



Translumbosacral Anorectal Magnetic Stimulation (TAMS)

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OBJECTIVES

- Neurophysiologic assessment of Anorectum/Pelvic floor
- What is TAMS?
- Evidence for TAMS in assessment of
 - Fecal Incontinence
 - Spinal Cord Injury
- TAMS vs Pudendal Nerve Latency
- How to perform TAMS
 - Equipment & Patient Preparation
 - Marking sites & Performing Test
- Interpretation
- Nuances & Pitfalls

Anorectal Neurophysiologic Tests/Evaluation

- **Electromyography**

- Surface
- Single Fiber Needle
- Concentric Needle

- **Nerve Conduction**

- Pudendal Nerve Terminal Motor Latency
- Perineal Nerve Terminal Motor Latency
- Spinal Motor Latency

- **Motor & Somatosensory Evoked Potentials**

- Sensation - Anal Electrical Stimulation
- Sensory Conduction - Balloon Distention/Electrical
- Anal/Rectal Cortical Evoked Potentials
- Cortico-rectal & Cortico-anal Motor Evoked Potentials (MEP)
- Translumbar/Transsacral Anorectal Magnetic Stimulation (TAMS)

ELECTROMYOGRAPHY-Pros & Cons

- Needle EMG although useful has not be widely accepted in research and clinical practice

-WHY ?

- Painful, requiring multiple insertions
- Poorly tolerated
- Variability in results; ?Reproducible
- Interpretation/Reliability
- Surface EMG may be useful BUT
 - Movement artifacts
 - Contact problems in FI

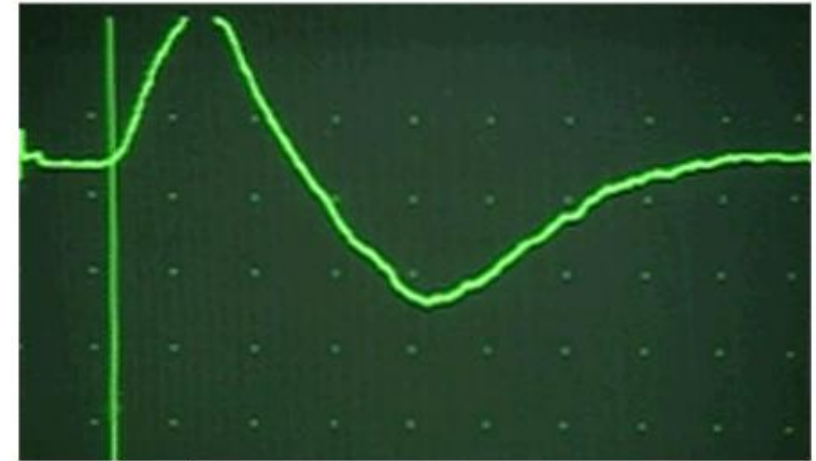


Pudendal Nerve Terminal Motor Latency



4pn01.mov

Pudendal Nerve Terminal Motor Latency



Stimulus Contraction
2.5 mSec.

4pn02.mov

AGA Position Statement -PNTML

“The PNTML cannot be recommended for evaluation of patients with fecal incontinence”

BECAUSE

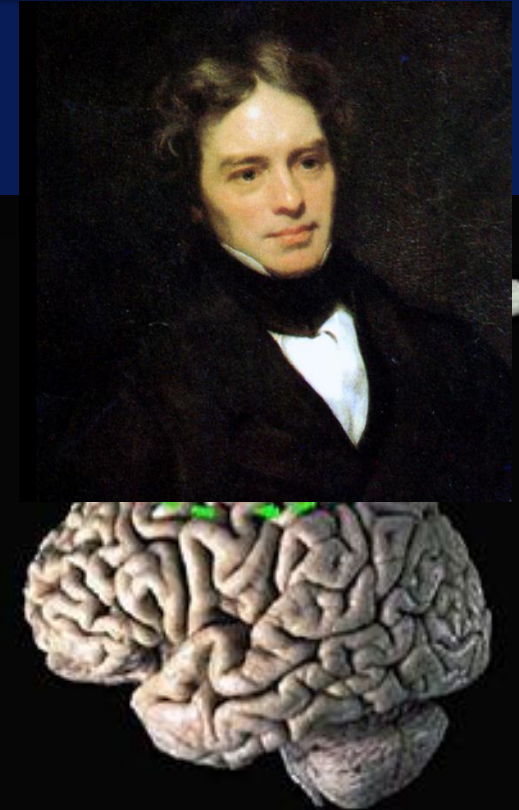
- Low specificity & sensitivity
- Operator dependent technique
- Poor Correlation with manometry
- Test does not predict surgical outcome.

