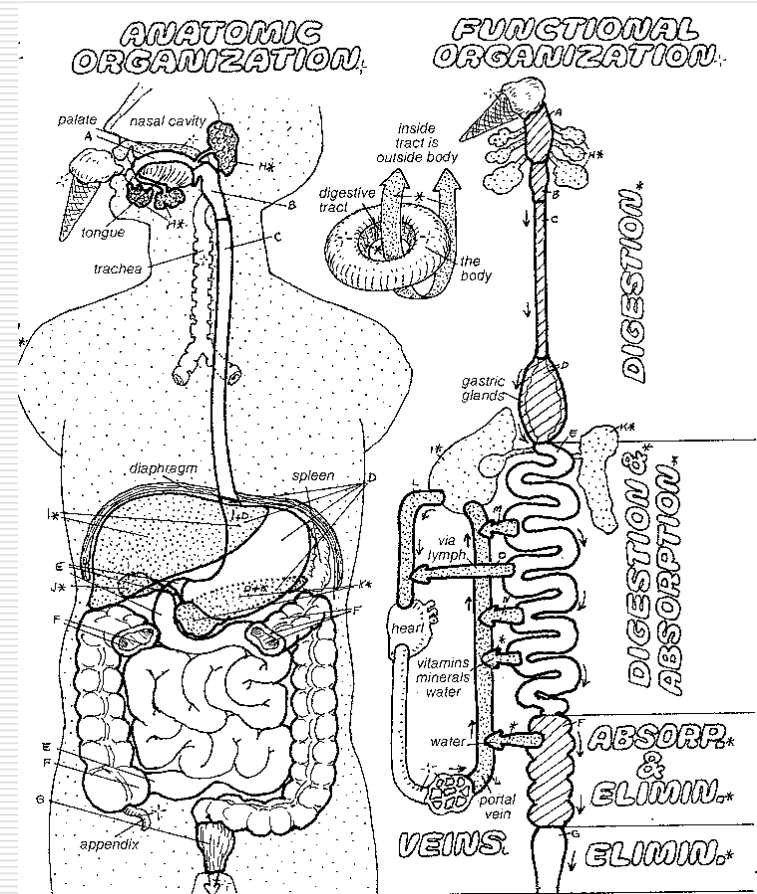


Introdução ao Biomagnetismo

Oswaldo Baffa Filho
Departamento de Física-FFCLRP
Universidade São Paulo
Aula #5-Aplicações em
Gastroenterologia

Motivação

- ❑ Para que o processo de digestão se realize o alimento tem que transitar por diferentes segmentos do tubo digestivo com uma velocidade apropriada.
- ❑ Enzimas
- ❑ Motilidade
- ❑ Irrigação
- ❑ Sinais elétricos

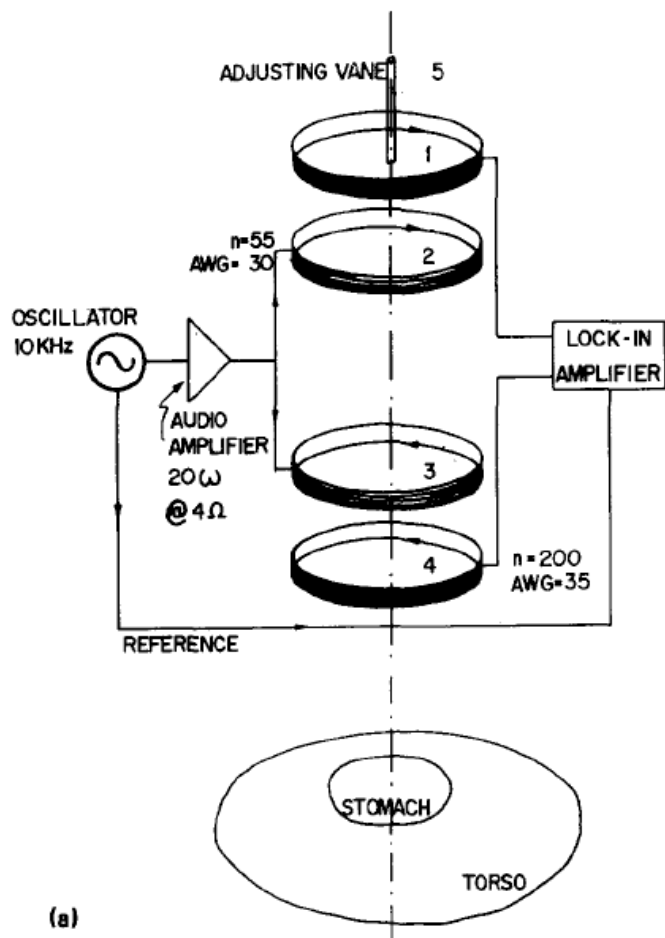


Métodos em Uso para o Estudo do Trato GI

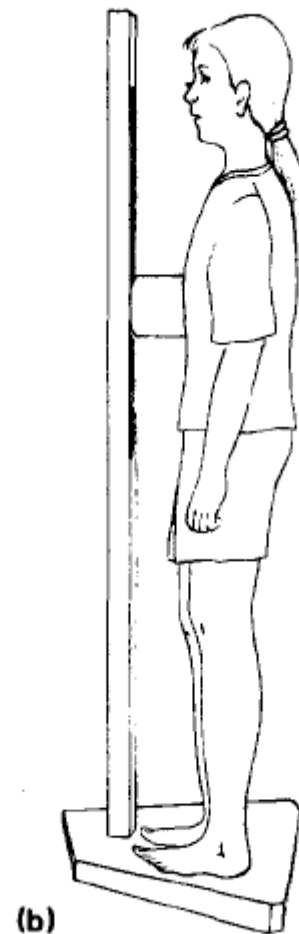
- Sondas e Cateteres
 - Medidas de pressão, pH, conteúdo gástrico
 - Raios X
 - Fluoroscopia com agente de contraste
 - Radioisótopos
 - Alimento teste com marcador radiativo
- Estes métodos são invasivos ou utilizam radiação ionizante



Esvaziamento Gástrico sensor (a) e posicionamento (b)



(a)



(b)

Esvaziamento Gástrico

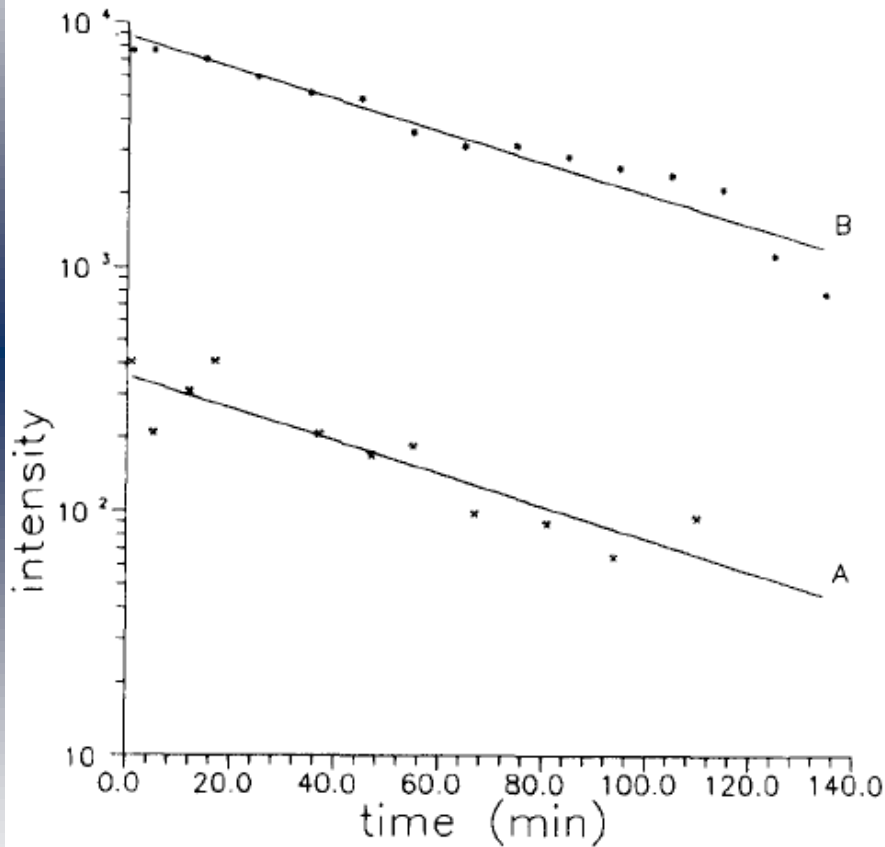


TABLE I. Gastric emptying times (minutes) with standard deviations.

Subject	Susceptometry	Gamma camera
JRM	61 ± 19	61 ± 17
MA	45 ± 18	47 ± 12
JVS	80 ± 20	70 ± 21

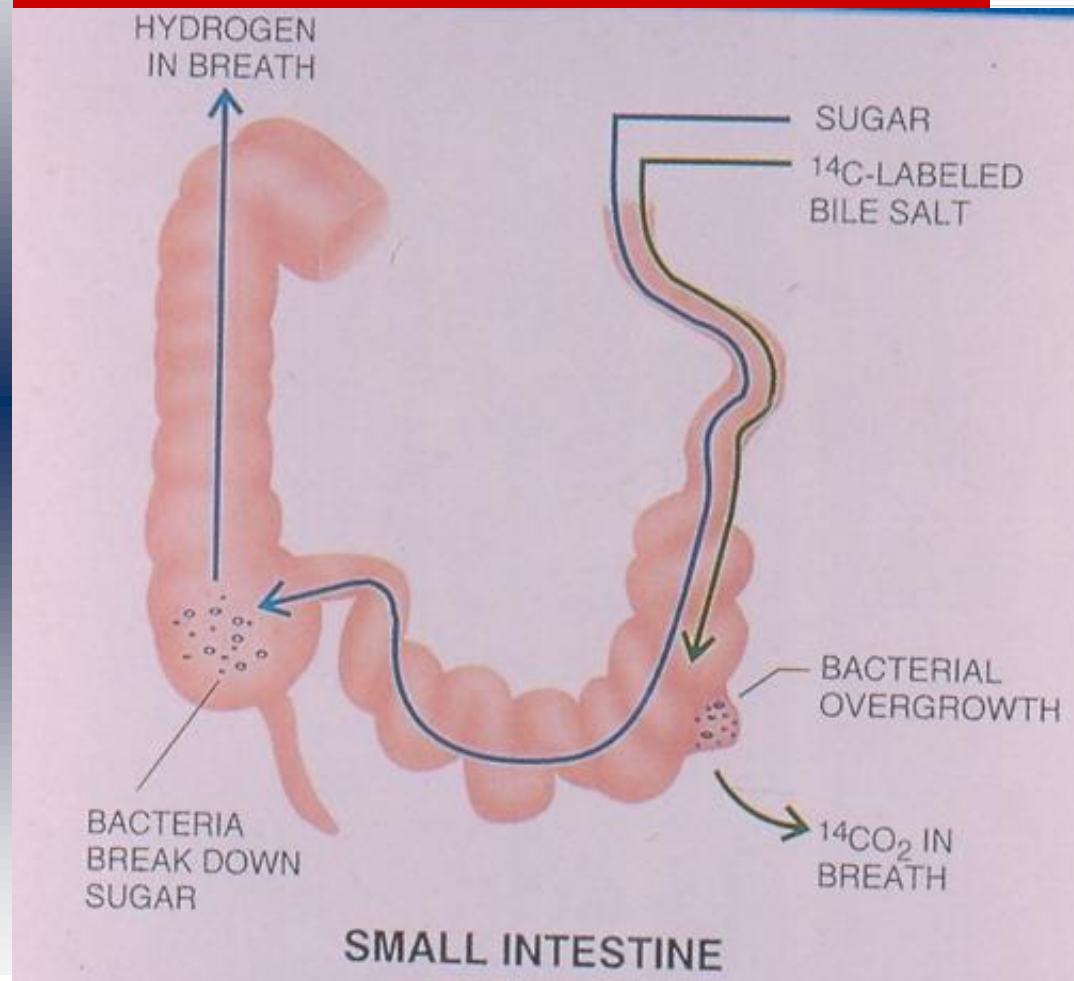
MIRANDA, J. R., BAFFA, O., OLIVEIRA, R. B., MATSUDA, N. M. An AC Biosusceptometer to Study Gastric Emptying. Medical Physics. , v.19, n.2, p.445 - 448, 1992.

Medidas de Tempo de Trânsito Orocecal

- ❑ OCTT foi medido por métodos biomagnéticos e os resultados foram comparados aos teste do hidrogênio expirado.
- ❑ Uma refeição de prova magnética contendo lactulose foi ingerida pelo sujeito e o hidrogênio expirado foi analisado por cromatografia gasosa.

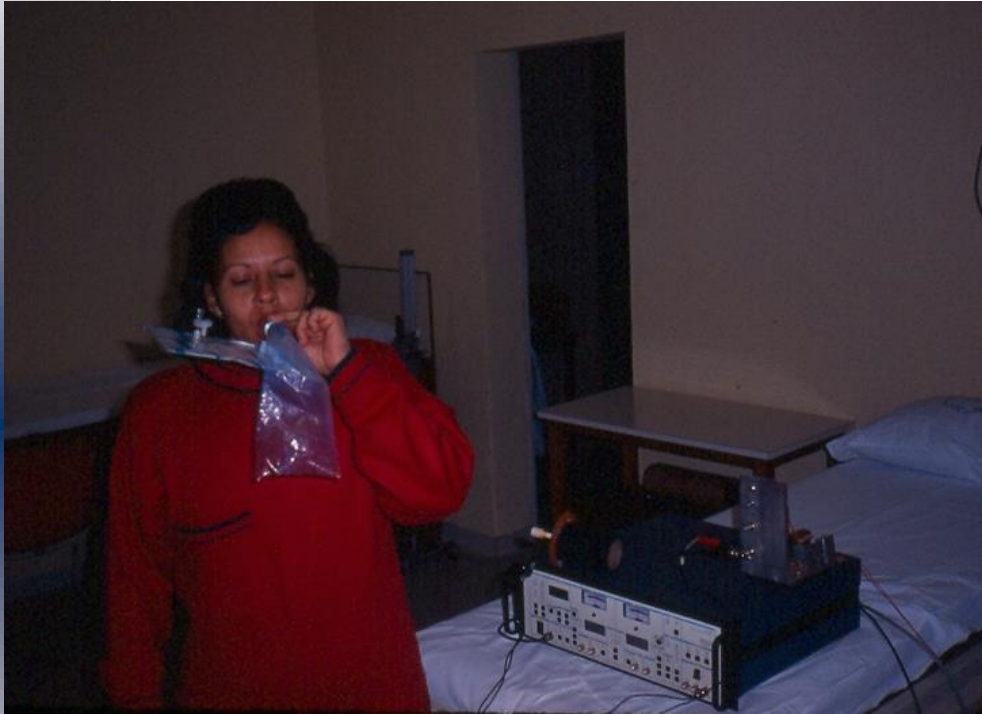
OLIVEIRA, R. B., BAFFA, O., TRONCON, L. E. A., MIRANDA, J. R. A., CAMBREA, C. R. Evaluation of a Biomagnetic Technique for Measurement of Orocaecal Transit Time. *European Journal Of Gastroenterology Hepatology.* , v.8, p.491 - 496, 1996.

Tempo de Trânsito Orocecal-Teste do Ar Expirado

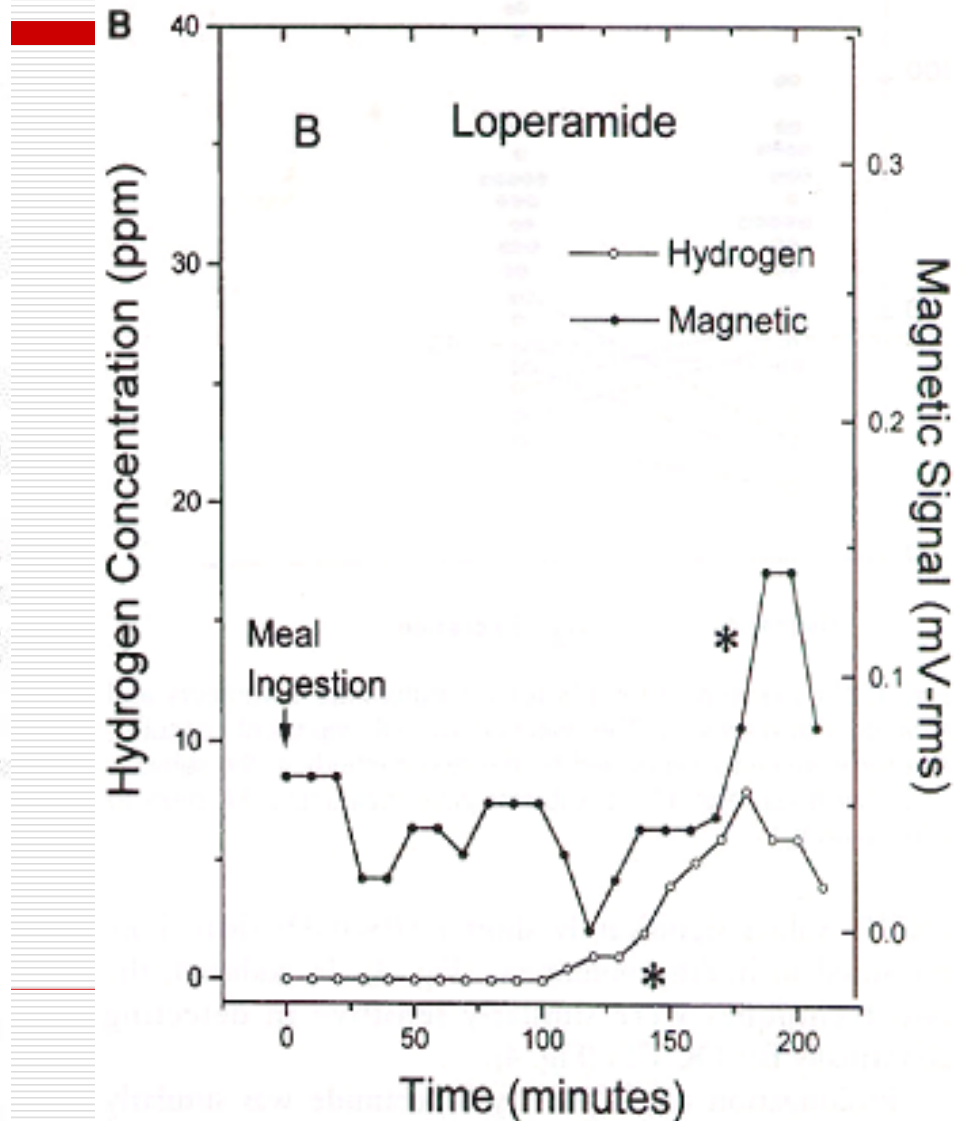
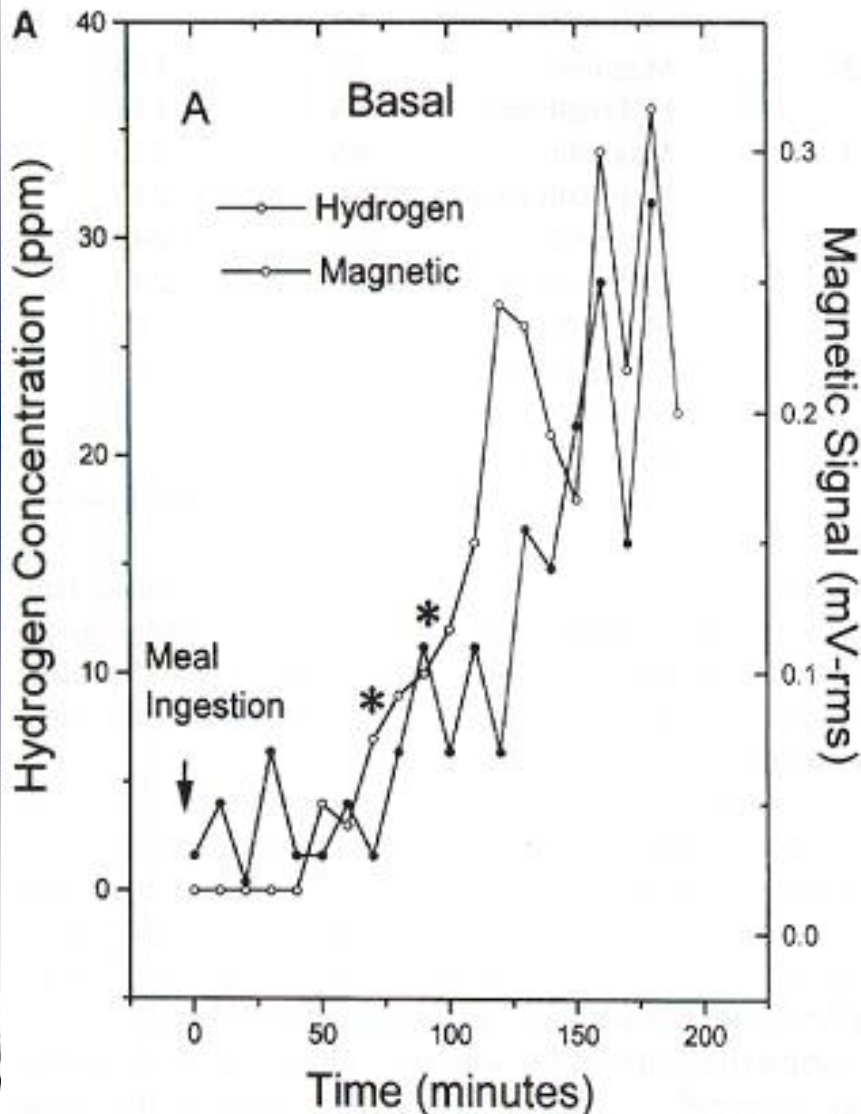


- Uma refeição de prova contendo lactulose chega ao ceco onde o açúcar é digerido por bactérias produzindo hidrogênio

