ion leakage across cellular membranes in traumatized cells. These injury currents, resulting from the gradient potential causing cation entry into the negatively charged intracellular compartment, decay slowly providing a 'near DC' magnetic field. Direct Current Magnetoencephalographic (DC MEG) recordings of nerve and muscle injury currents have been measured noninvasively in rats and human specimens using SQUID (Superconducting Quantum Interference Devices) detectors [1]. Tumor growth leads to injury to surrounding tissue. We measured the magnetic fields arising from injury currents developing during tumor growth in rats injected with gliosarcoma cells.

Measurement of treatment efficacy is a challenge in both research and clinical applications. For this reason, we also measured magnetic fields arising from tumored rats that received chemotherapy, anticipating injury currents developing from tumor injury in response to treatment.




## Results

DC MEG shifts were seen in the Tumor No Treatment and Chemotherapy Treated Tumor animals, Groups One and Two. In these groups, the field shifts continued until sacrifice. The Saline control animals (Group Three), showed lower amplitude DC MEG shifts that resolved when the animals recovered around Day 7 post surgery. No DC shifts were seen in the Normal control animals (Group Four). No significant DC shifts were seen in Group Five, the BCNU treated rats with no tumor. The location of the MEG sensors relative to the tumor location are shown in Figure 1. Statistically, the differences between Tumor No Treatment and Normal as well as Chemo Treated Tumor and Normal groups were significant for all Sensors. Differences between Tumor and Saline groups were significant in all but Sensor 3 beyond Day 7 post surgery. Significant differences are seen in all Sensors between Chemo Treated Tumor and BCNU No Tumor groups.

## Conclusion:

DC shifts in Group One and Group Two suggest continued injury currents due to changes in potentials in the brain.

DC MEG can be used to study and measure changes due to injury currents arising from tumor growth and treatment in rats.

Thus DC MEG may have use as a noninvasive marker in clinical applications for evaluating tumor growth and tumor response to treatment.

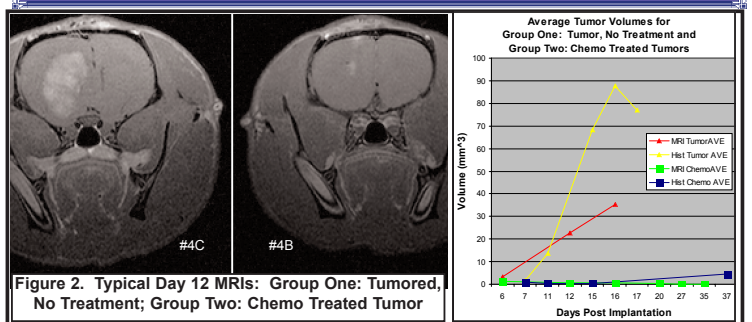


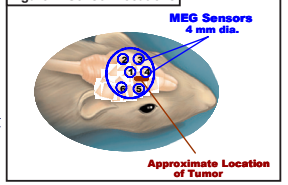

Figure 2. Typical Day 12 MRIs: Group One: Tumored, No Treatment; Group Two: Chemo Treated Tumor

Tumor Volumes - Group One Tumor No Treatment vs. Group Two Chemo Treated Tumors

## Methods

Male Fisher rats (200-225 g) were implanted with tumor, 50,000 9L gliosarcoma cells in a 5microliter volume, or with an equivalent volume of saline. Select groups were treated with 1,3 Bis[2-chloroethy]-1-nitrosuorea (BCNU), delivered at 2 x LD10 Dose, 26.6 mg/kg, intra-peritoneally in a single dose five days post tumor implantaion.

Figure 1. Sensor Locations




Group One – Tumor with No Treatment
Group Two – Chemotherapy (BCNU) Treated Tumors
Group Three – Saline Control with No Treatment
Group Four – Normal Control with No Tumor and No Treatment
Group Five – BCNU Chemotherapy Treatment with No Tumor

Our laboratory has developed a technique for sequential measurement of DC MEG fields ideally suited for this study [2]. The amplitude of the DC magnetic field adjacent to the head was quantified by measuring the change in magnetic field associated with the distance from the MEG sensor array. A stereotactic fixture reproducibly postitioned the rat's head under the probe and controlled its lateral translation to a second position 3 cm away during MEG data acquisition. Translation was repeated 12-15 times. Average absolute field shifts were calculated after subtraction of ambient and fixture magnetic noise. Measurements were repeated every other day after implantation until sacrifice due to tumor burden or until Day 36.

DC MEG measurements were made with our six-channel Tristan Model 606 Animal Biomagnetometer System[3]. Anatomical MRIs were performed on some animals using a 7 Tesla Magnex Scientific MRI to estimate tumor volume at 4-6 day intervals. Histology was performed to evaluate tumor size at sacrifice.

## References

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2. Tepley, N., et al., A technique for sequential measurements of DC neuromagnetic fields. Electroencephalogr Clin Neurophysiol, 1996. 99(1): p. 16-8.
3. Weiland B., Bowyer, S.M., Moran JE, Jenrow K, Tepley N., Imaging DC MEG Fields Associated with Epileptic onset in Rat. in 14th International Conference on Biomagnetism. 2004. Boston, Massachusetts.

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