Diamant et al *Gastroenterology* ;March, 1999

There is a need for an alternative test that overcomes these drawbacks and measures the entire spino-anorectal nerves

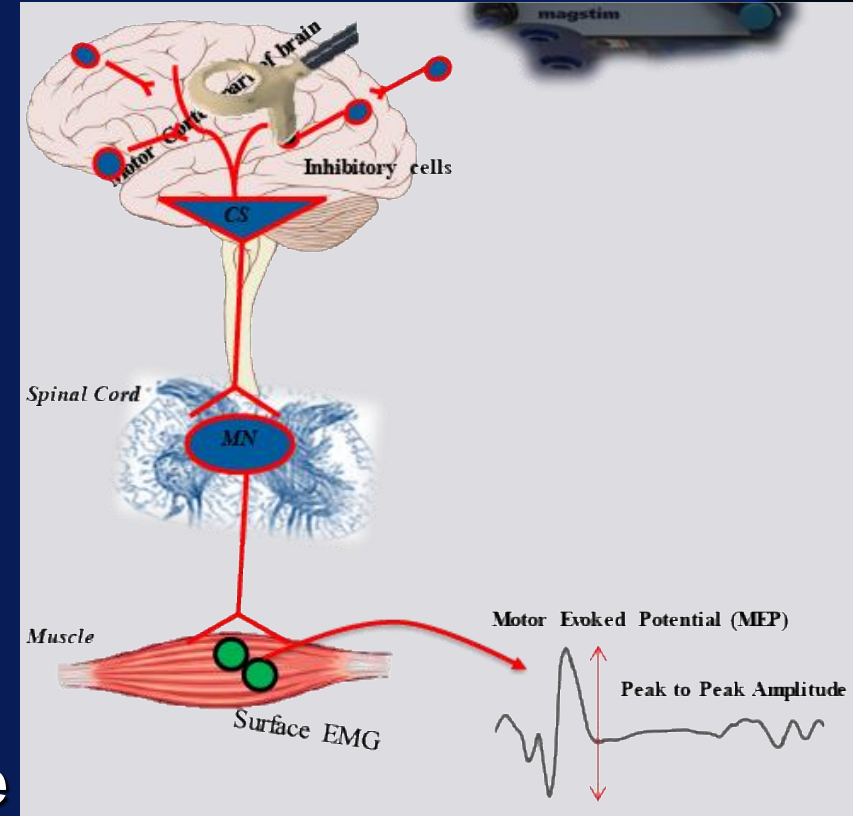
Origin & What is TMS?

- 1831- Michael Faraday discovered principles of magnetic induction
- 1985- Anthony Barker, Sheffield, First developed electromagnet for human use
- Electrical current through a coil induces MRI-strength magnetic field perpendicularly
- Magnetic field passes 2-3 cm into cortex or peripheral nerves inducing electrical currents in nerves and axons
- This stimulates firing of nerve cells, release of neurotransmitters and activation of muscles



Principles of TAMS

- Magnetic Stimulator coil induces pulse magnetic fields that upon contact with conducting tissue- "Nerves"-produces Excitatory Postsynaptic Potentials (EPSP).
- EPSP evoked in spinal roots induces activation of peripheral nerve axons.
- The activated nerves in turn activate muscles
- The discharges evoked in muscles manifests as muscle contraction of anus and rectum
- If a surface electrode is positioned near the muscle the electrical response from the muscle can be recorded as the muscle or Motor Evoked Potential (MEP)