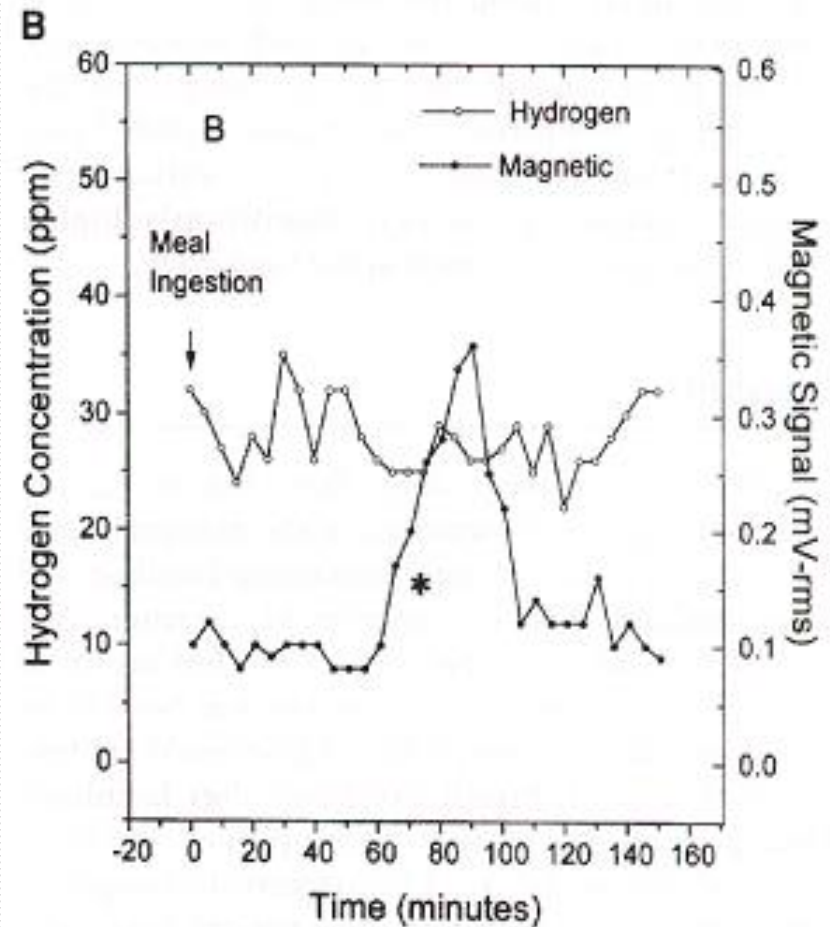
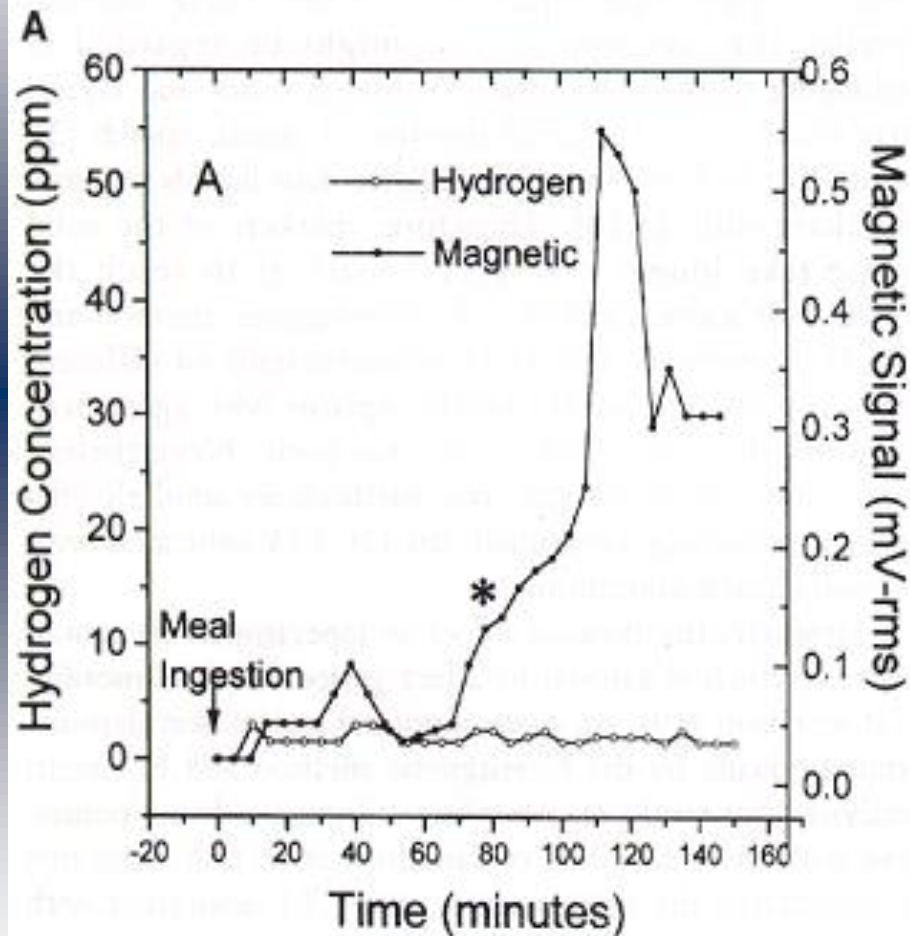
Coleta of Hidrogênio Expirado



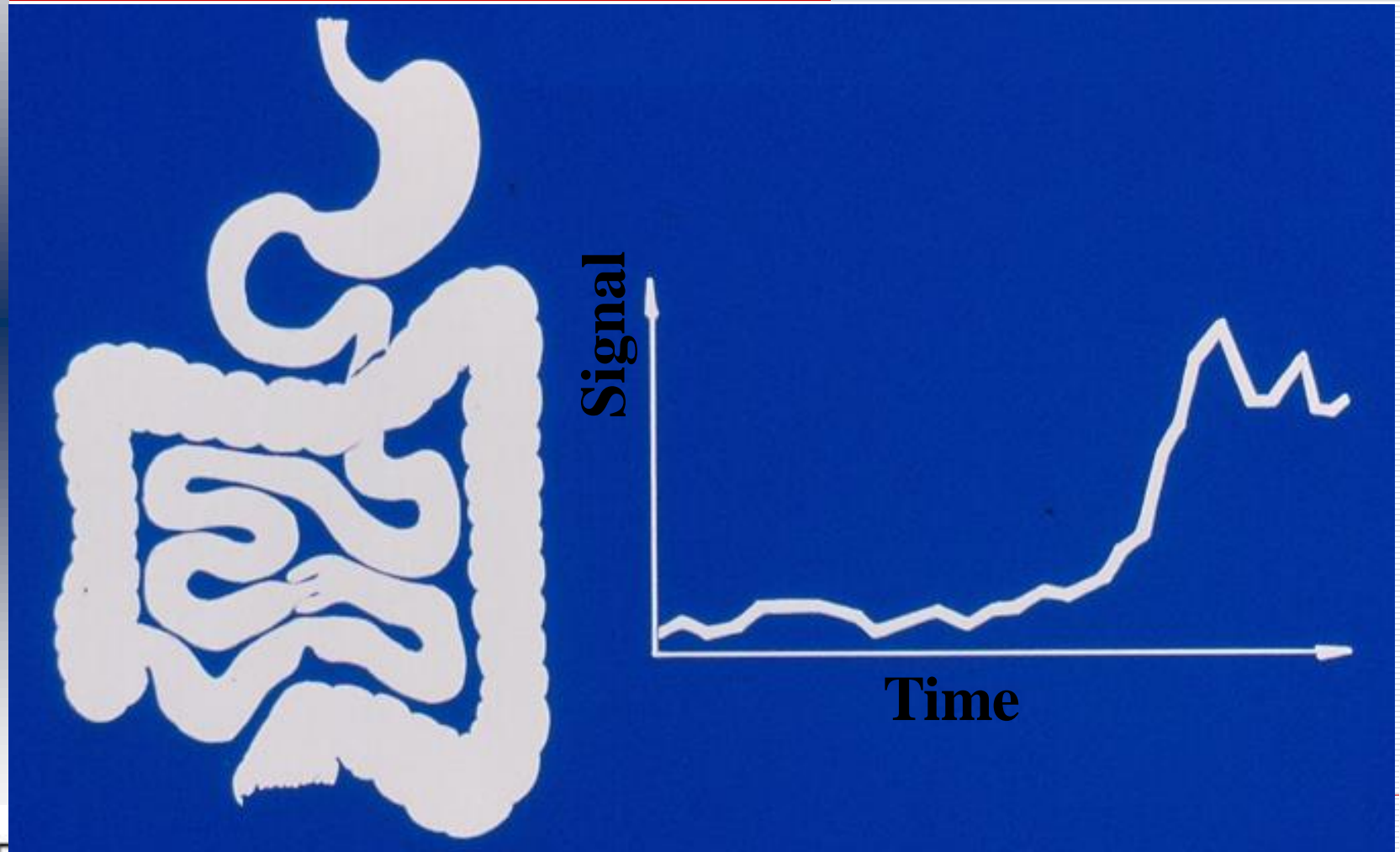
OCTT do Mesmo Sujeito Antes e Depois da Administração de Loperamida



OCTT para um Sujeito que Não Produz H₂ e para um Sujeito com Elevada Produção em Comparação com o Método Magnético

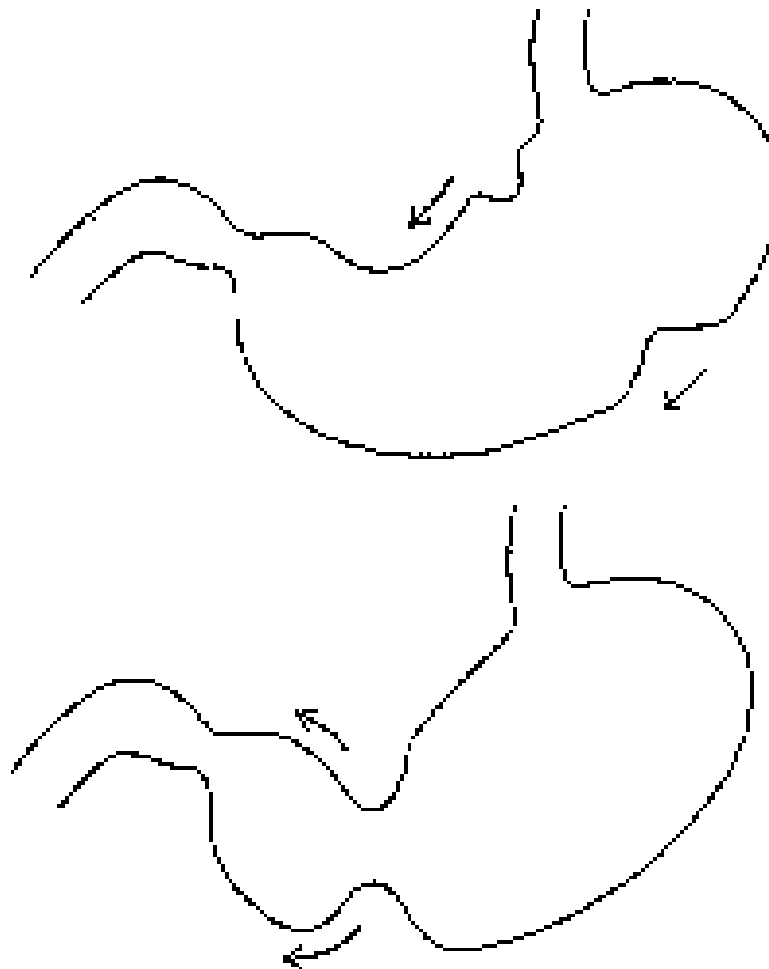


Como interpretar os dados ?



Atividade Mecânica do Estômago

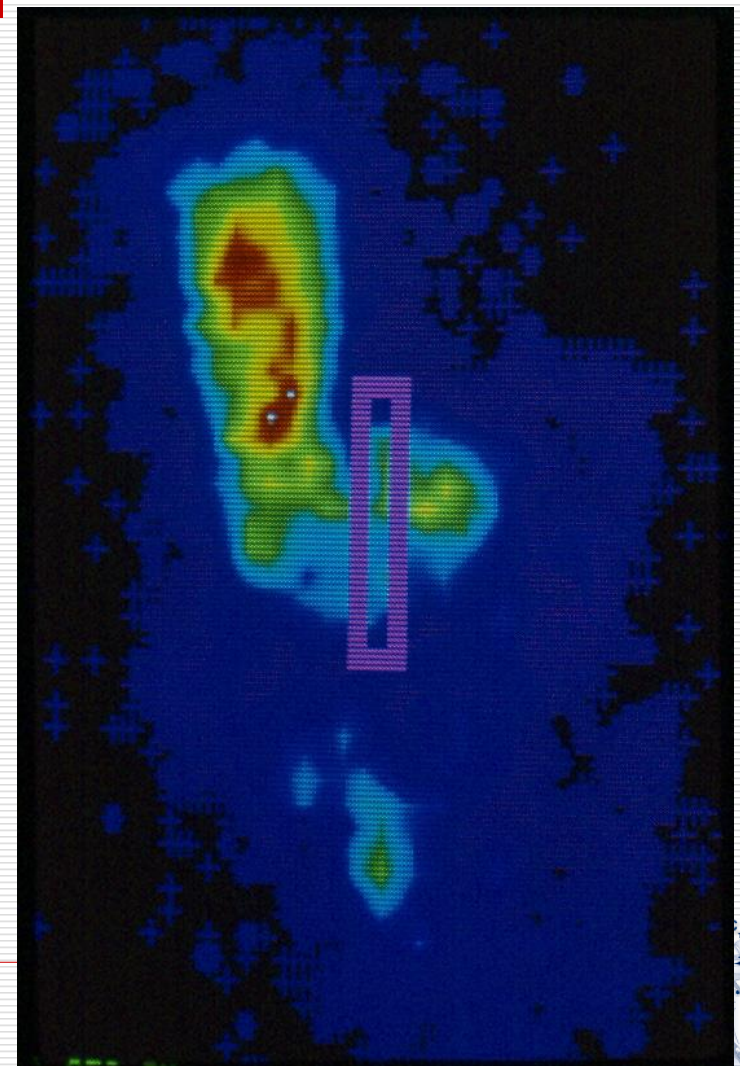
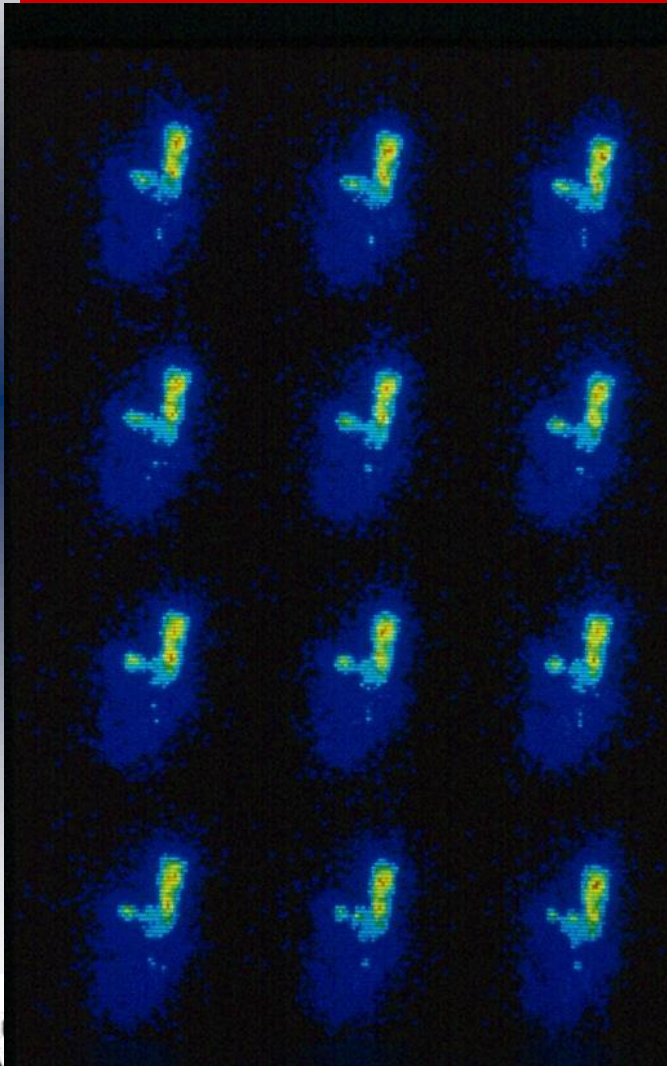
“Ondas Lentas”



Alimento Teste

- As medidas com o biosusceptômetro AC (BAC) exigem a ingestão de uma refeição de prova contendo marcadores ou traçadores magnéticos inertes. A ferrita em pó e magnetita são utilizadas em concentrações de 1-4% em peso.

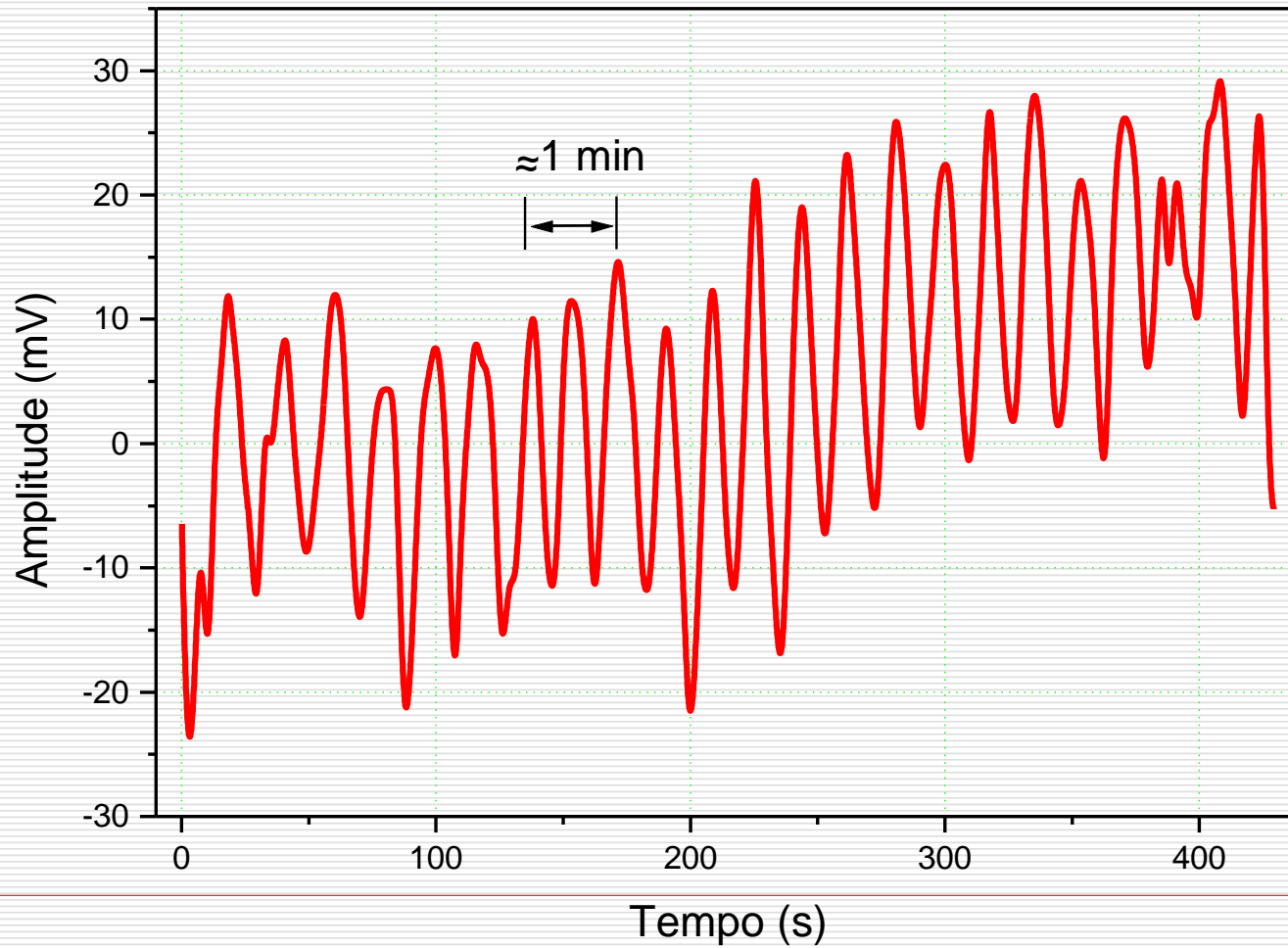
Atividade Mecânica do Estômago



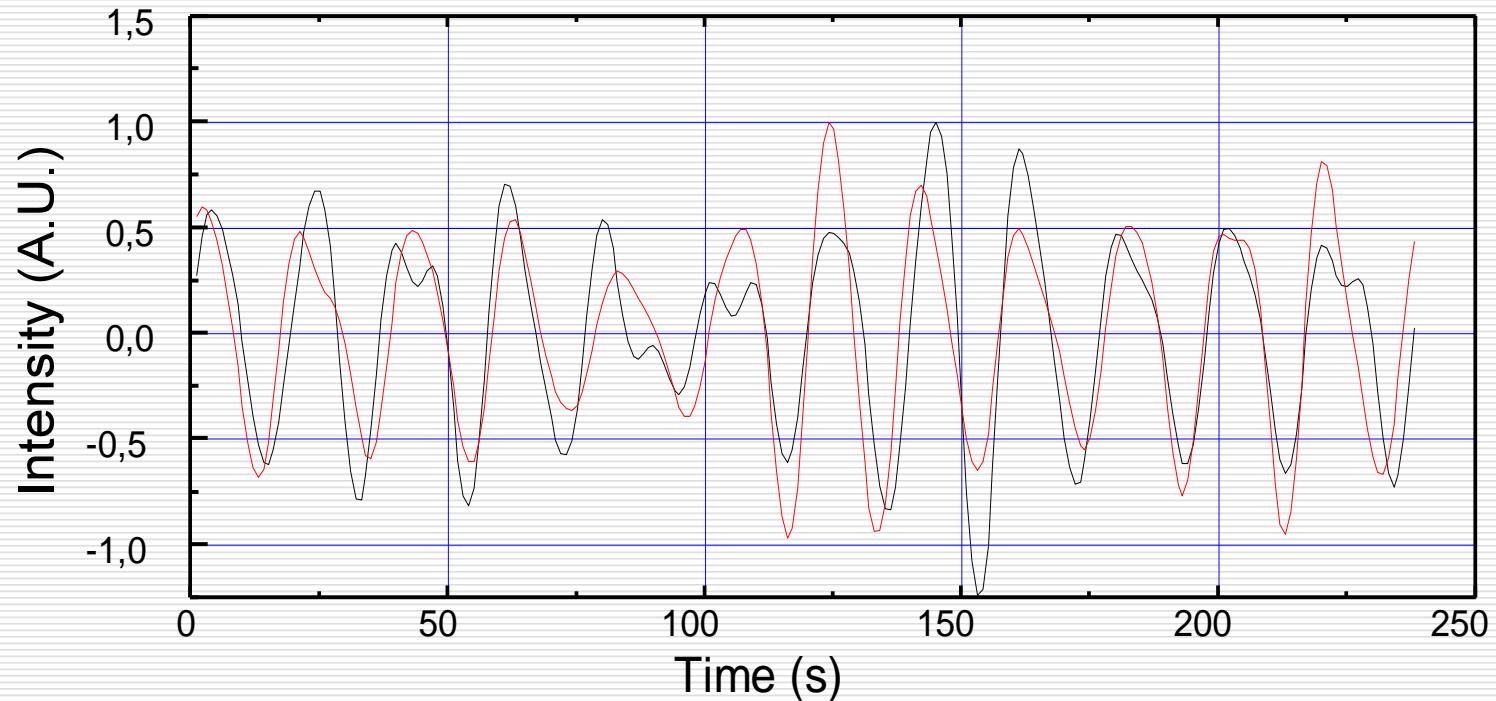
Arranjo Experimental para Medidas Gástricas



