

# Identification of Intestinal Ischemia Using Magnetic Vector Projection Analysis

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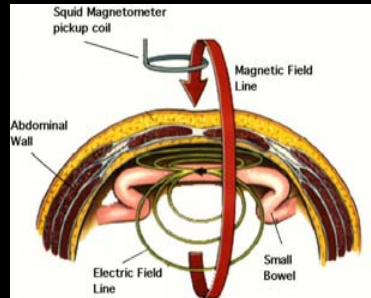
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## Introduction:

Currently there is no noninvasive noncontact method to reliably diagnosis mesenteric ischemia of the small bowel. The morbidity and mortality of mesenteric ischemia are high due to a delayed diagnosis and lack of specificity. It is believed an earlier diagnosis would improve patient out comes.

The normal frequency of the Electrical Control Activity (ECA) of the small bowel is 8-12 cpm. Ischemia is known to cause a slowing of the frequency of the ECA of the small bowel.

A Superconducting QUantum Interference Device (SQUID) magnetometer has the ability to detect the magnetic fields produced by the ECA. The SQUID is the most sensitive flux to voltage converter available and provides a **noninvasive noncontact modality** for detection of the ECA and changes in the ECA during ischemia.



## Gastric Magnetic Fields

•Magnetic fields are attenuated with distance but not significantly affected by tissue thickness and discontinuities

•GI magnetic fields 1 million times smaller than the Earth's magnetic field

•Magnetic field is a vector

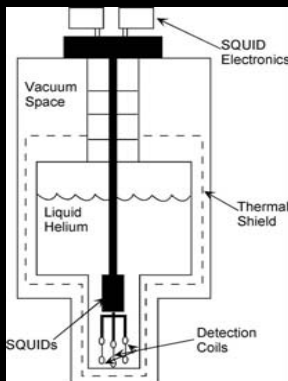
•Electric field is a scalar

## SQUID Magnetometer:

•No need for patient preparation

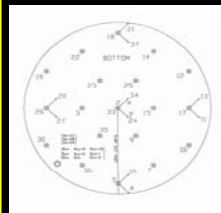
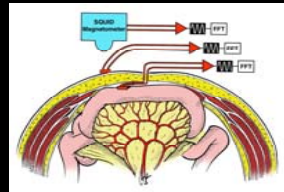
•No danger to patient from radiation or magnetic field

•Can measure all 3 magnetic vector components

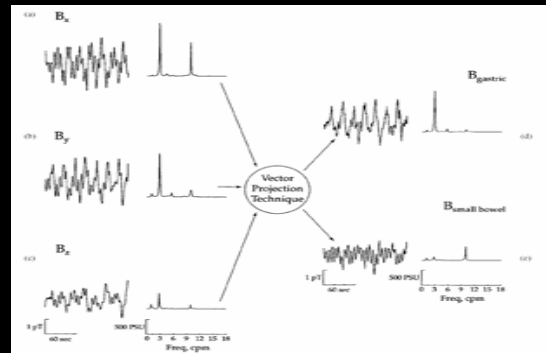


## Experimental Methods:

A vector magnetometer was used to record the 3 orthogonal magnetic field components from the gastrointestinal tract in 4 male pigs. The SQUID and the pig are placed within a magnetically shielded room to reduce environmental magnetic noise. The pig is placed underneath the SQUID with the stomach centered under the channel array and baseline data was taken for 15 minutes.

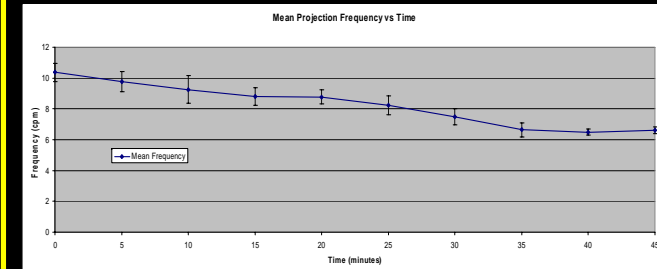


The animal was removed from beneath the SQUID and a laparotomy was performed. The mesenteric blood supply was isolated for a section of intestine and ligated, inducing ischemia. The animal was once again placed under the SQUID in a similar position and recordings were taken for an 45 additional minutes.



All data segments were analyzed during breath holds to eliminate interference from the respiration artifact. The x,y, and z vector components were projected into specific directions using 1 minute segments. The directions of the projections were determined by maximizing the normalized frequency power of the intestinal ECA compared to all other sources and noise.

## Results:

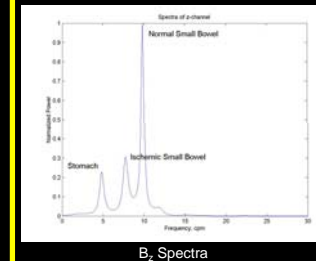


During baseline the average frequency of the intestinal ECA was found to be  $10.6 \pm 0.45$  cpm. The ECA decreased to  $6.6 \pm 0.45$  cpm after 45 minutes of induced ischemia.

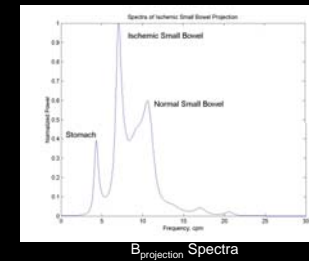
Table 1: Comparison of Frequency Dominance of Projections vs. Single Vectors

	X Vector	Y Vector	Z Vector	Total Single Vectors	Vector Projection
Times Dominant	2	10	7	19	30
Segments Used	48	48	48	144	48
Percentage	4.17%	20.83%	14.58%	13.19%	62.5%

The frequency of the ischemic small bowel ECA becomes dominate more often when Vector Projection is used. When individual vectors are examined the ischemic small bowel is rarely the dominate frequency found.



B<sub>z</sub> Spectra



B<sub>projection</sub> Spectra

Vector Projection is able to better isolate the ischemic signal from the other sources as well as environmental noise and increase the normalized frequency power of the ischemic small bowel signal.

## Conclusions:

The SQUID provides a noninvasive noncontact method for detecting ECA of the gut and changes in the frequency of the ECA caused by ischemia. Magnetic Vector Projection provides a better representation of the ECA from specific sources than any single vector component.