Advantages of Magnetic Stimulation

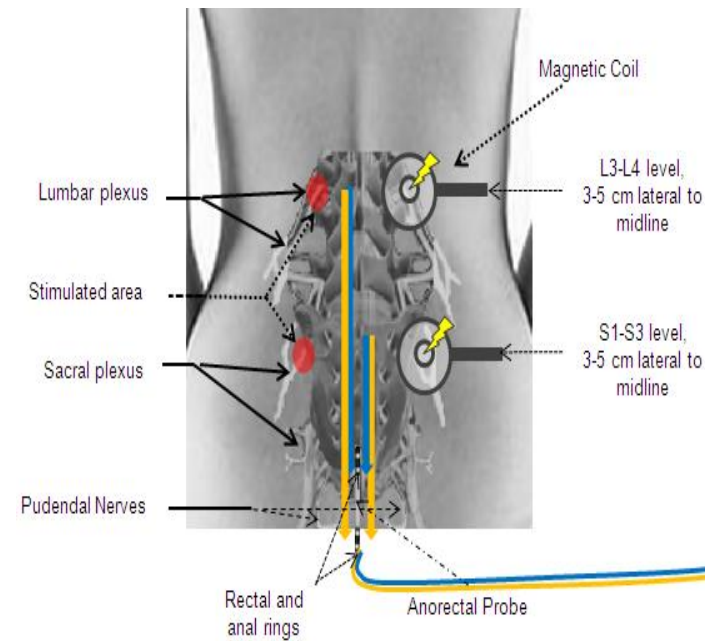
- **Non-Invasive**
- **Focal**
- **Limited penetration depth**
- **Pain Free**
 - **The induced electrical current does not pass through the skin where most pain fibers are located, but remains in coil**
- **Magnetic energy is more diffuse unlike electrical stimulation with high current densities underneath**
- **Stimulates deep peripheral nerves without causing pain**

TAMS Test- Facts

- What is TAMS Test?
 - TAMS is a NEW anorectal physiological test designed to comprehensively evaluate the anorectal and pelvic floor neurophysiology
- What are the indication for TAMS Test?
 - Fecal Incontinence
 - Urinary Incontinence
 - Anorectal neuropathy and pain (Levator ani syndrome)
 - Spinal cord Injury
 - Pelvic floor disorders

TAMS Test-Facts

- What does TAMS Measure?
 - TAMS measures the peripheral nerve conduction of the lumbar and sacral plexus nerves that innervate the Anorectum
- How does TAMS measure nerve conduction?
 - It uses non-invasive magnetic stimulation to evoke 8 separate motor evoked potentials (MEP) to comprehensively assess all nerves that supply the anorectum
 - Right Lumbo-rectal & Right Lumbo-anal MEPs
 - Left Lumbo-rectal & Left Lumbo-anal MEPs
 - Right Sacro-rectal and Right Sacro-anal MEPs
 - Left Sacro-rectal and Left Sacro-anal MEPs
- Is TAMS test Reimbursed by Insurance?
 - Yes, CPT code: 95908 and 97032