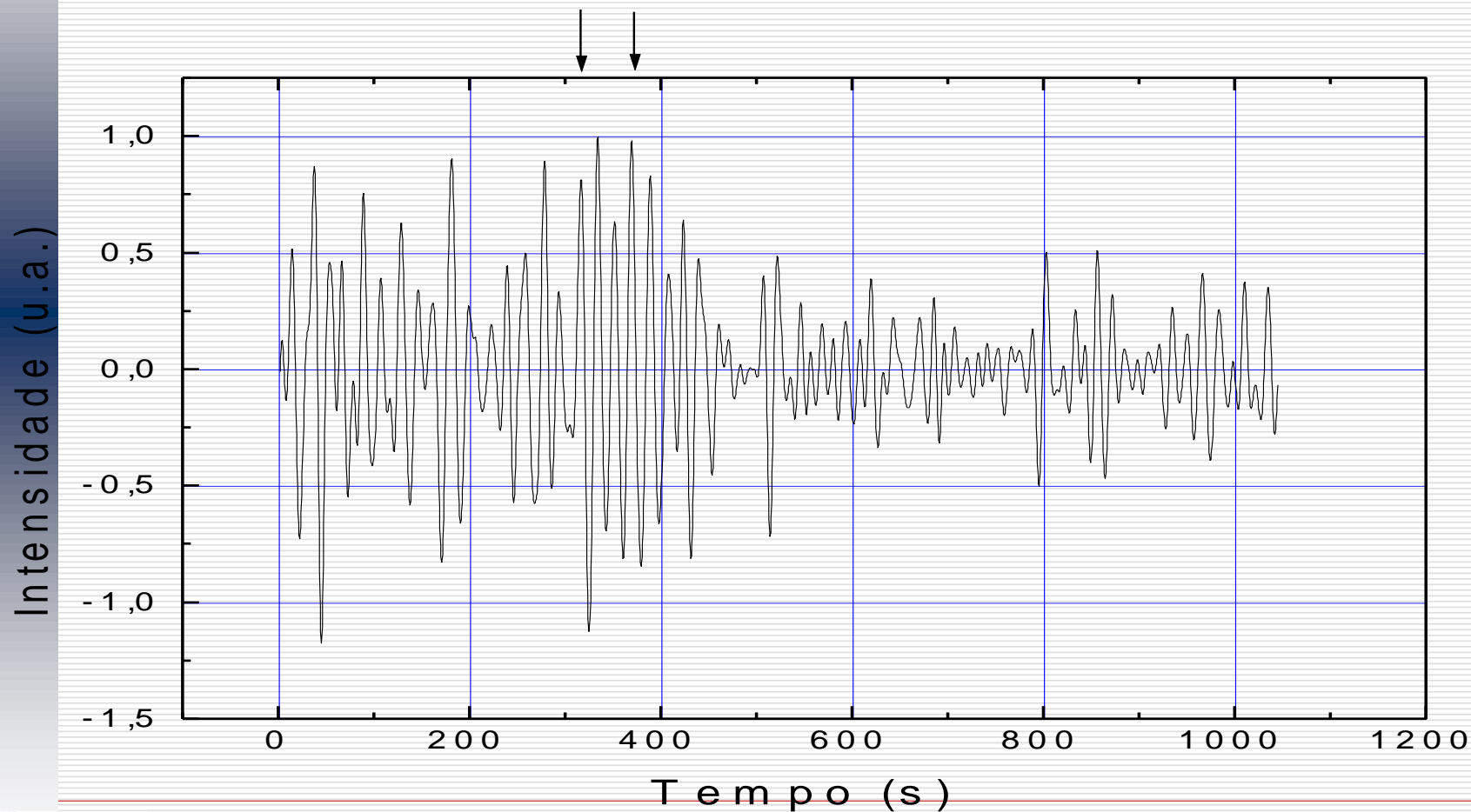
Contrações Gástricas



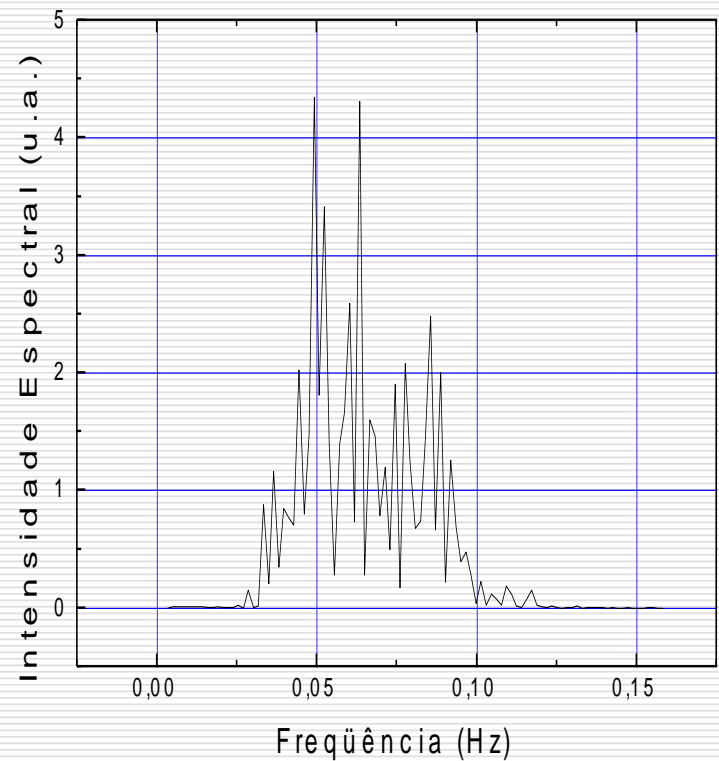
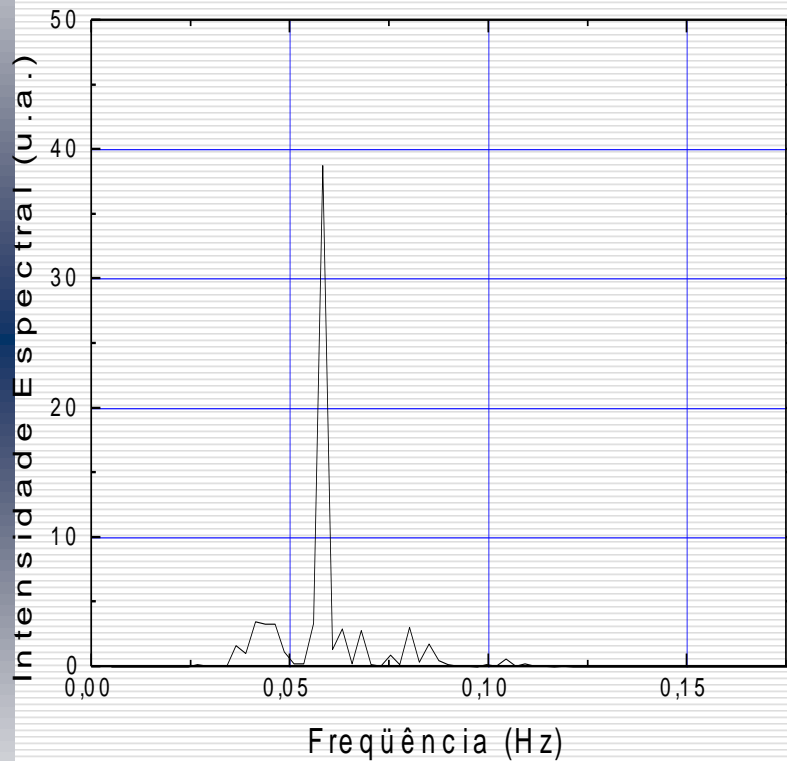
Registro simultâneo da ACG Susceptometria & Cintilografia



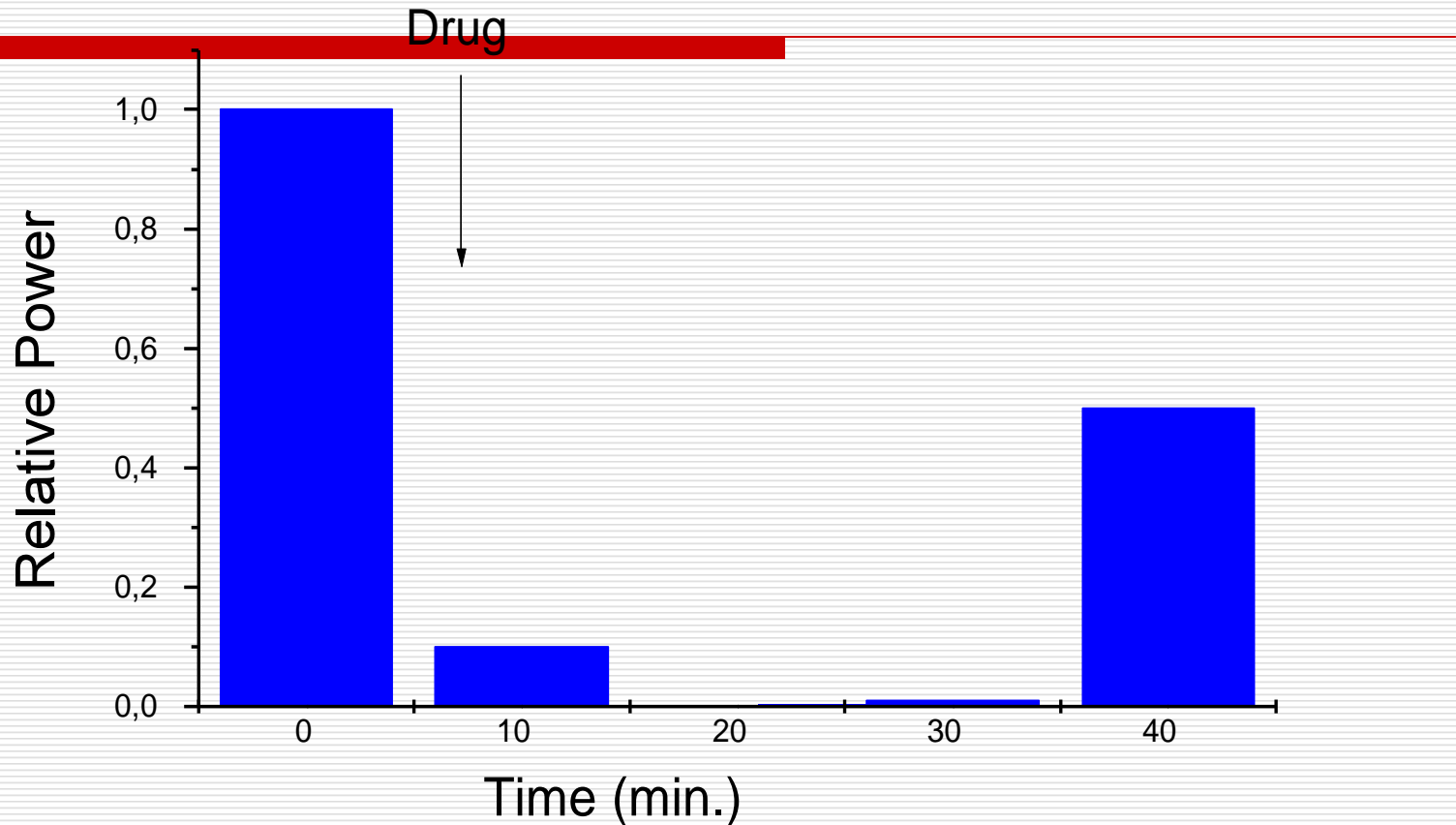
Estudo da Ação de uma Droga



Transformadas de Fourier (antes e depois)

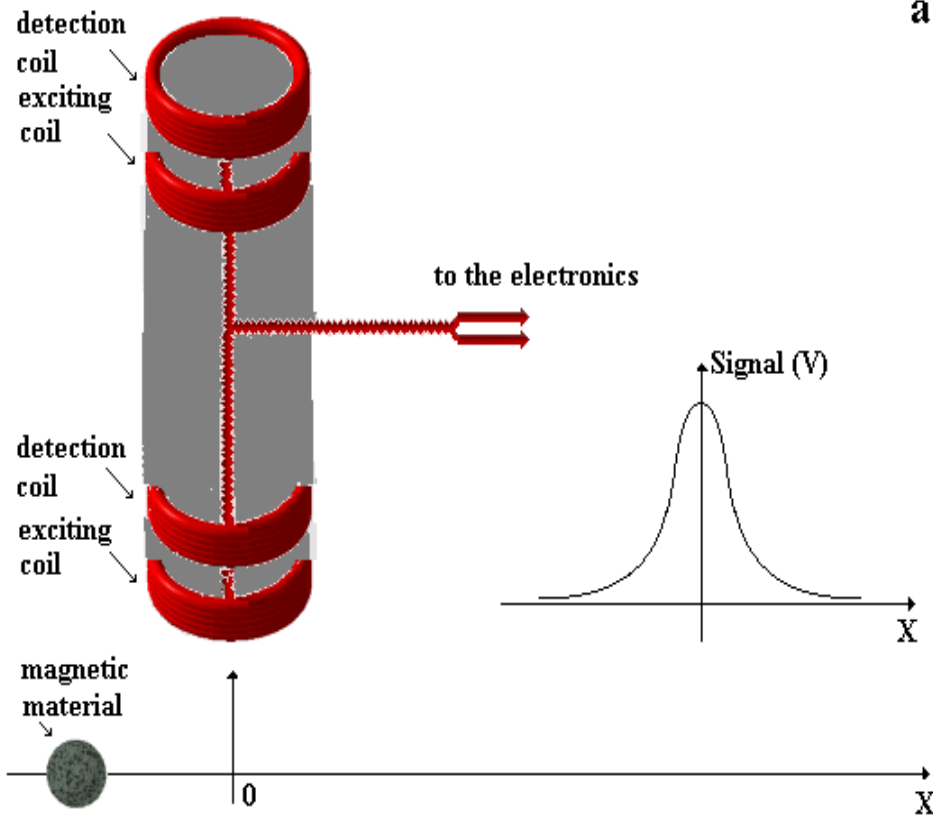


Amplitude do Sinal Versus Tempo Devido a Ação da Droga



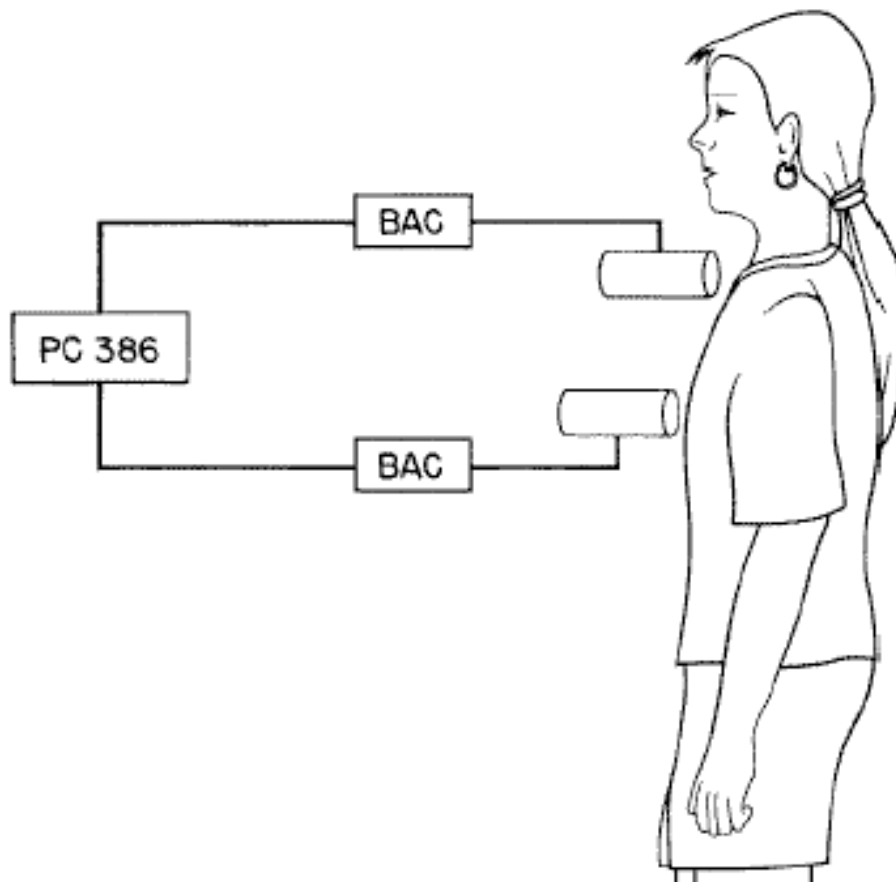
MIRANDA, J. R. A., OLIVEIRA, R. B., SOUSA, P. L., BRAGA, F. J. H. N., BAFFA, O. A Novel Biomagnetic Method to Study Gastric Antral Contractions. *Physics in Medicine and Biology*. , v.42, n.9, p.1791 - 1799, 1997.

Tempo de Transito Esofagiano (ETT) Configuração dos Sensores



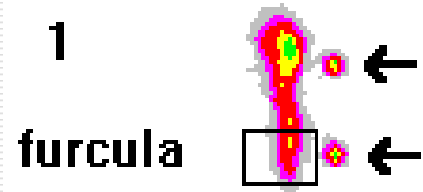
- a
- Biosusceptometro em configuração axial
 - A passagem do alimento teste magnético próximo ao a uma das extremidades produz um sinal

Posicionamento dos Sensores

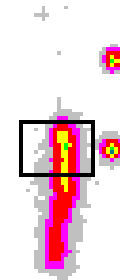


- DAGHASTANLI, N. A.,
BRAGA, F. J. H. N.,
OLIVEIRA, R. B.,
BAFFA, O.
Oesophageal Transit
Time Evaluated by a
Biomagnetic
Technique.
Physiological
Measurements v.19,
n.3, p.413 - 420, 1998

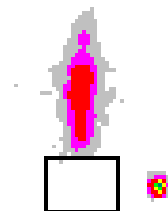
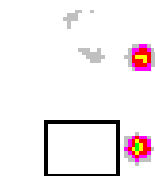
ETT Visto pela Cintilografia



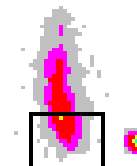
2



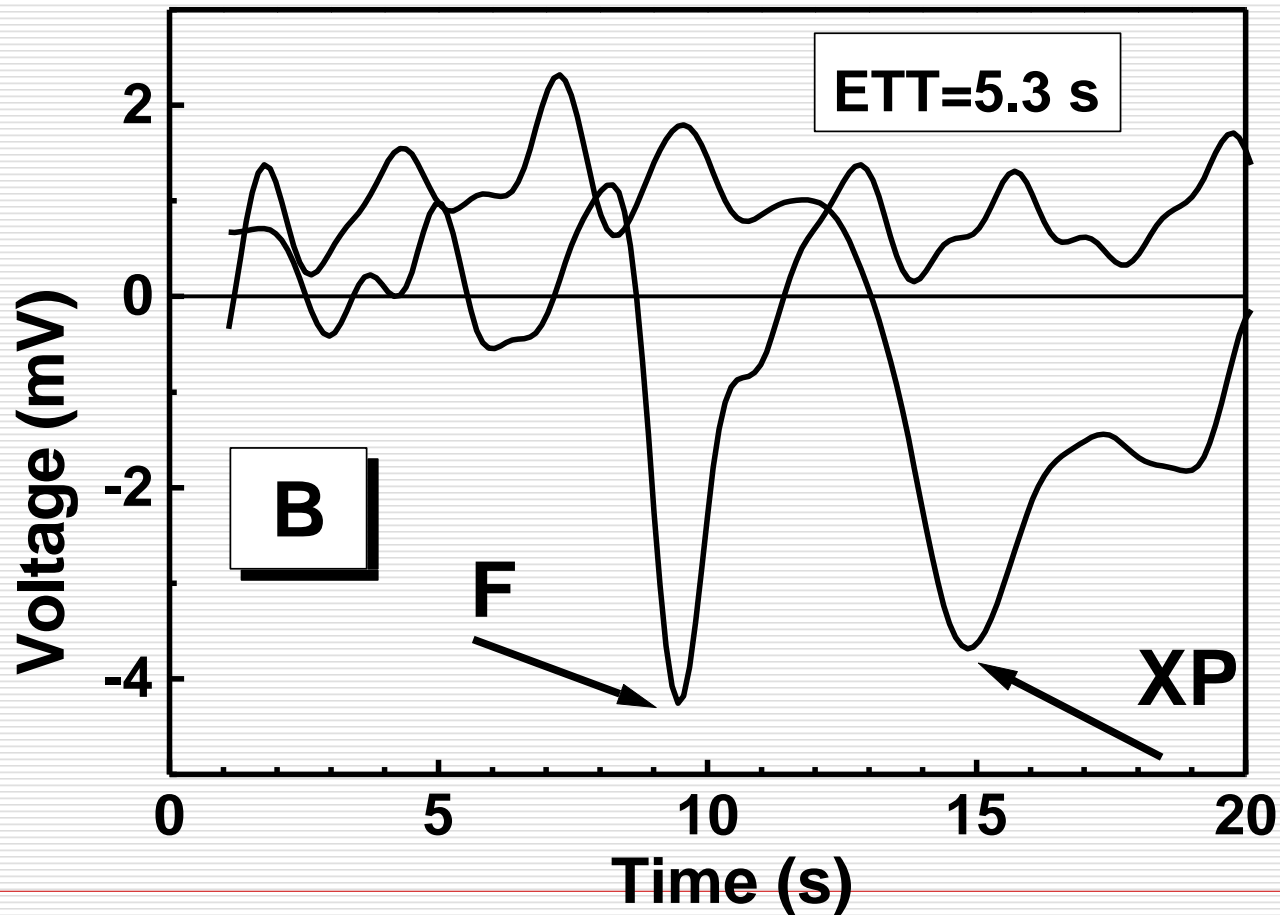
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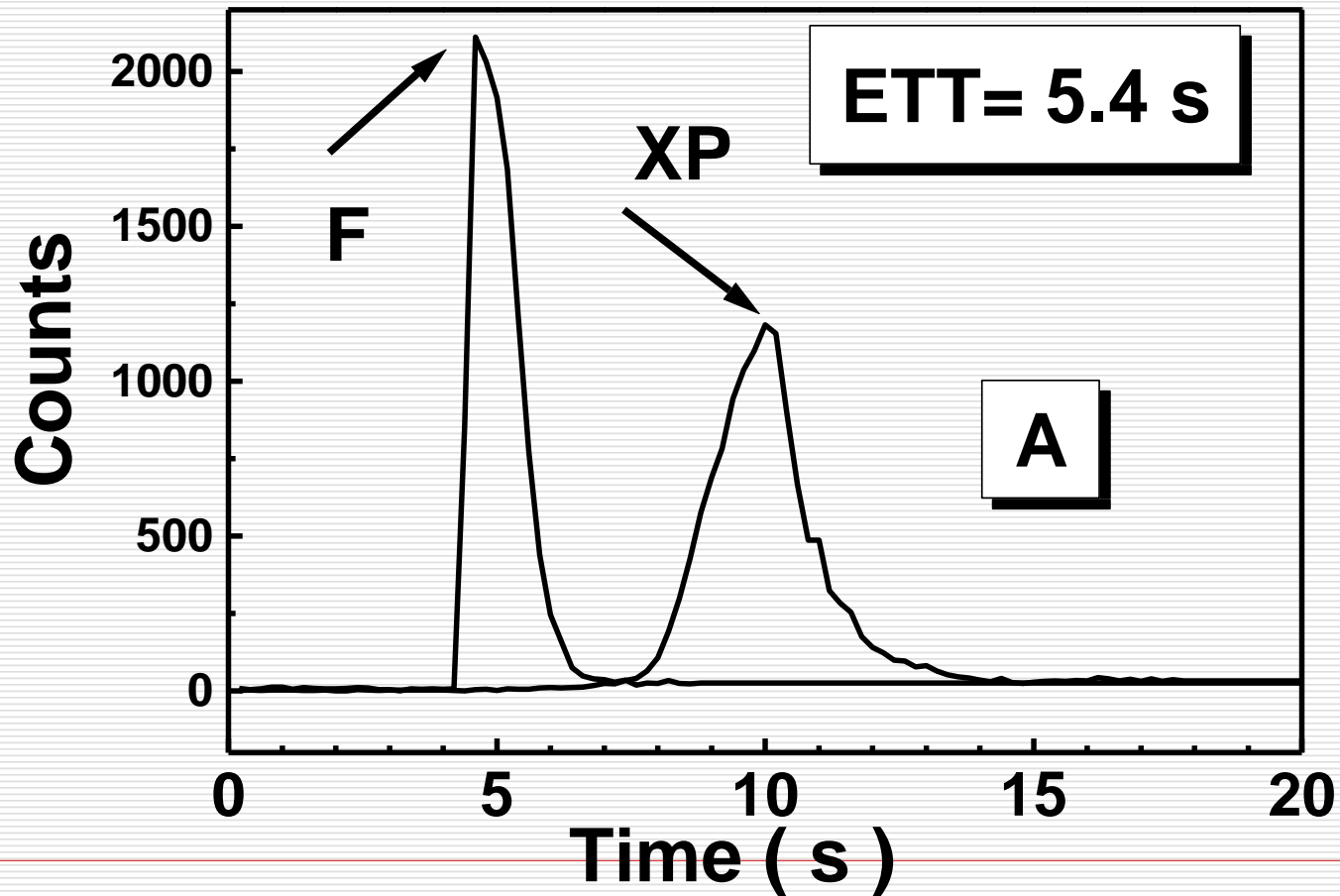
4