TAMS-Equipment

Magnetic stimulator



Magnetic coil



Neurophysiology Recorder



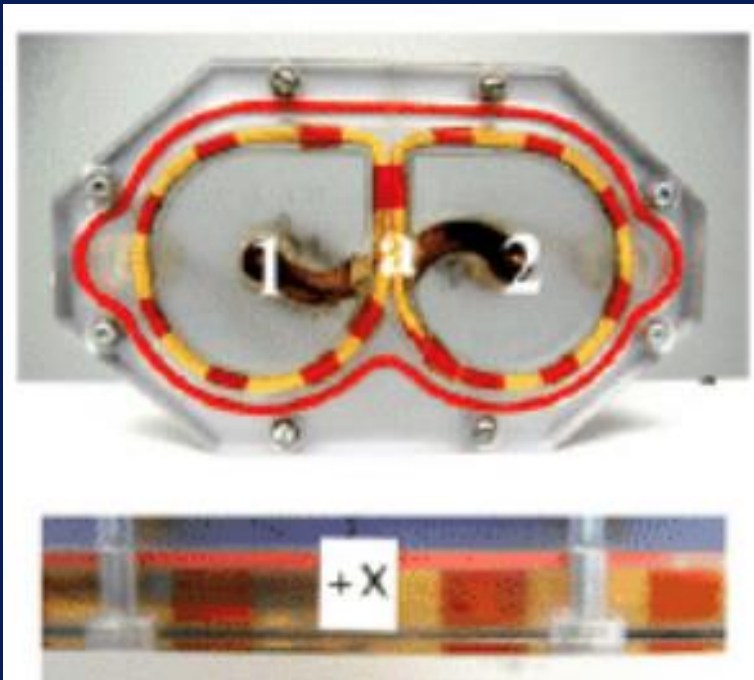
Anorectal MEP probe



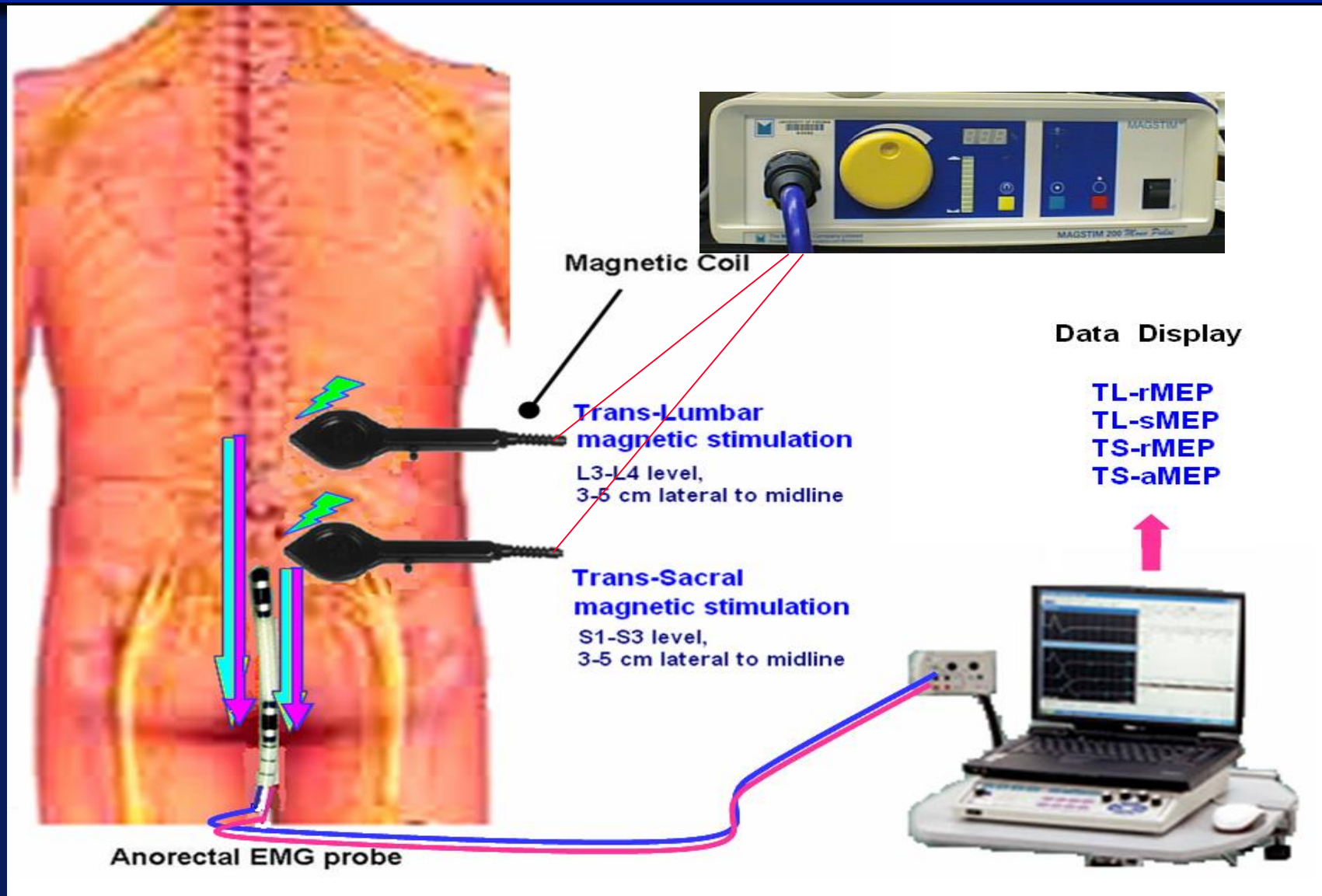