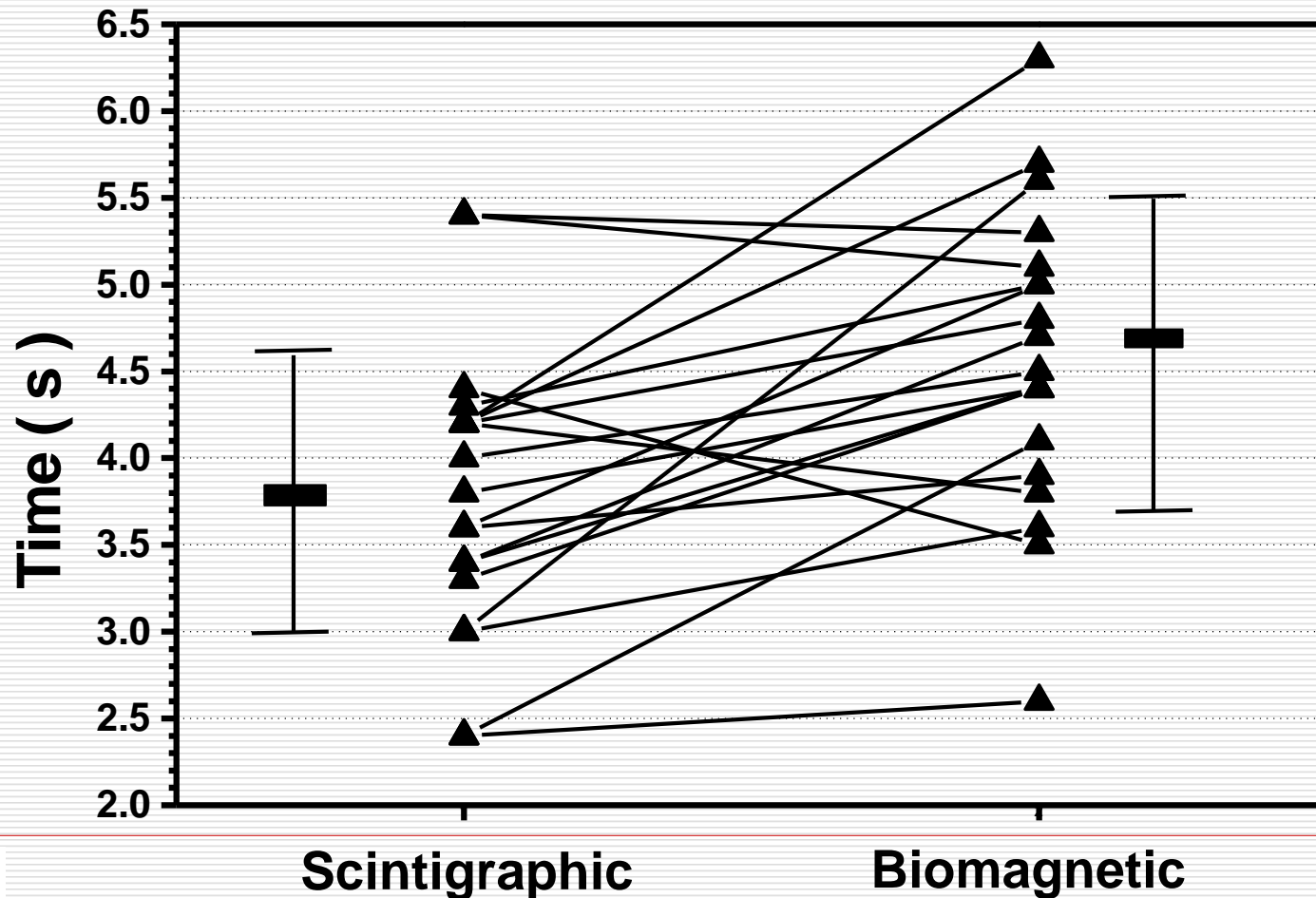
ETT-Medida Biomagnética



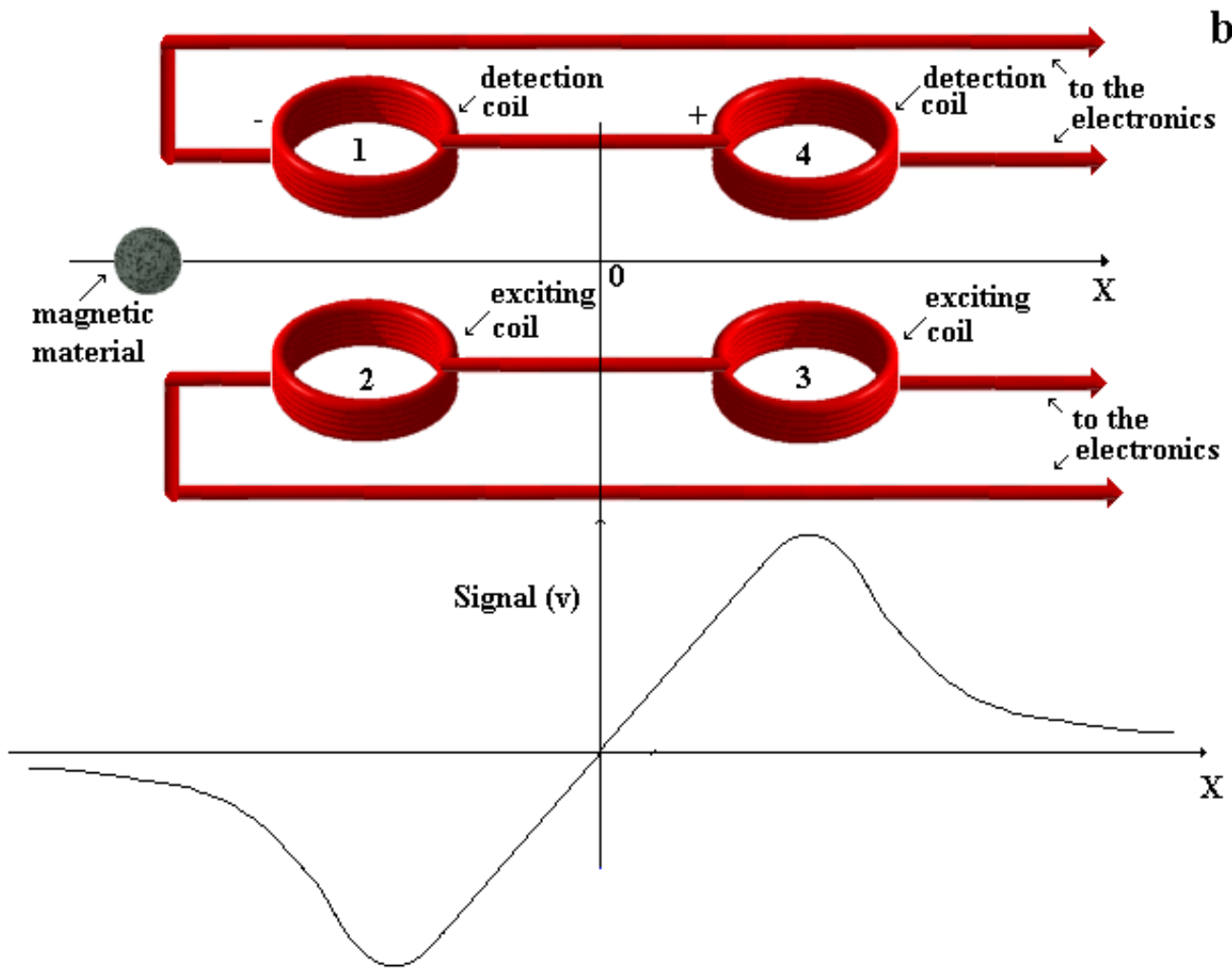
ETT-Medida Cintilográfica



Comparação entre os Métodos Biomagnético e Cintilográfico

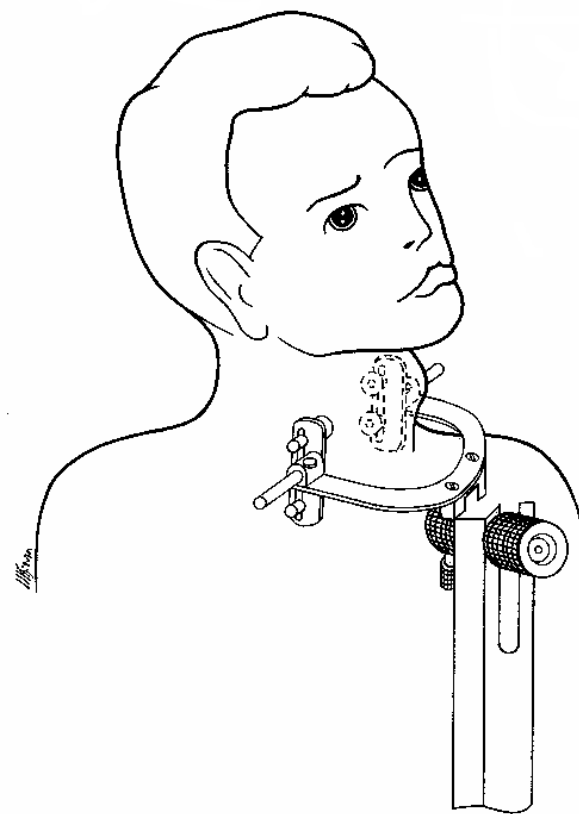
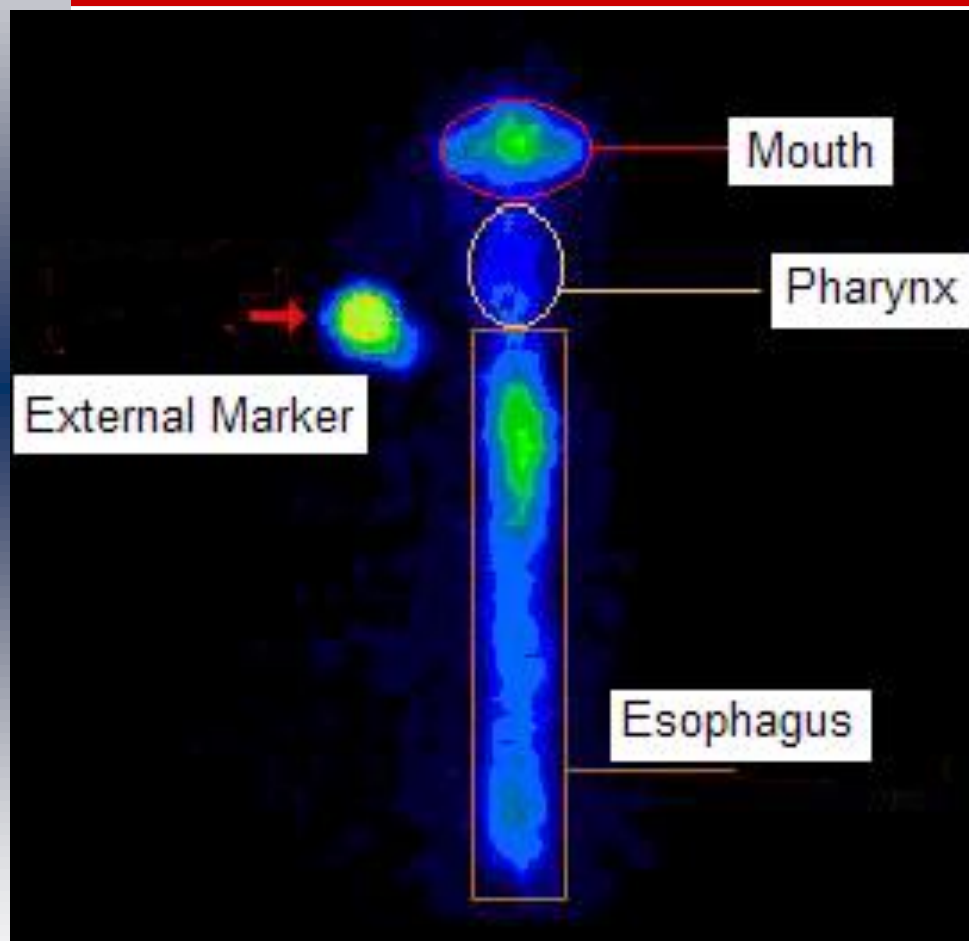


“Clearance” e Tempo de Trânsito Faringeano

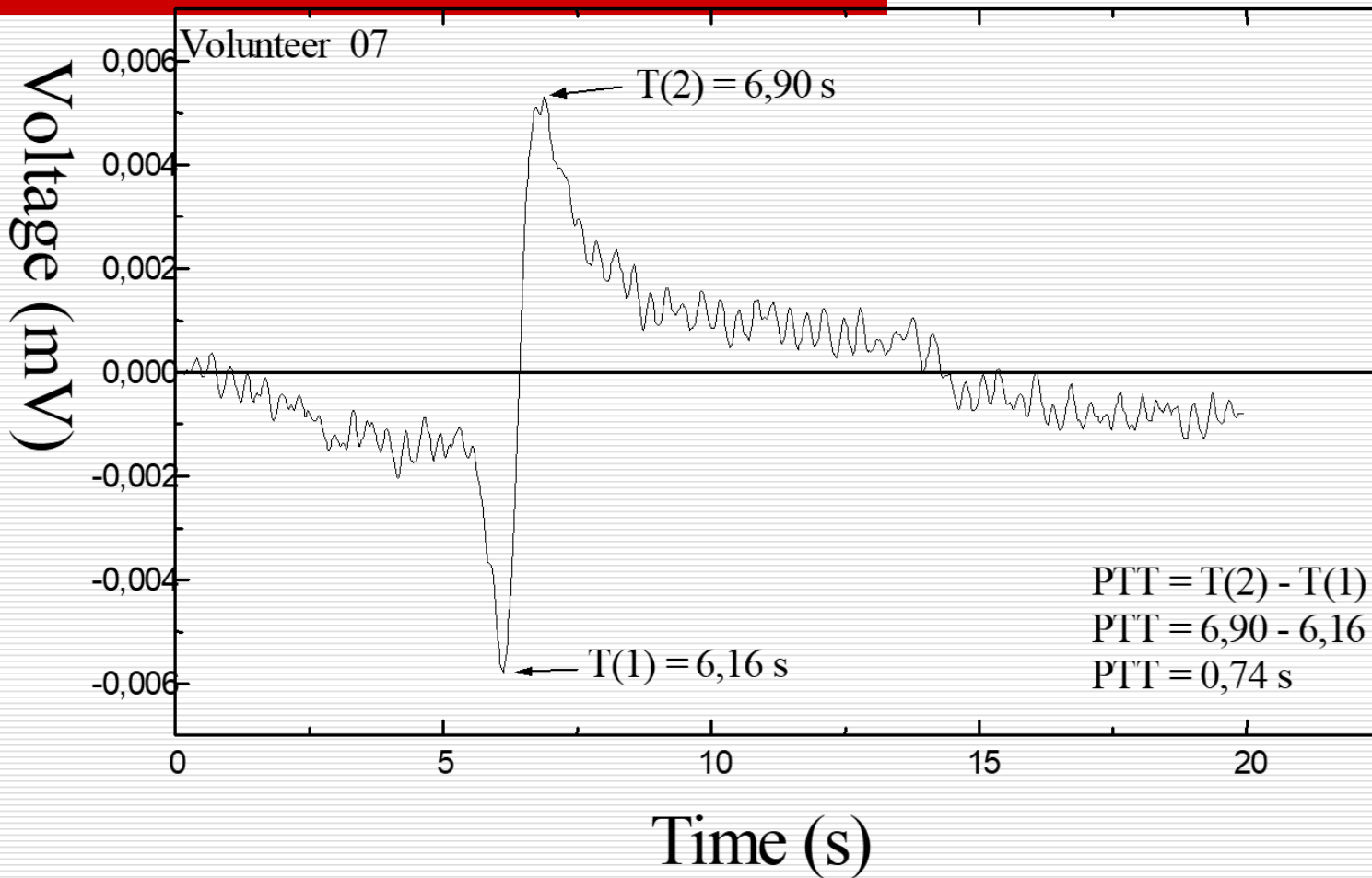


MIQUELIN, C. A.,
BRAGA, F. J. H. N.,
DANTAS, R. O.,
OLIVEIRA, R. B.,
BAFFA, O.
Pharyngeal
clearance and
pharyngeal transit
time determined by
a biomagnetic
method in normal
humans.
Dysphagia. , v.16,
p.308 - 312, 2001.

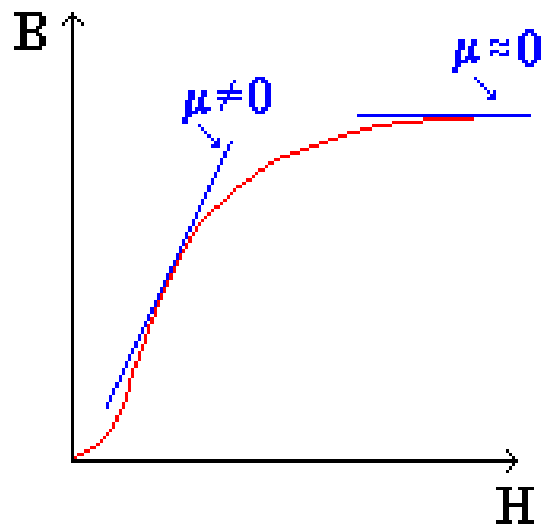
Imagem Cintilográfica e Posicionamento dos Sensores



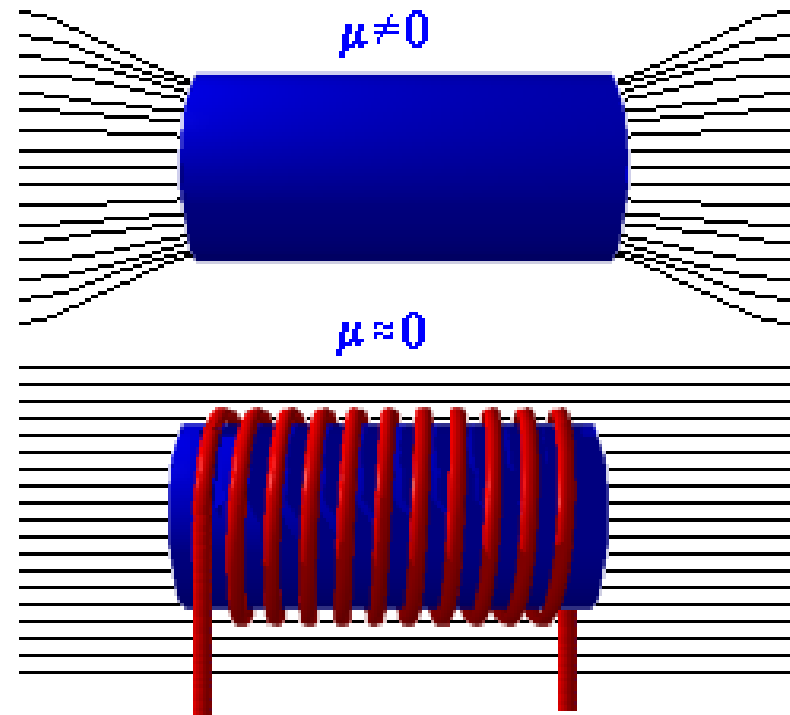
Sinal Típico do PTT



Princípio de Funcionamento de Um Fluxgate



(a)

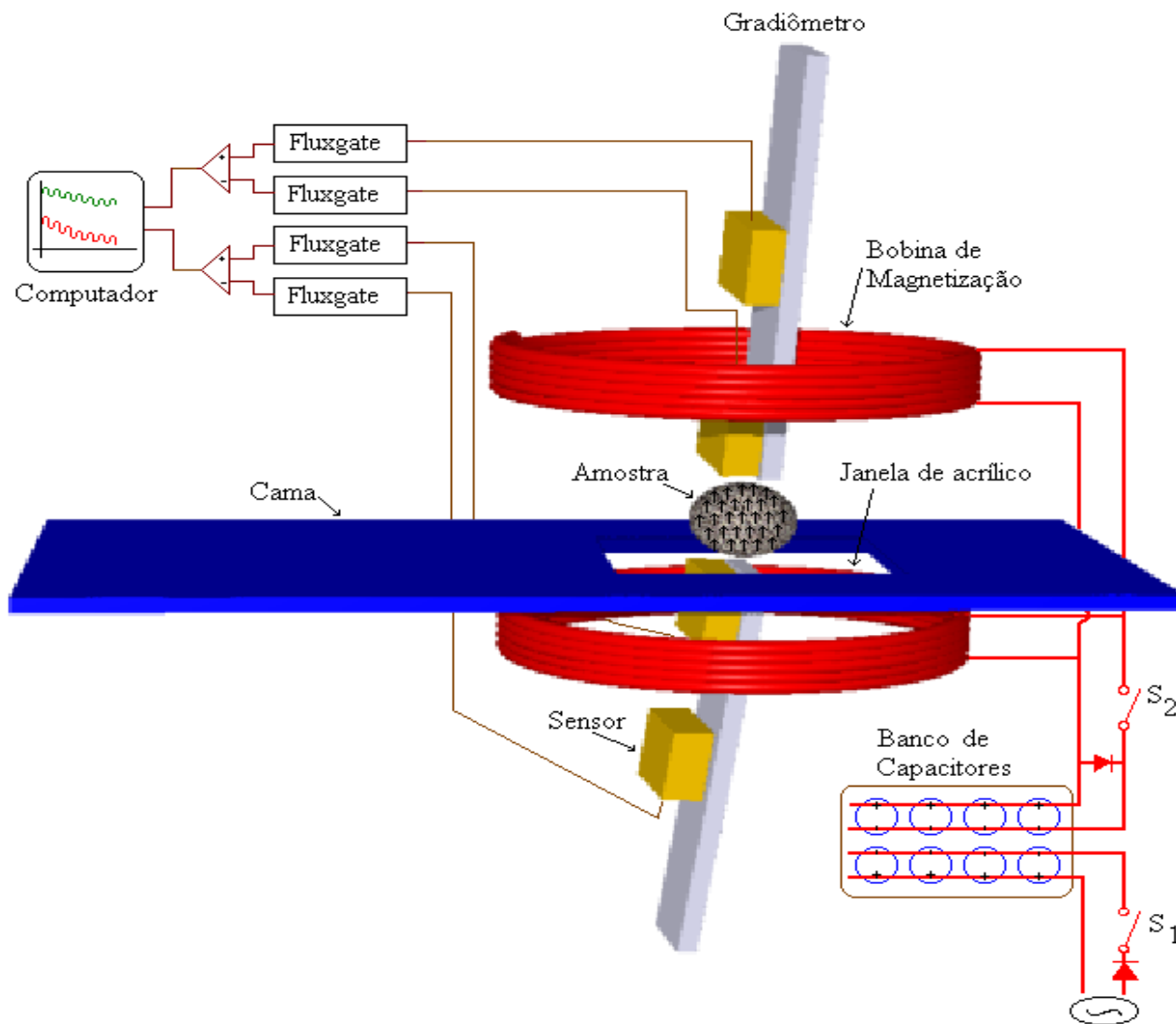


(b)

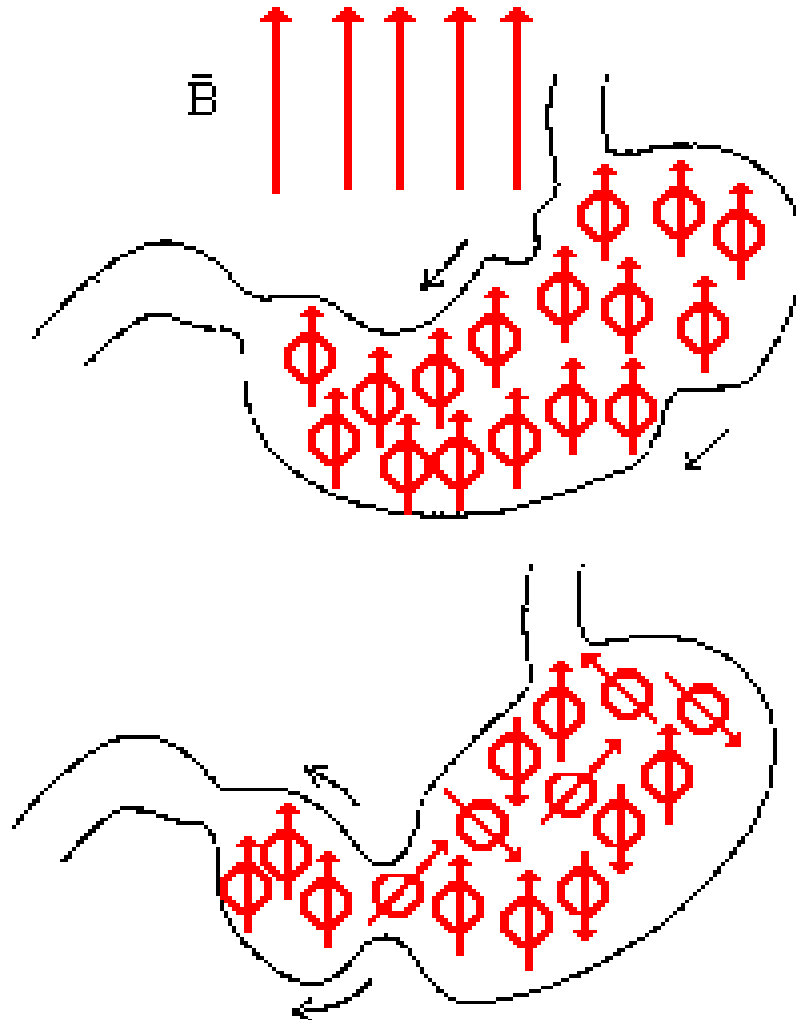
Fluxgate com Núcleo de Anel



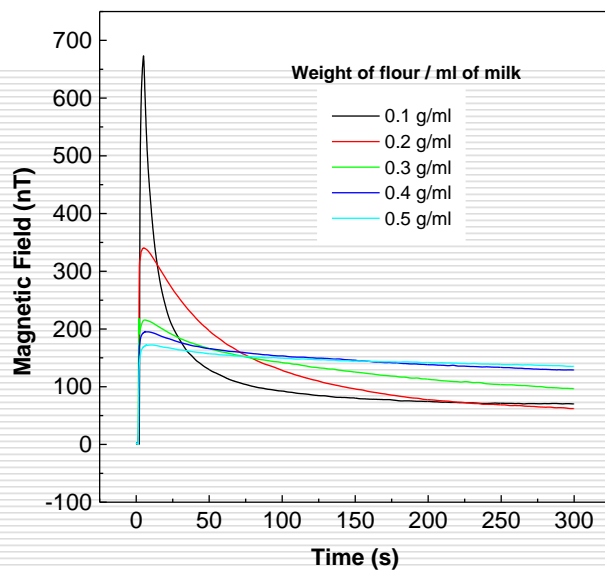
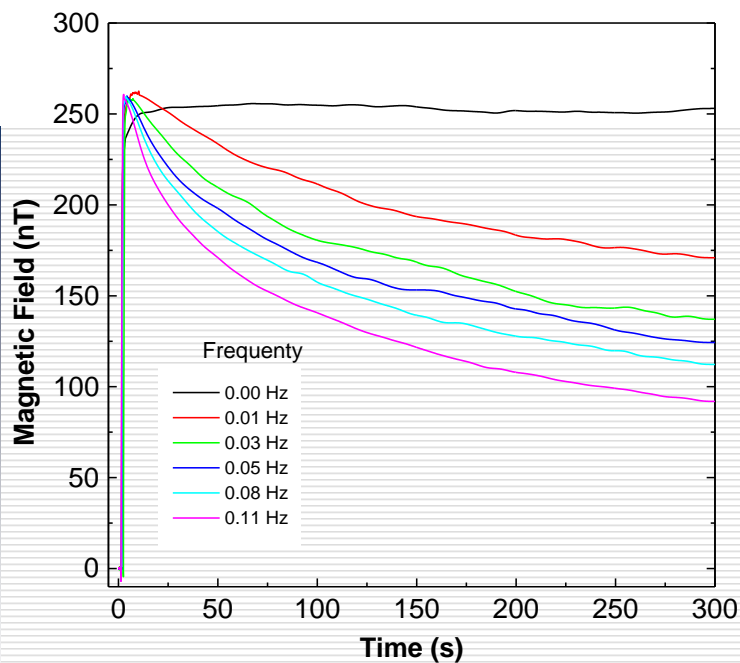
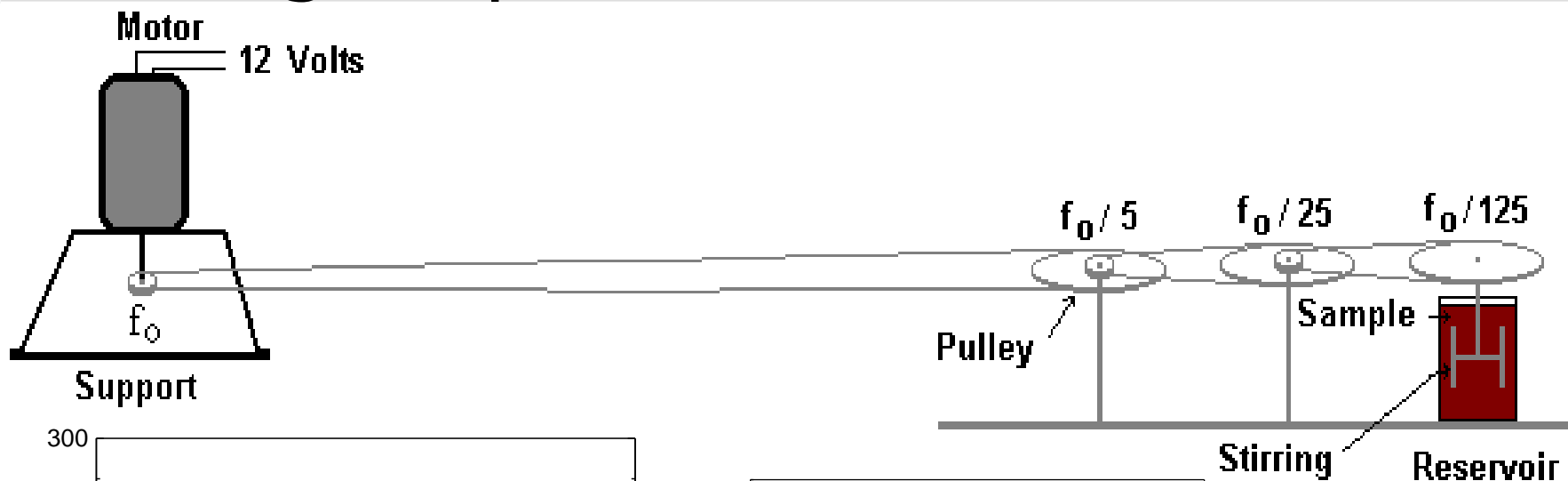
Arranjo Experimental para Medida da Magnetização em Grandes Volumes



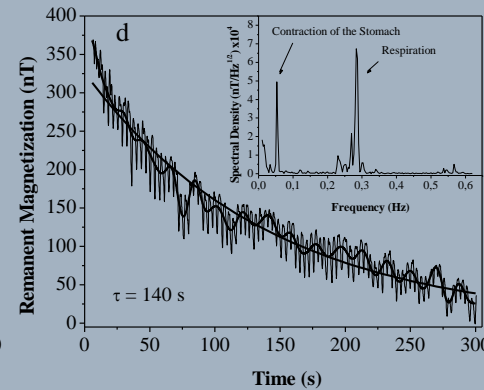
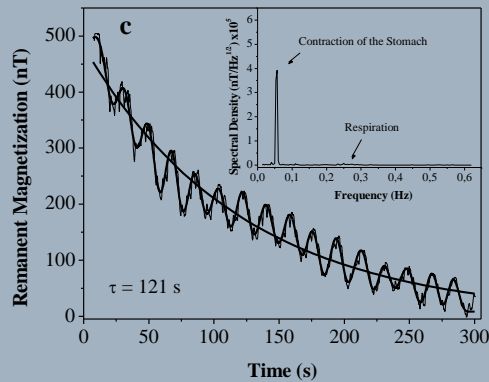
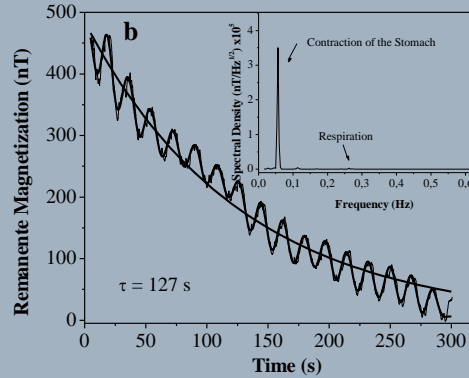
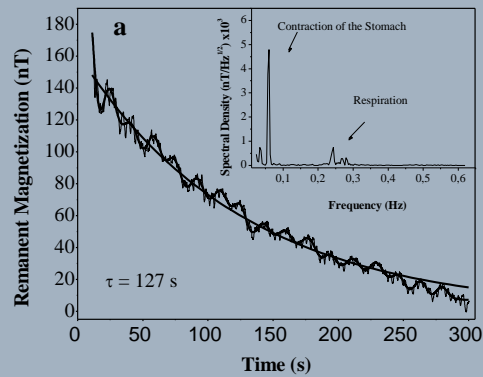
Processo de Relaxação



Montagem para testar o Sistema

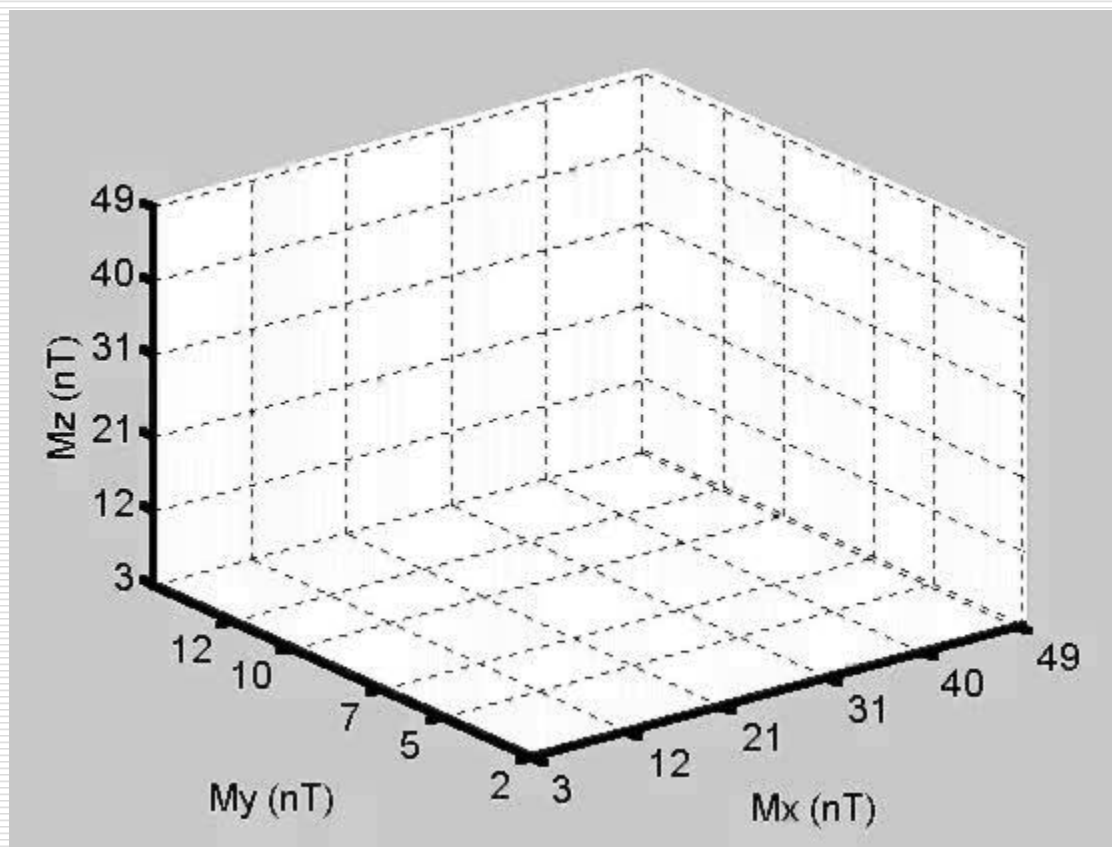


Decaimento da Magnetização Devido à Atividade Mecânica do Estômago

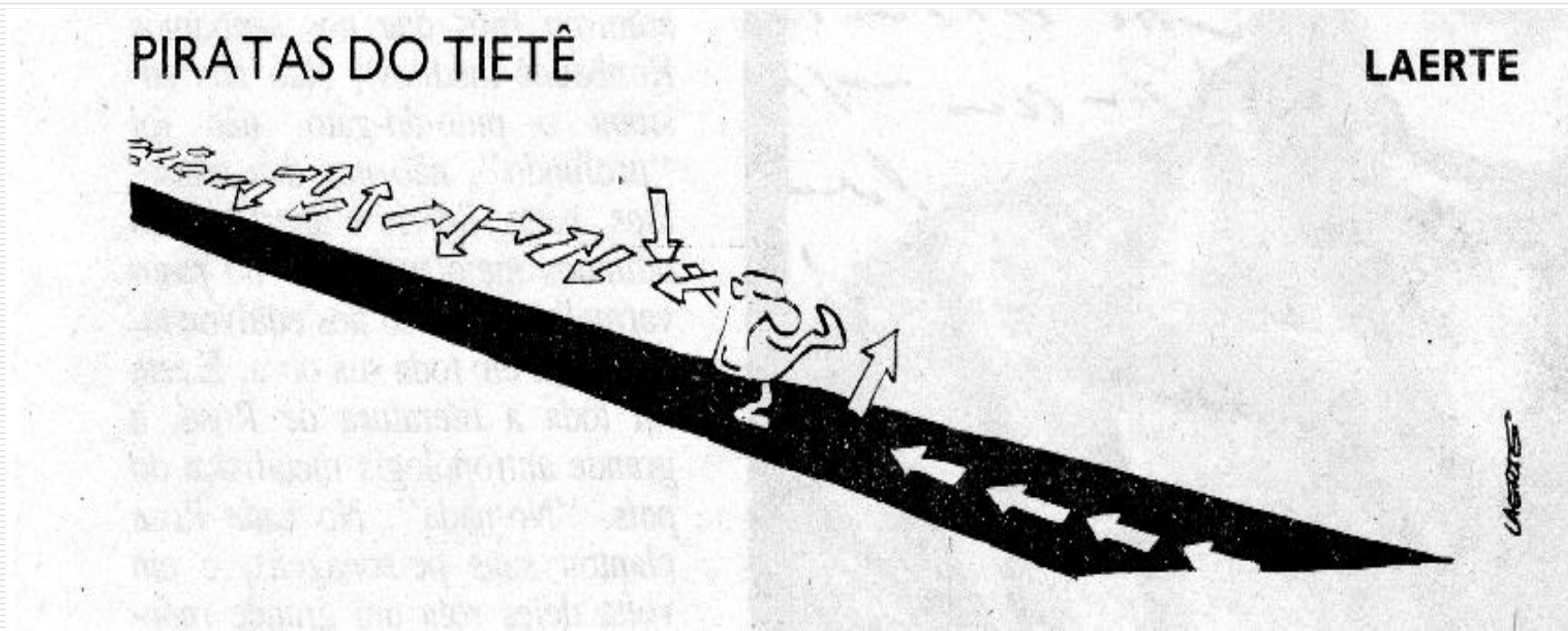


Medidas realizadas em um intervalo de 40 minutos

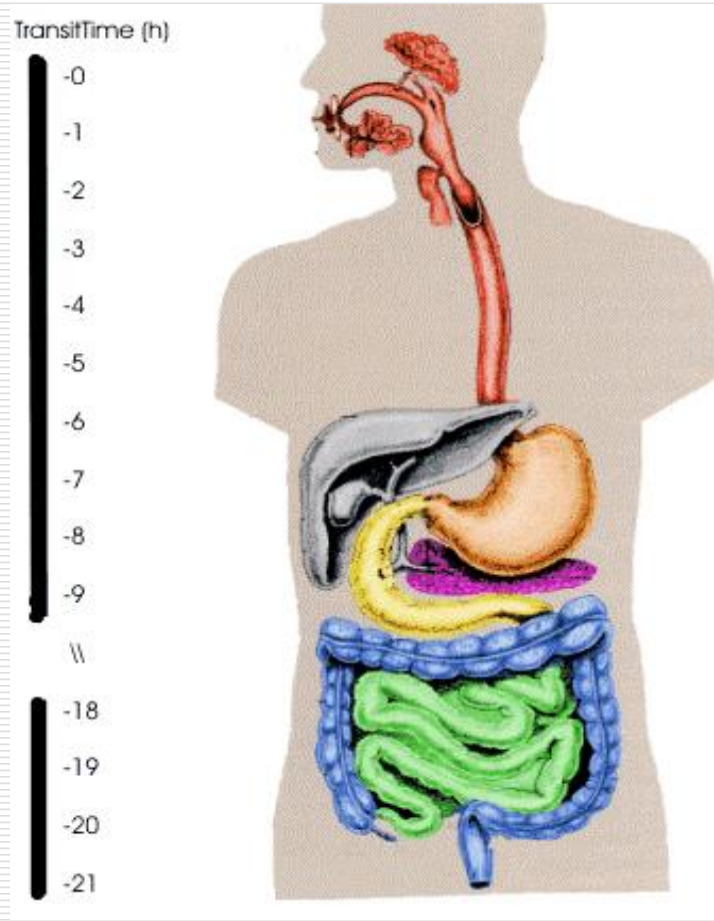
Magnetização Remanente



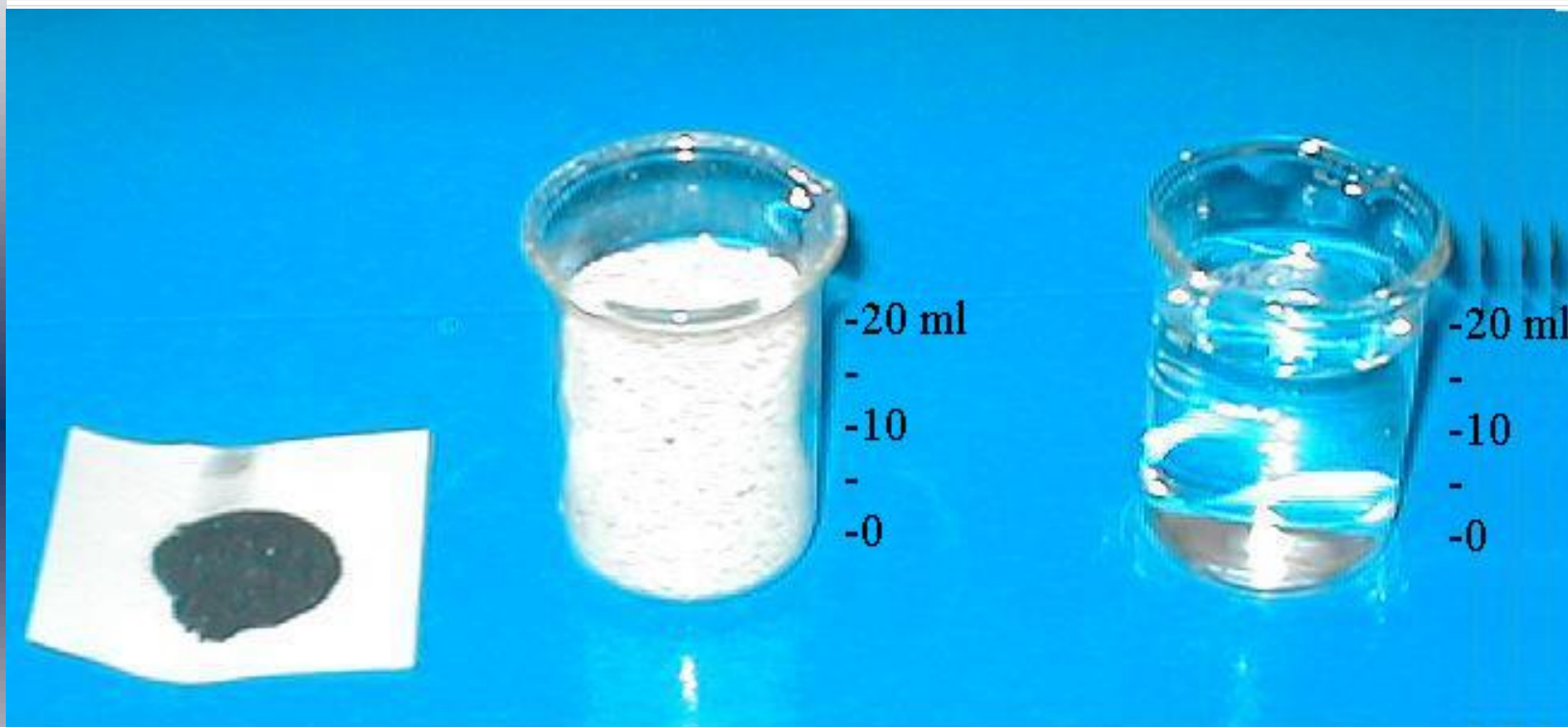
Um Possível Mecanismo Agitador do Estômago



Reflexo Gastrocólico



Alimento Teste

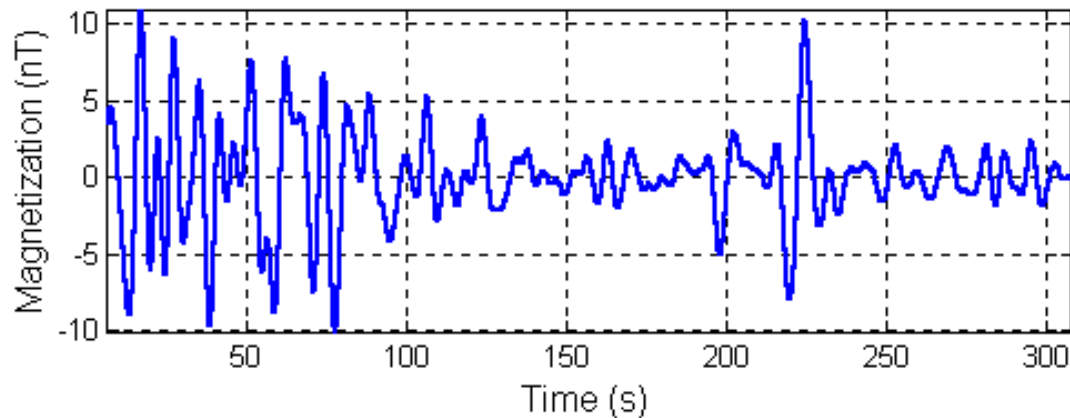
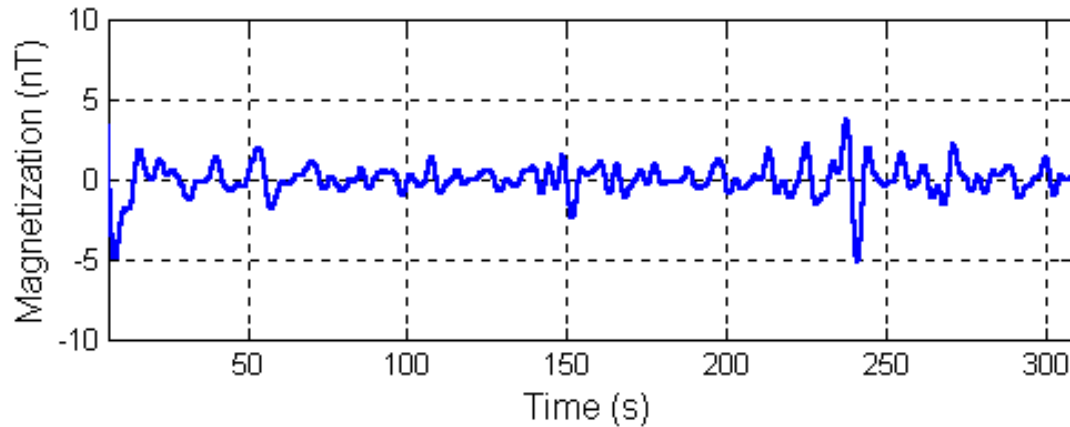


3 g magnetita
(Fe_3O_4)

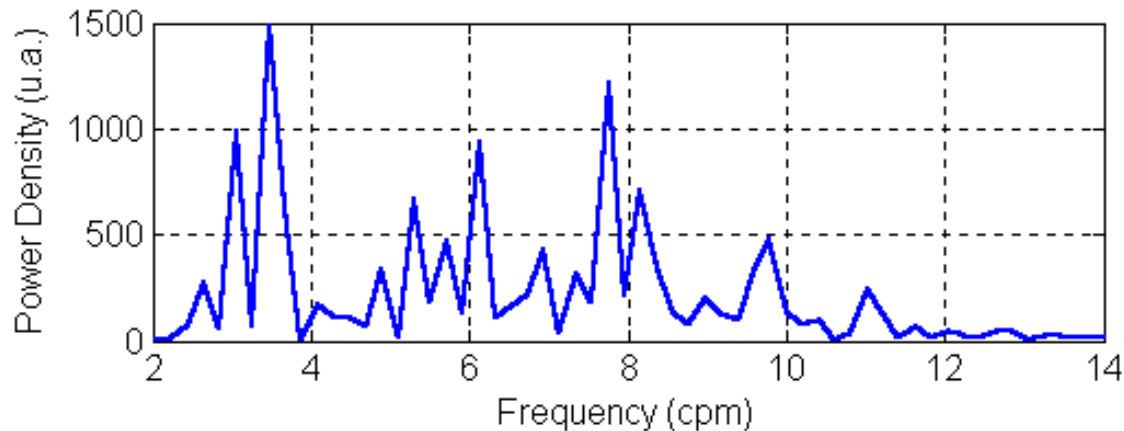
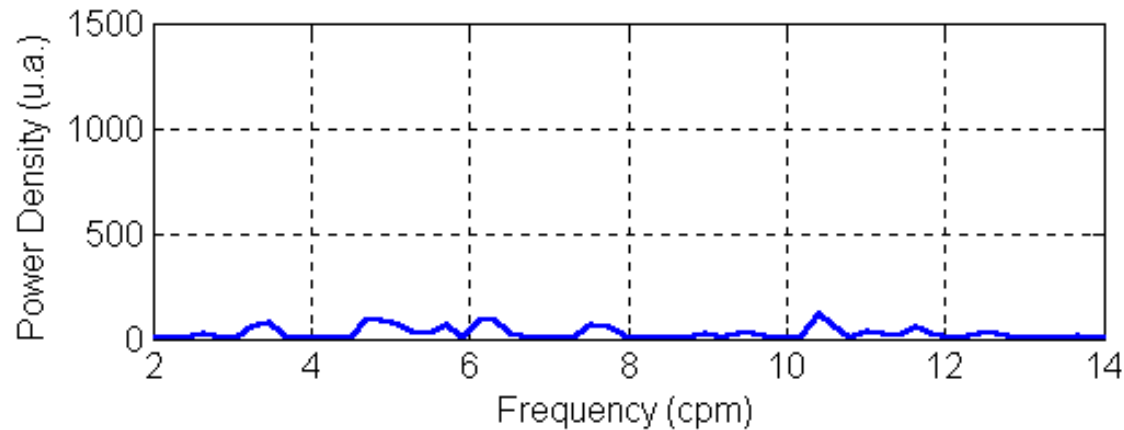
15 g aveia

Água

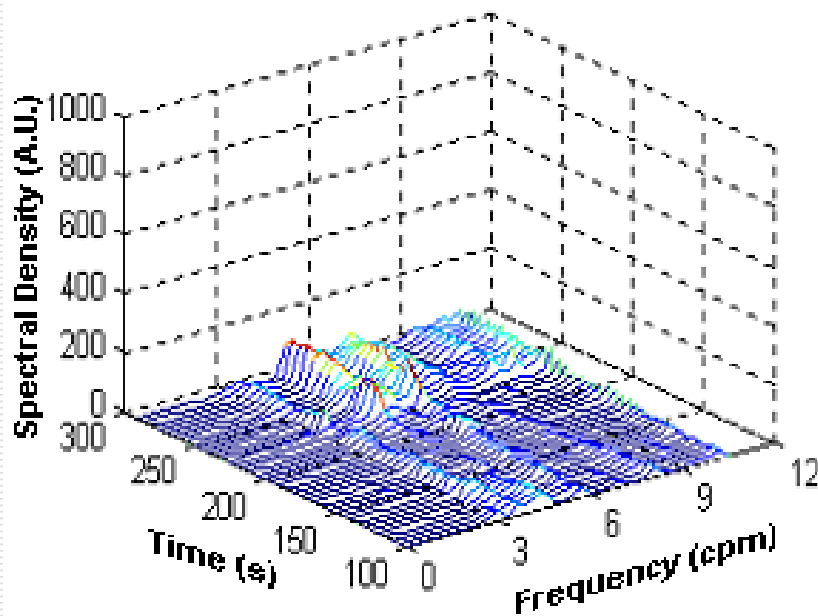
Sinal Magnético da Região do Ceco



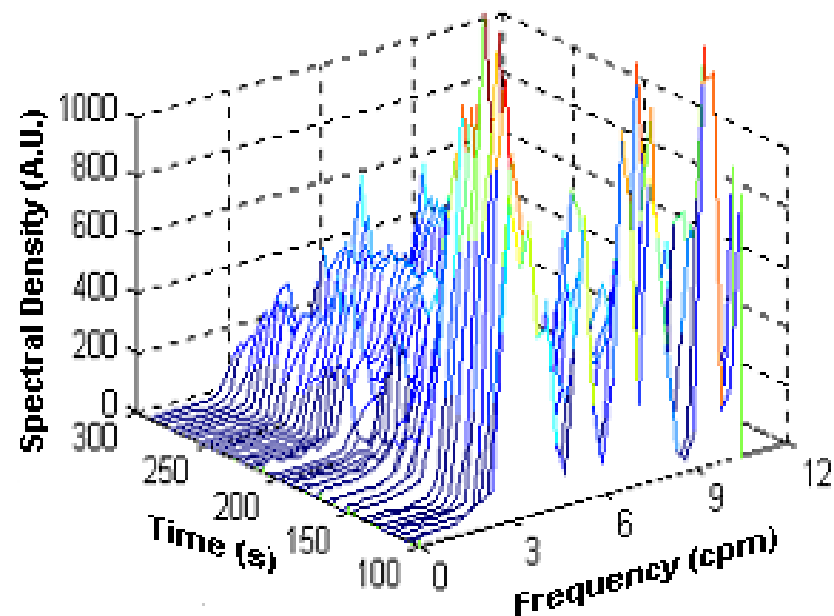
Transformada de Fourier do Sinal Magnético



Evolução da Componente Z do Campo magnético

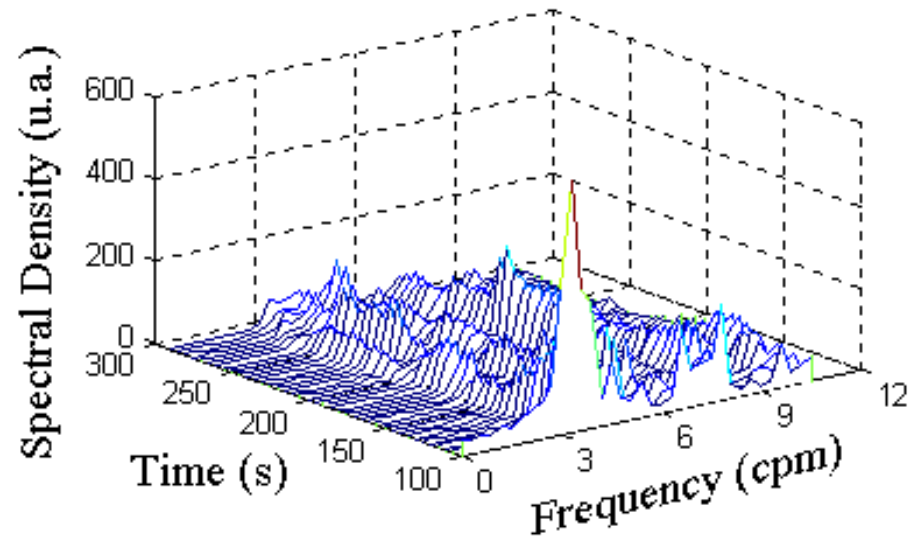


Antes da
Refeição

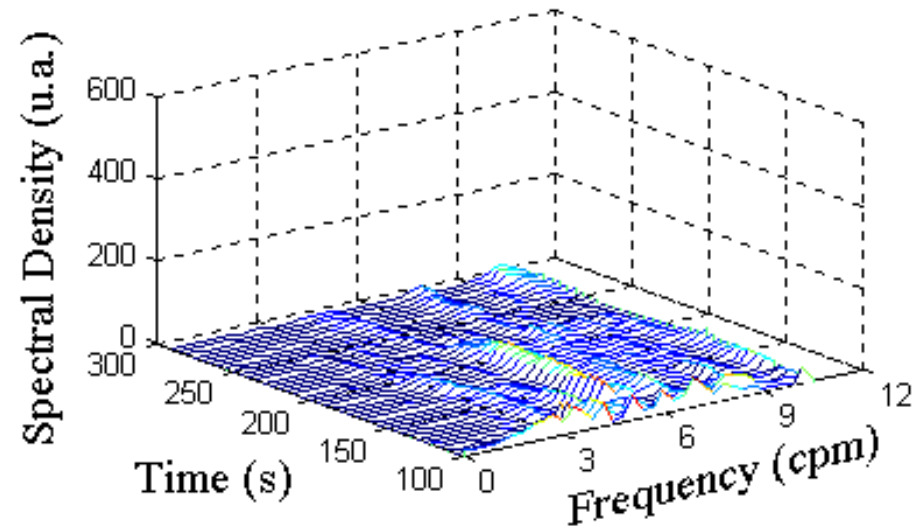


Depois da
Refeição

Efeito de uma droga sobre o reflexo gastrocólico (Buscopan 40 mg)



Antes



Depois



Universidade Estadual Paulista

“Júlio de Mesquita Filho”

Instituto de Biociências de Botucatu



Imagens Magnéticas de Farmacêuticas Sólidas no Trato Gastrointestinal Humano

Luciana A. Corá¹, Fernando G. Romeiro¹, Madileine F. Américo²,
Oswaldo Baffa², Murilo Stelzer³, José Ricardo de Arruda Miranda¹

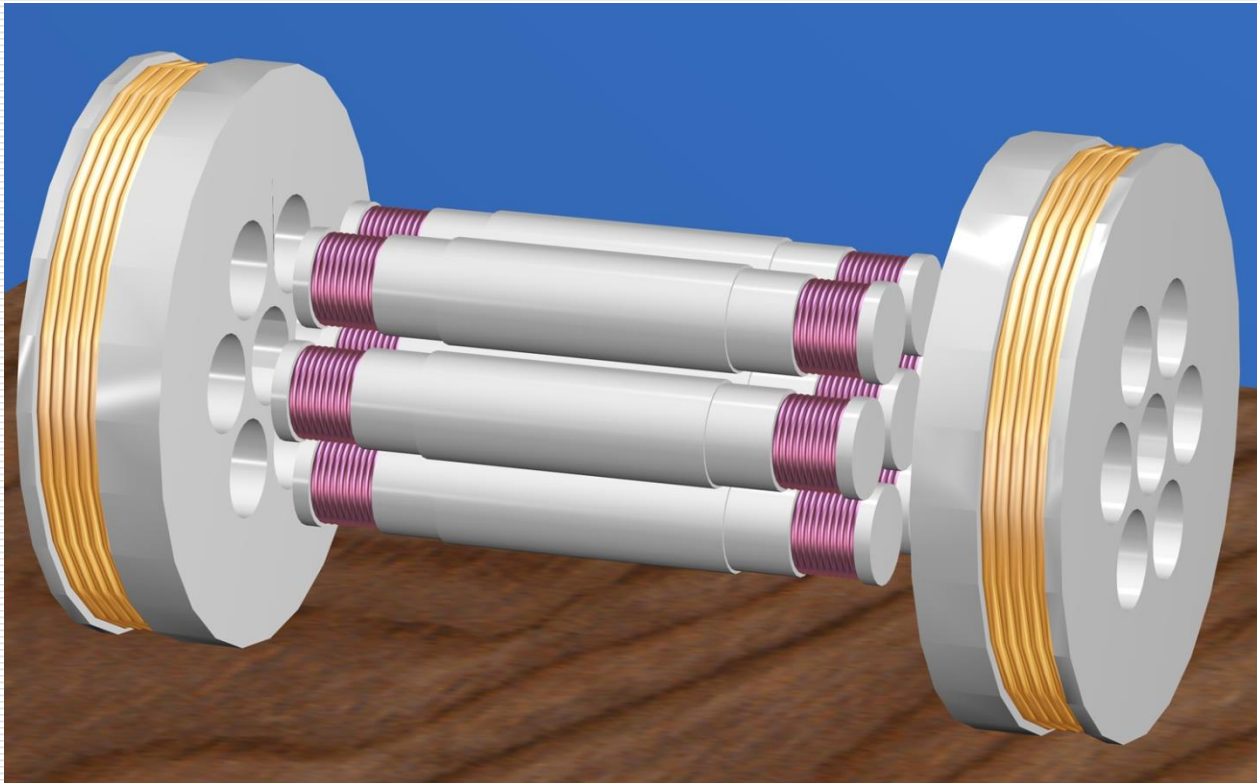
¹ Universidade Estadual Paulista – UNESP, Botucatu

² Universidade de São Paulo – USP, Ribeirão Preto

³ Universidade Federal de São Carlos – UFSCar



BAC multi-sensor



Materiais e Métodos

Obtendo as formulações magnéticas

→ Pílulas

Compressão Direta

1,00 g ferrita (MnFe_2O_3); 0.63 g excipientes

Eudragit® E100 e S100

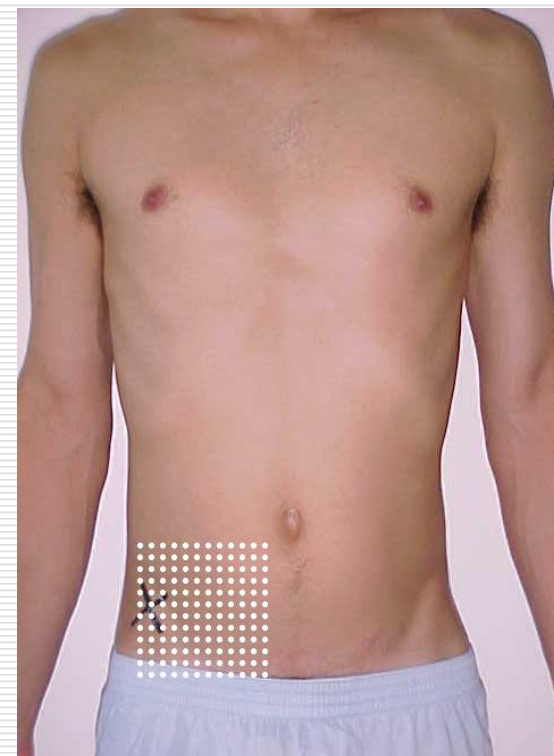
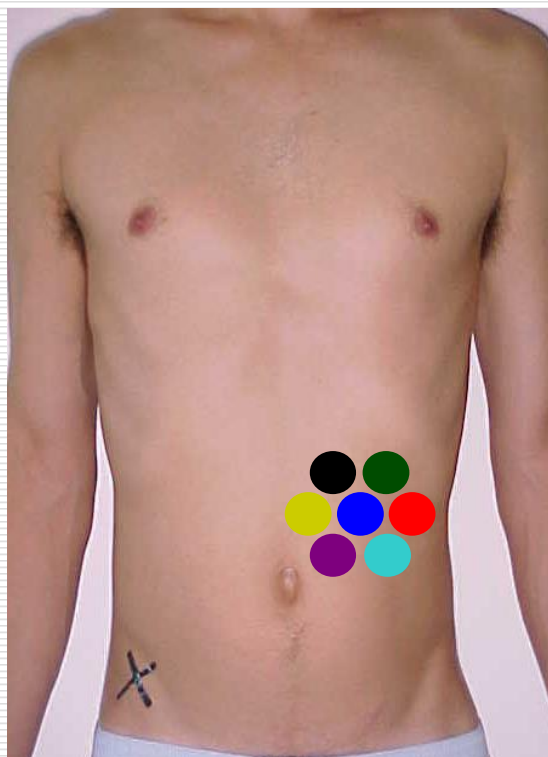
→ Cápsulas

Coni-Snap™, size nº 00

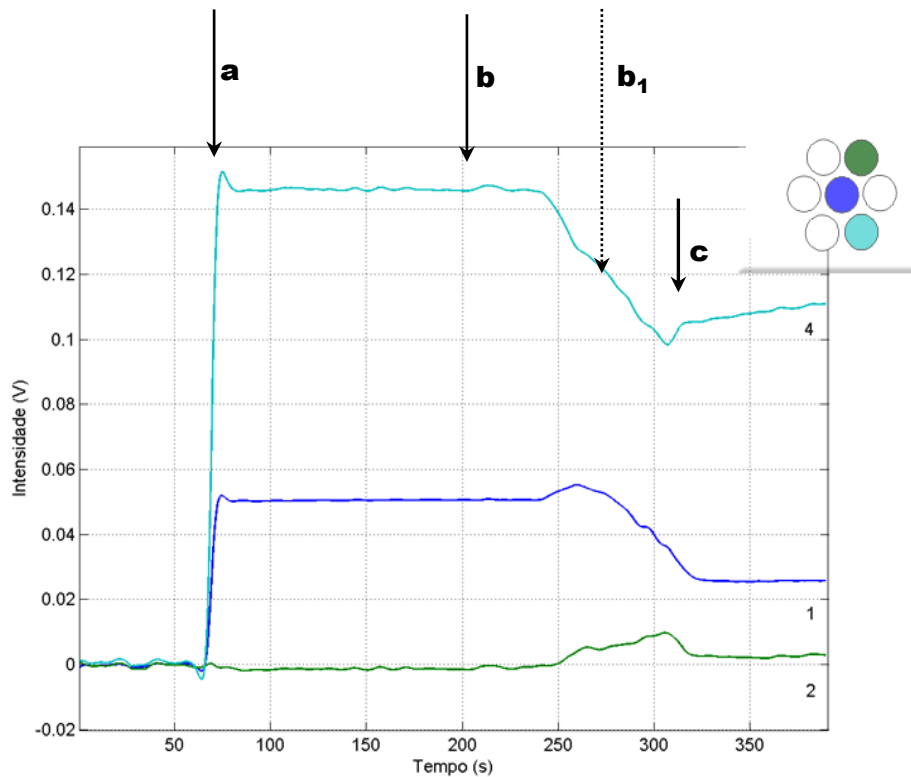
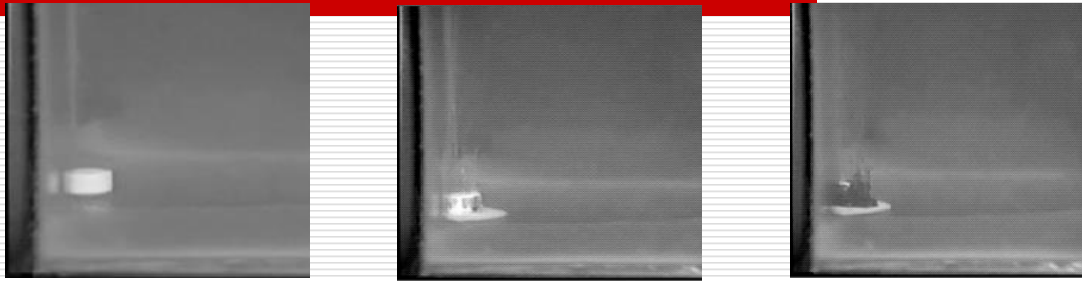
1,00 g ferrita (MnFe_2O_3); 0.53 g excipientes

Eudragit® S100

Posicionamento dos sensores para aquisição dos sinais



Desintegração *in vitro*



Desintegração do comprimido no estômago

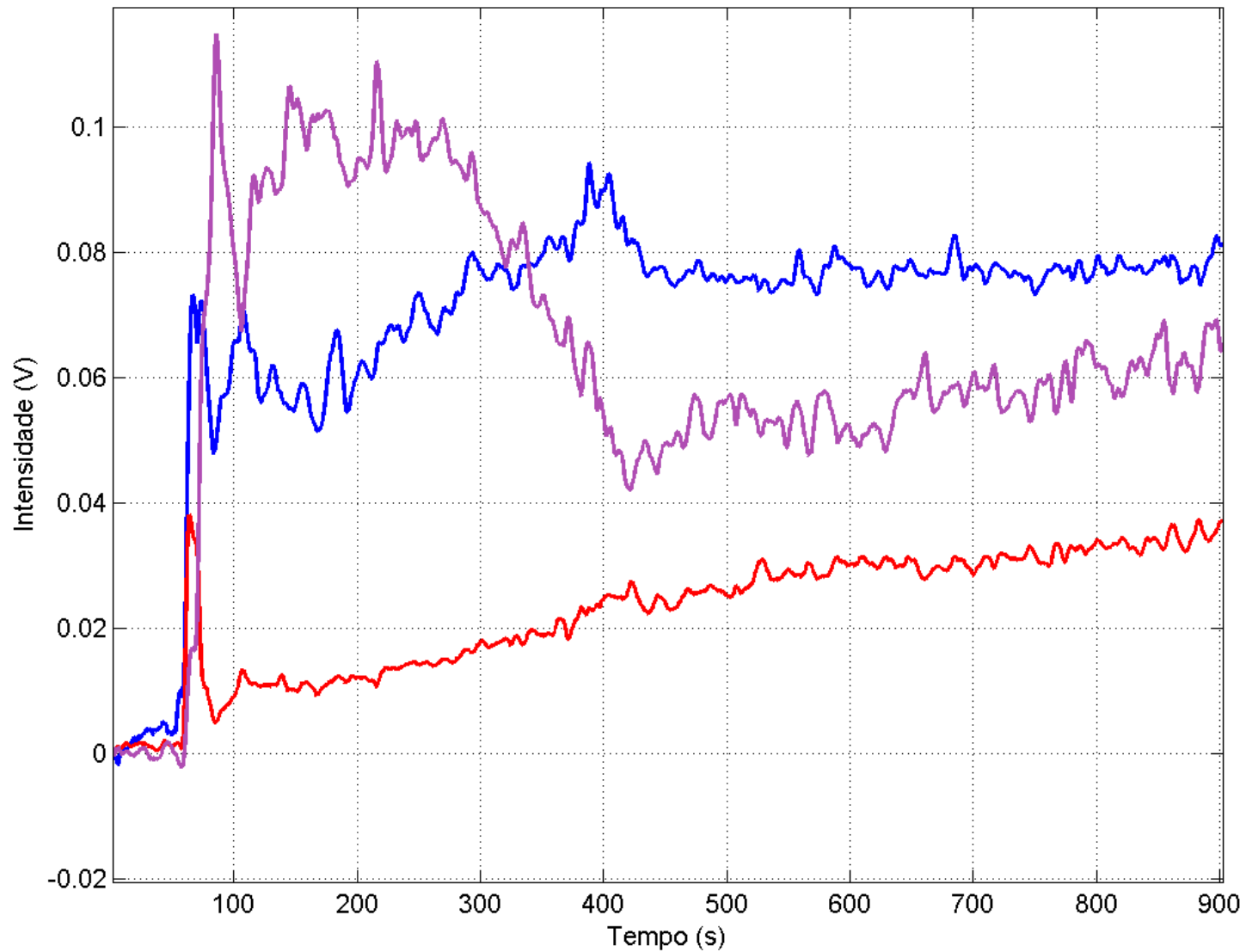


Imagem da desintegração da pílula magnética na região do estômago



t_1



t_2



t_3



t_4

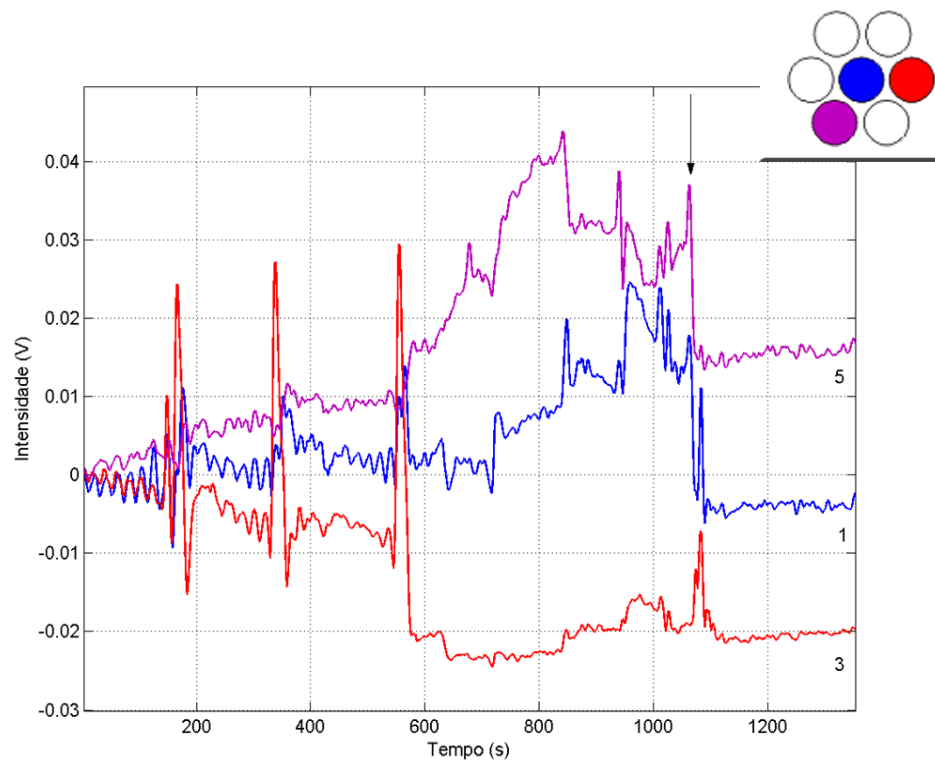
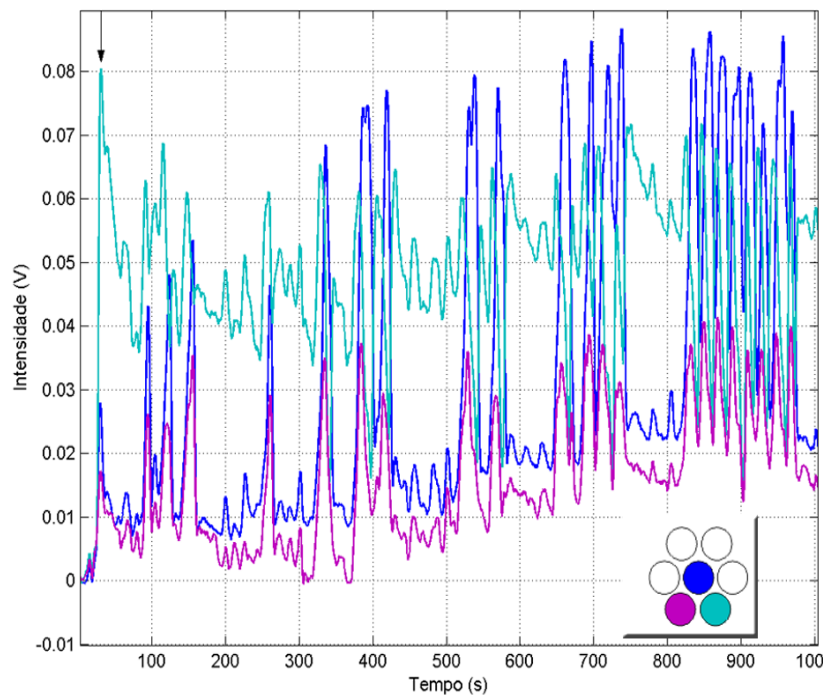


t_5

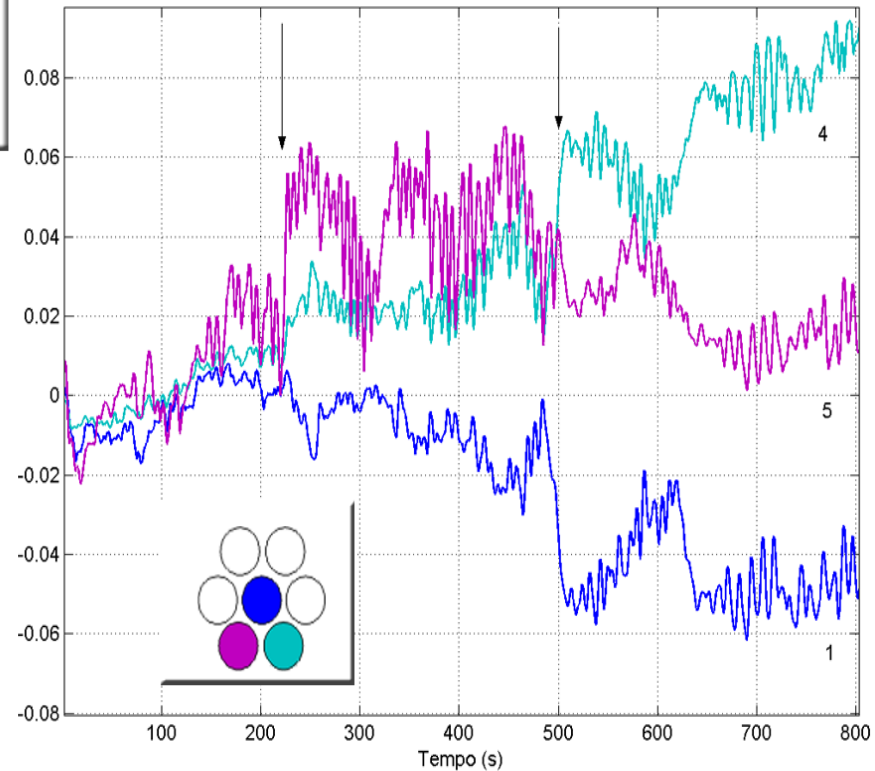
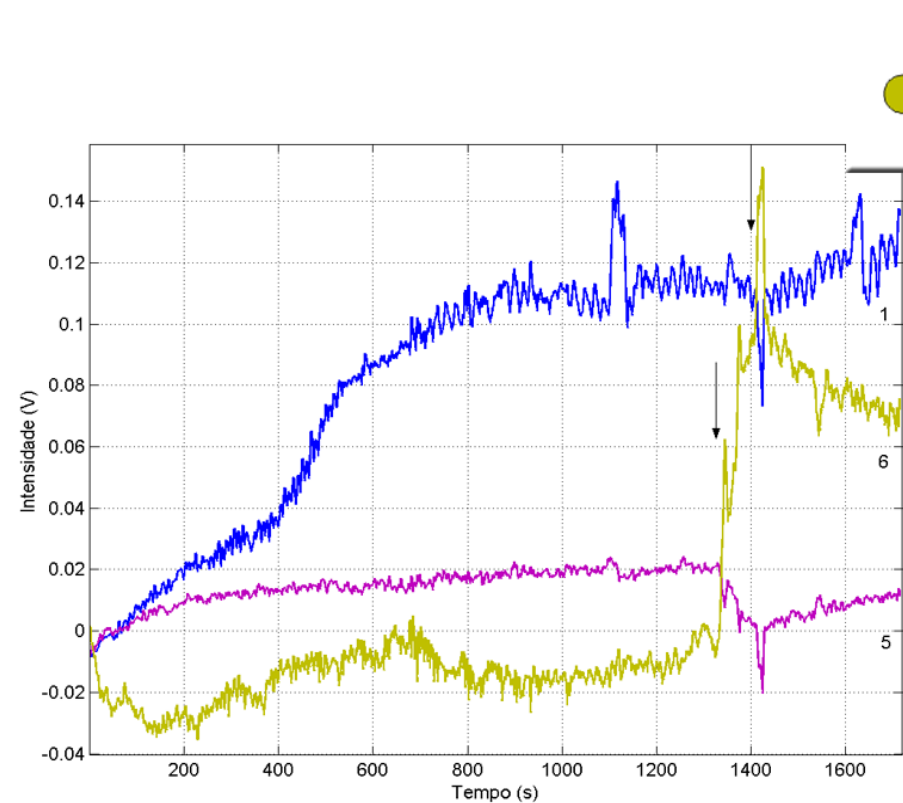


t_6

Tempo de retenção gástrica



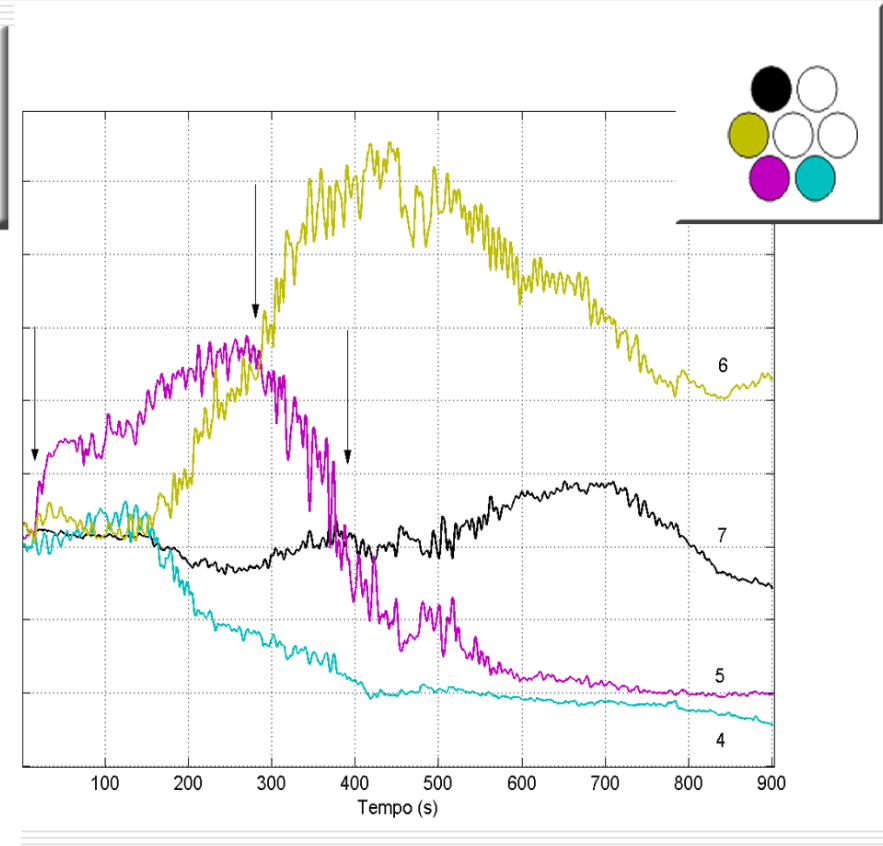
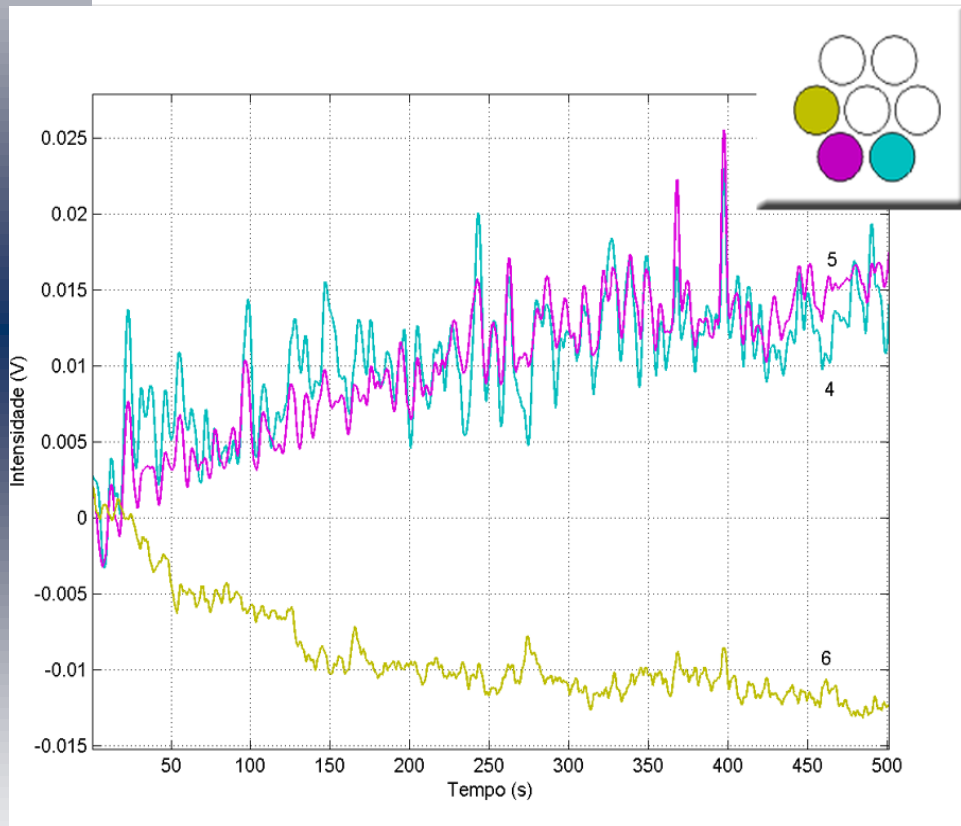
Chegada da pílula magnética no cólon



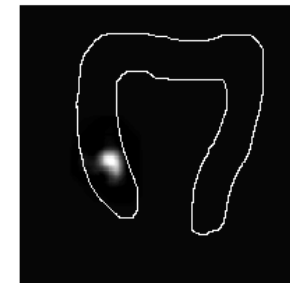
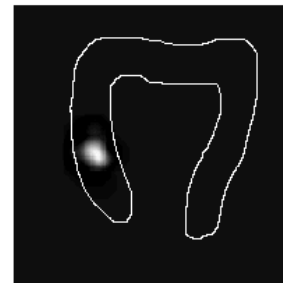
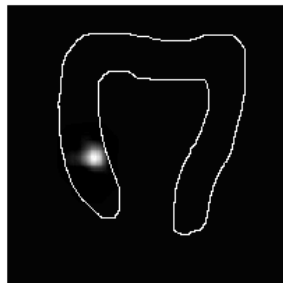
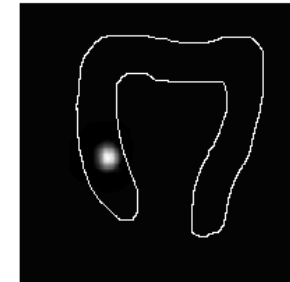
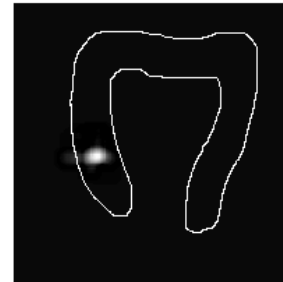
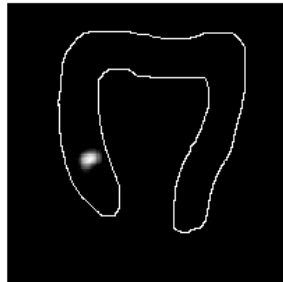
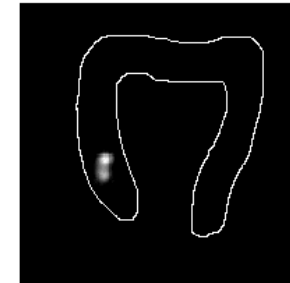
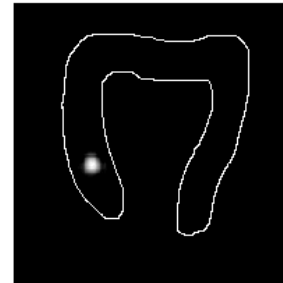
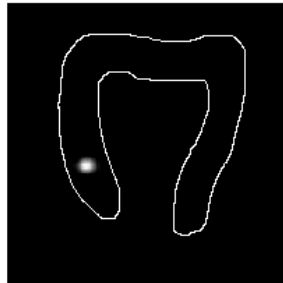
Tempo de trânsito gastrintestinal e Tempo de Desintegração

Subject	Time (min)			
	GRT	SITT	OCTT	DT
1	70	121	191	152
2	130	150	280	90
3	60	160	220	60
4	42	200	242	52
5	32	145	177	184
6	45	180	225	60
7	55	210	265	120
8	27	180	207	70
9	80	180	260	90
X	60.11	169.55	229.66	97.55
SD	31.31	28.11	34.91	45.70
CV (%)	52.08	16.57	15.20	46.84

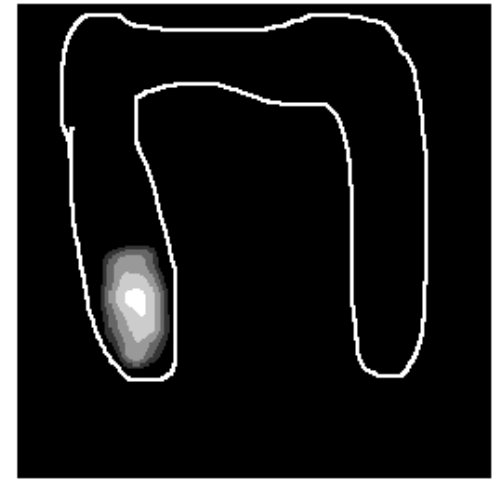
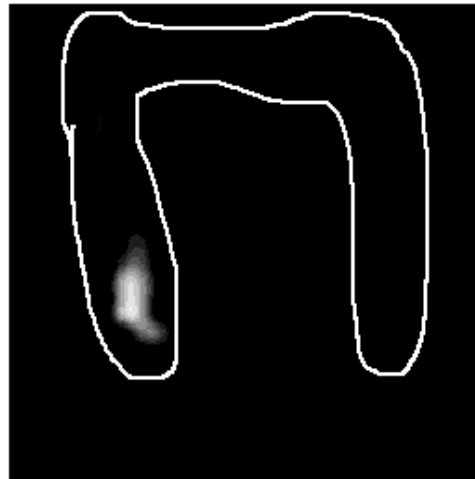
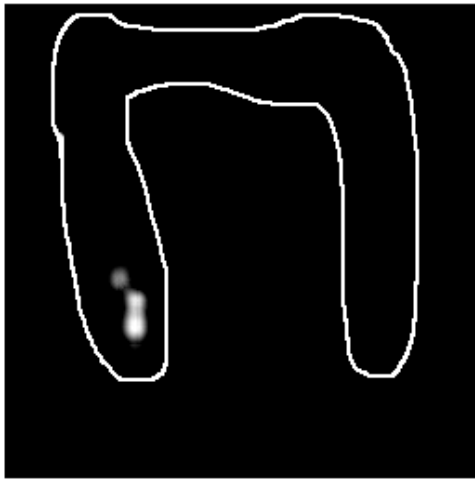
Desintegração do comprimido c6lon



Seqüência de imagens da desintegração do comprimido no estômago

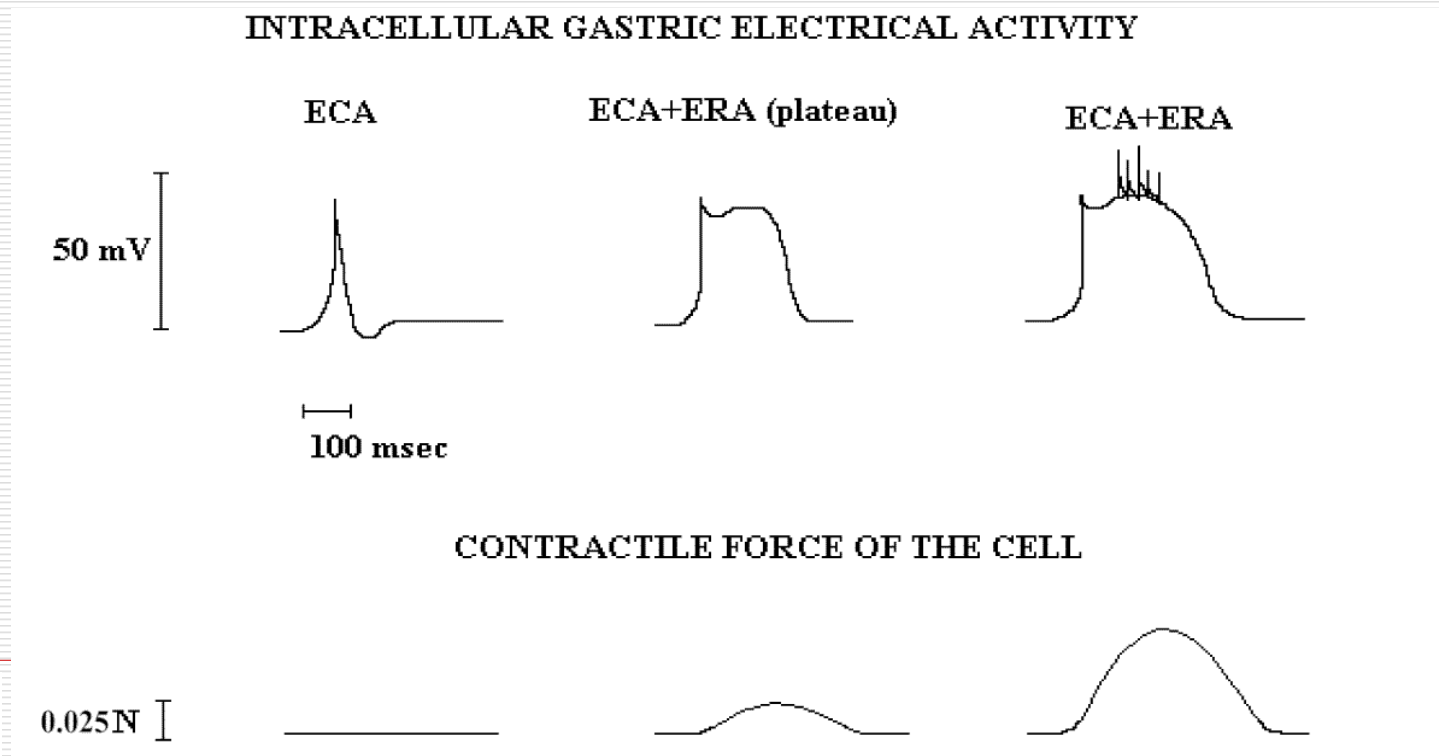


Desintegração do cápsula magnética no cólon



Atividades Eletromecânicas

- ❑ BER/EC → 50mHz, sempre presente, modelada por um dipolo de corrente, equação do cabo e osciladores
- ❑ ERA → acoplamento eletromecânico
- ❑ Ondas de contração → Função do estomago

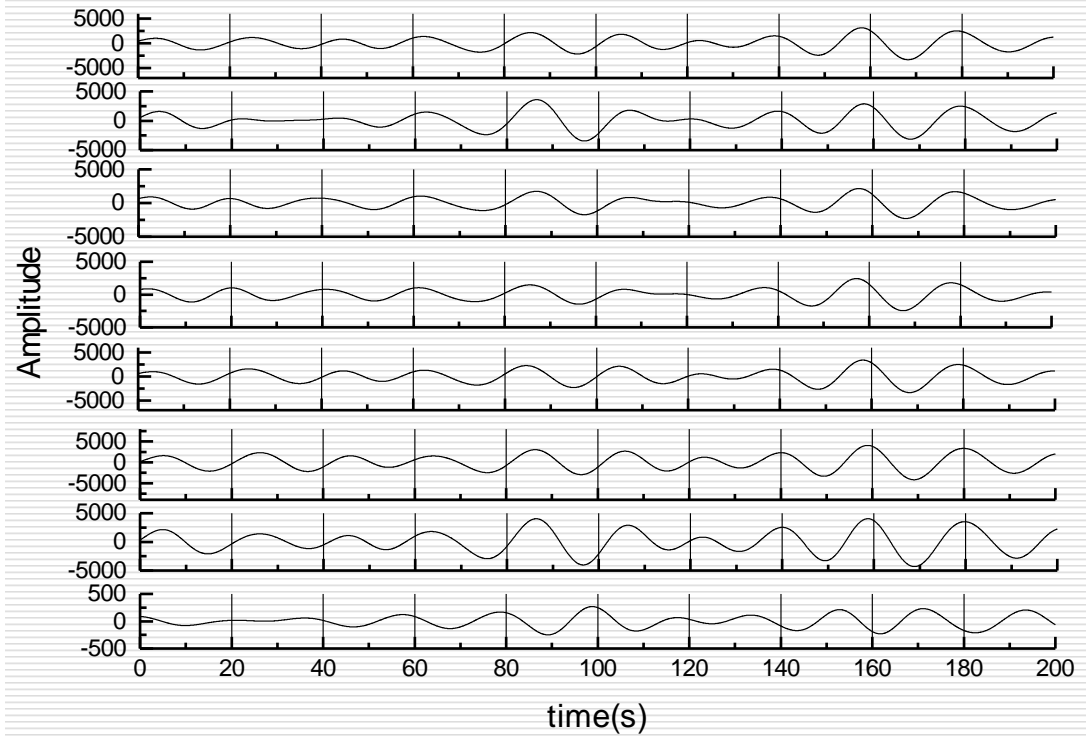
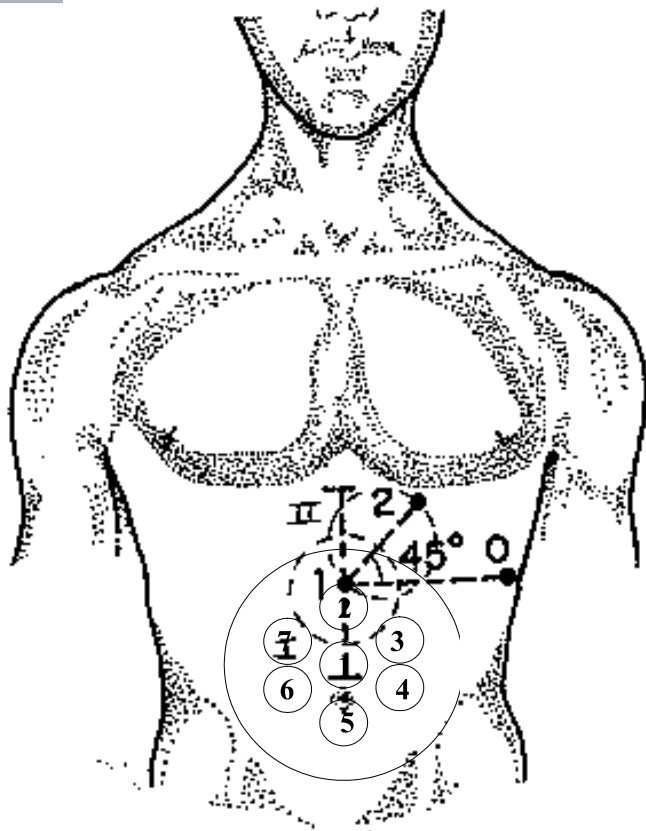


Biogradiometro Monocanal

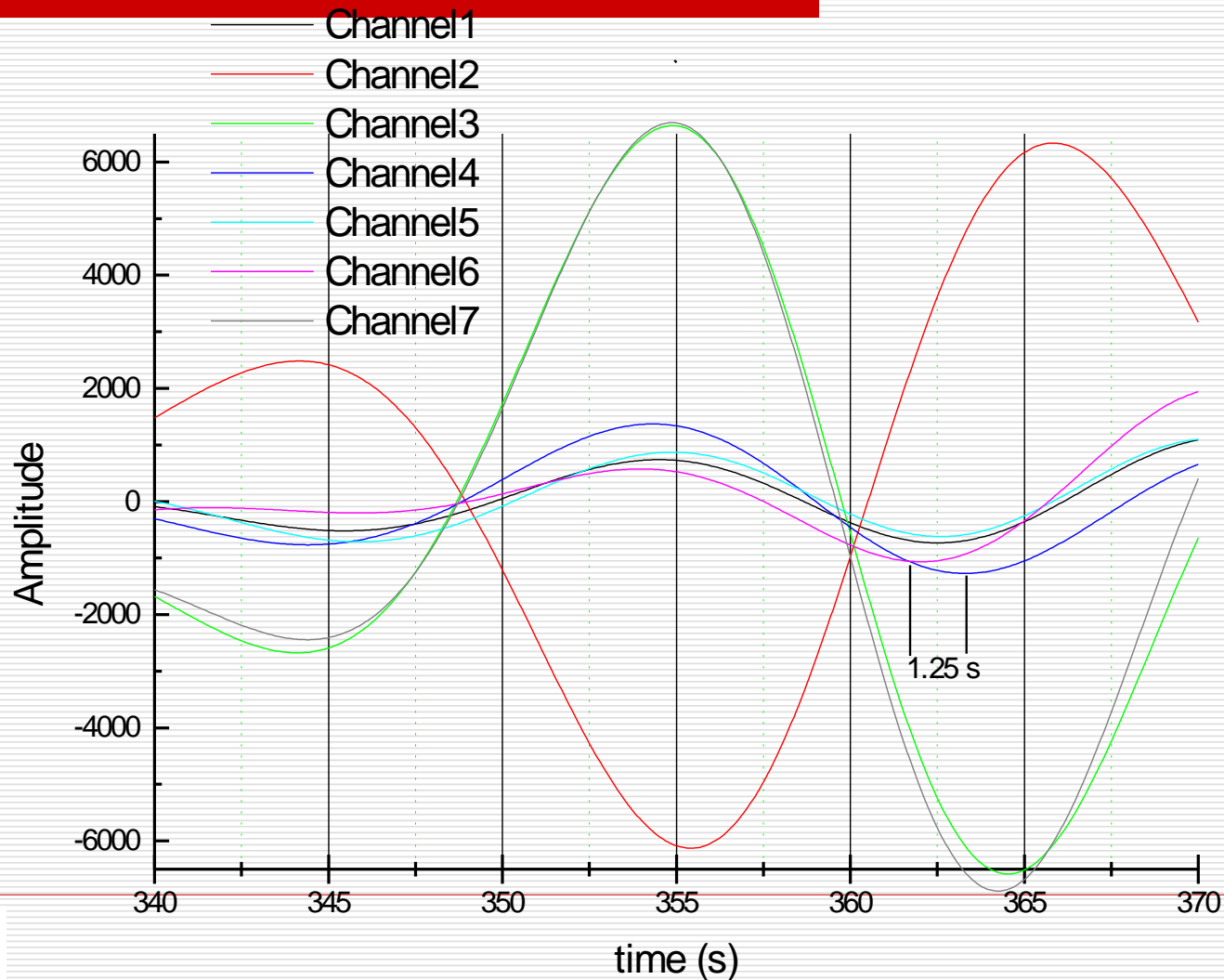


Vista de um biogradiometro monocanal, com um SQUID, gradiometro com 2,5 cm de diâmetro e 7 cm de linha de base, posicionado sobre o estomago para medidas de MGG. A componente vertical vertical do campo é medida.

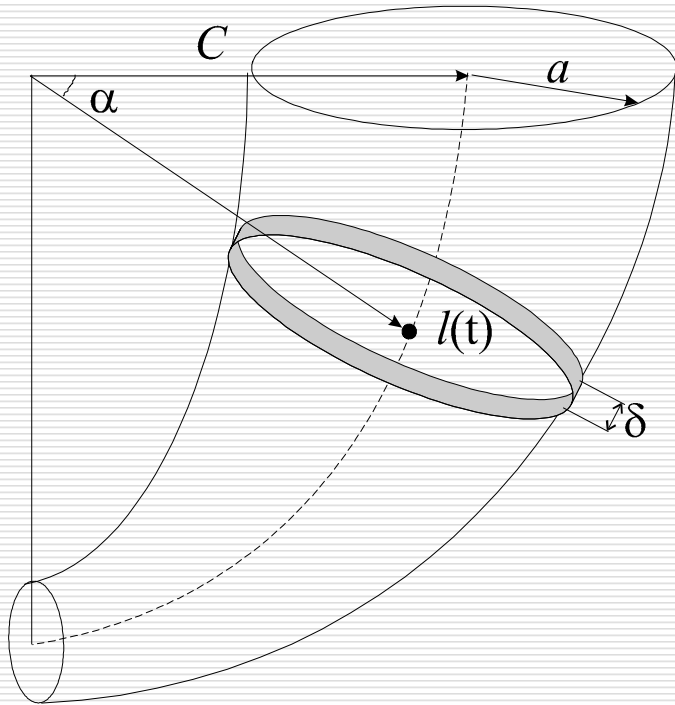
Posicionamento dos sensores e eletrodos para MGG & EGG --Registros Típicos



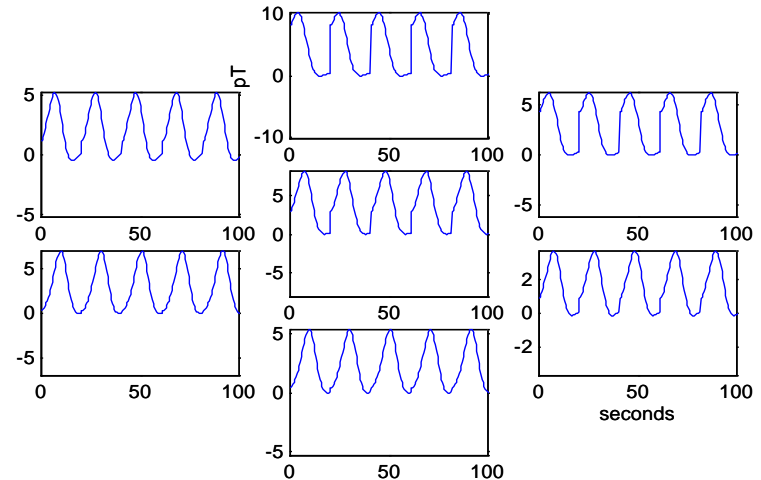
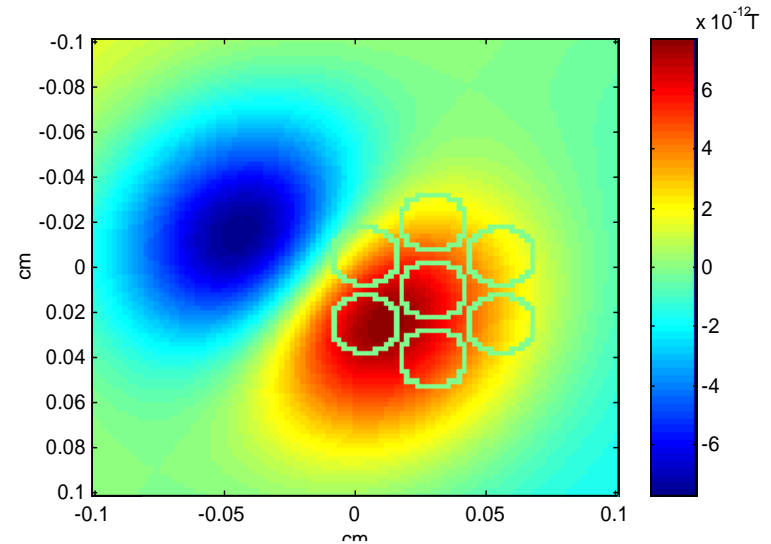
Segmento de Traçado de MGG Mostrando Defasagem



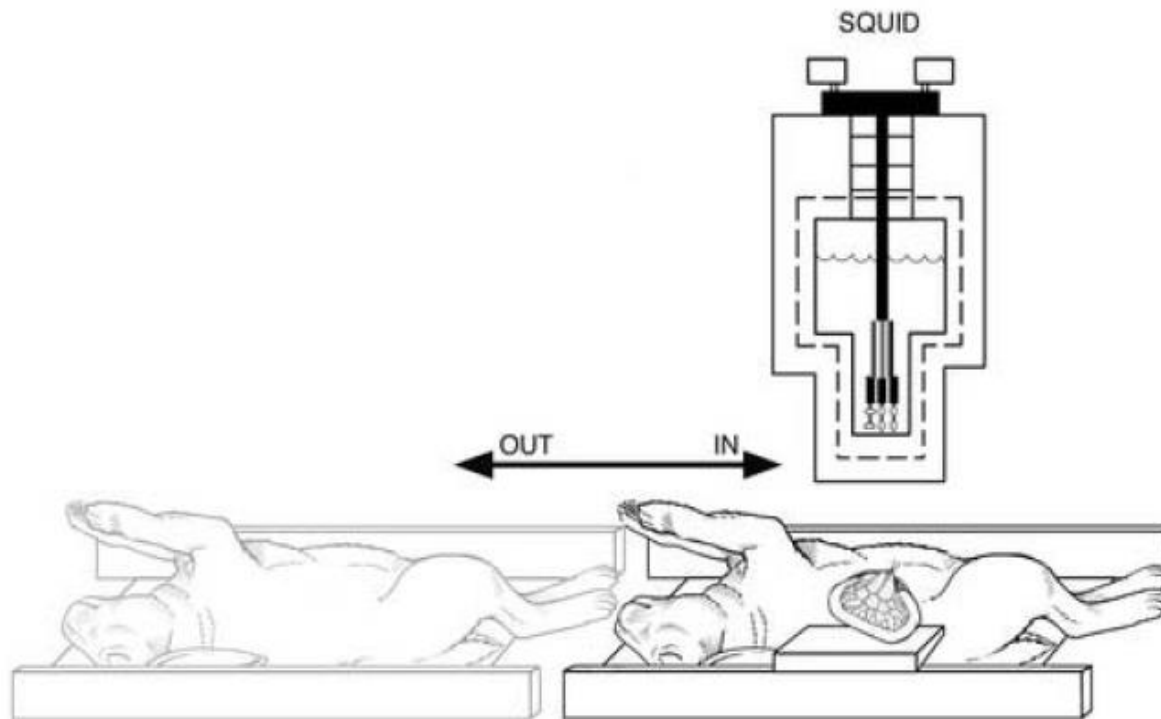
Modelando a Atividade Elétrica



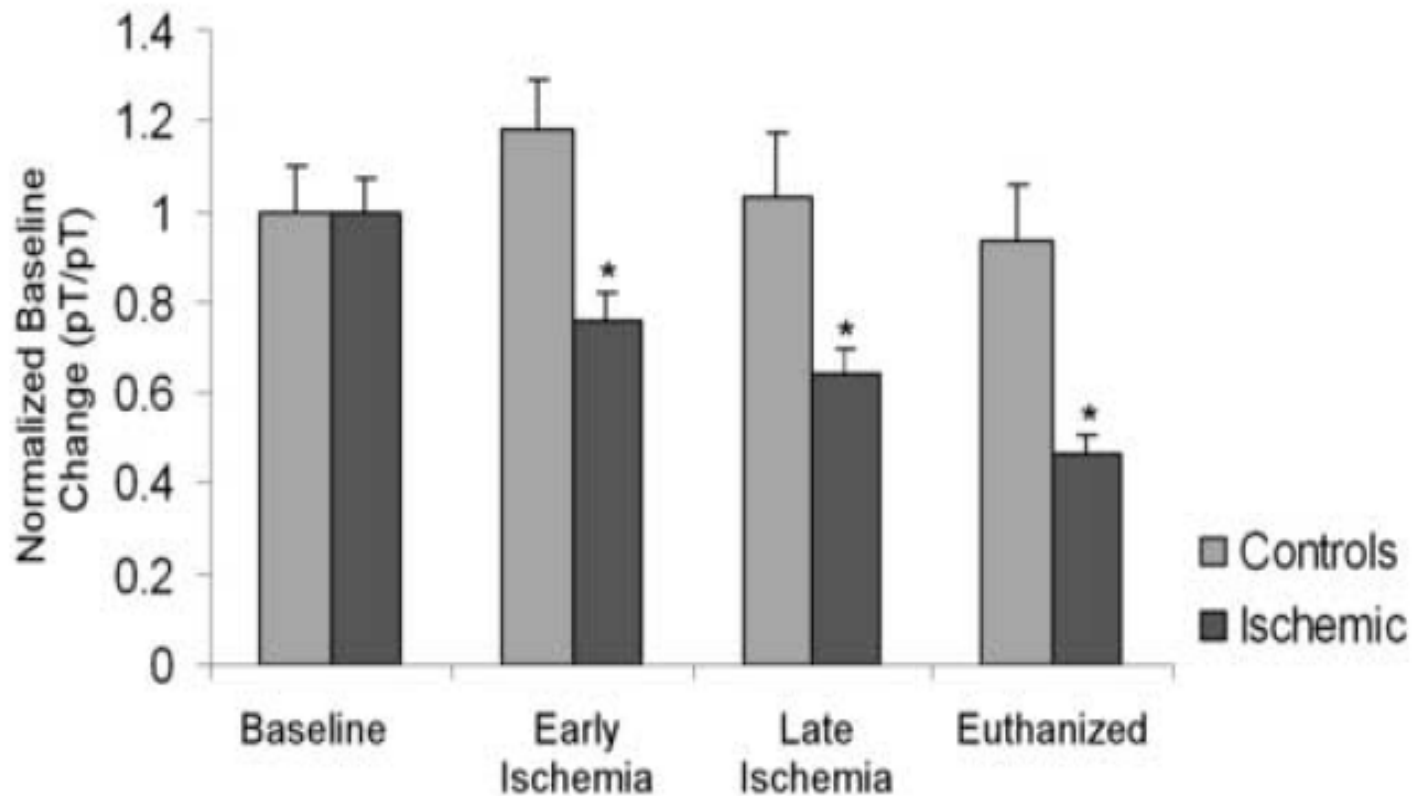
$$B = \frac{Q\mu_0}{4\pi R^2} \frac{1}{\left(1 - \frac{a^2}{R^2}\right)}$$



Estudo da isquemia



A isquemia leva a um diminuição da amplitude do sinal



Outras pesquisas

- ❑ Weitches et al, “drug delivery”
- ❑ Bradshaw et al, isquemia mesentérica

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