Interconnecting cable



Magnetic Stimulation Coil



Trans-lumbar & Trans-sacral MEPs

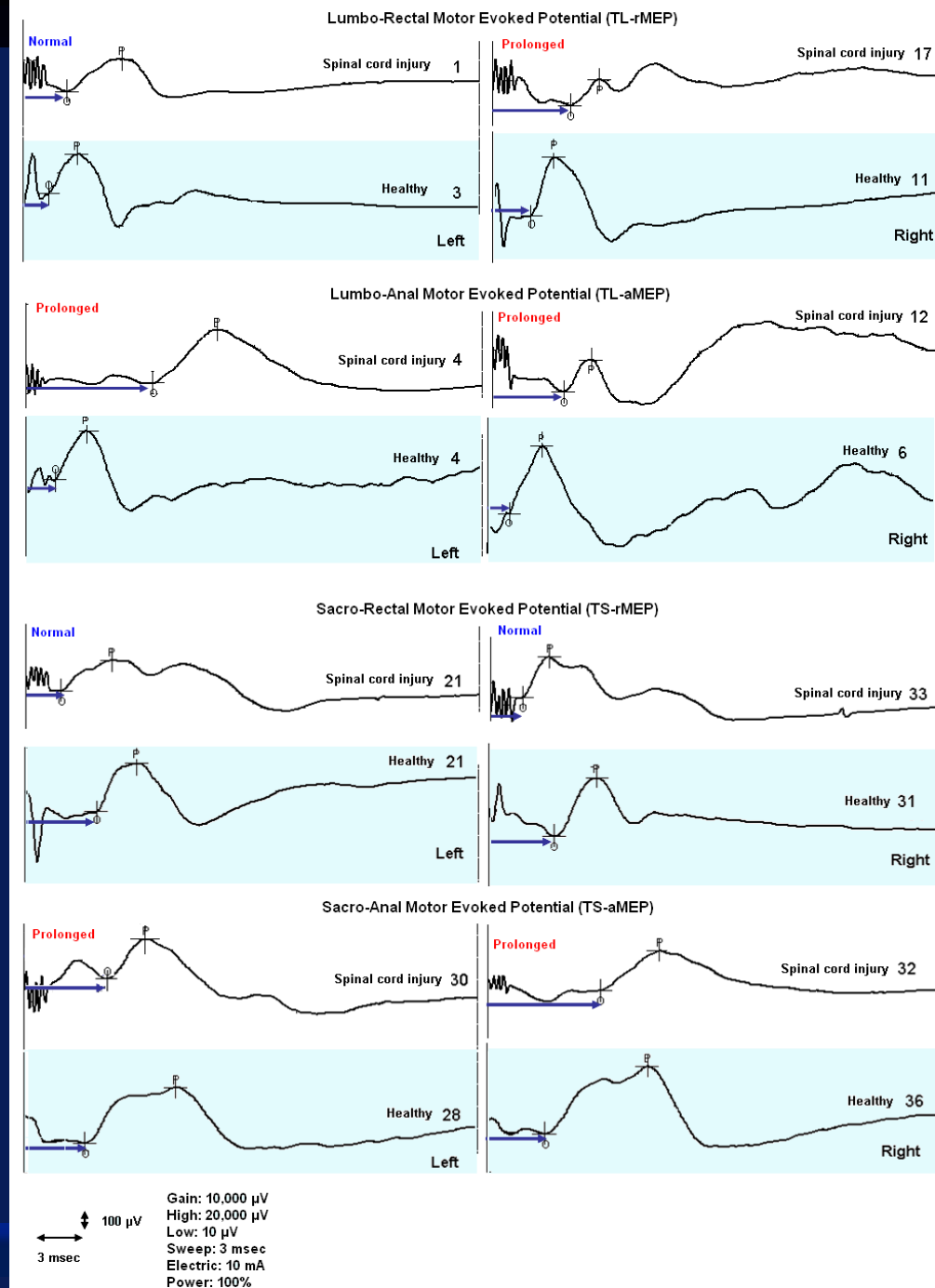


TAMS- Clinical Vignette showing Utility

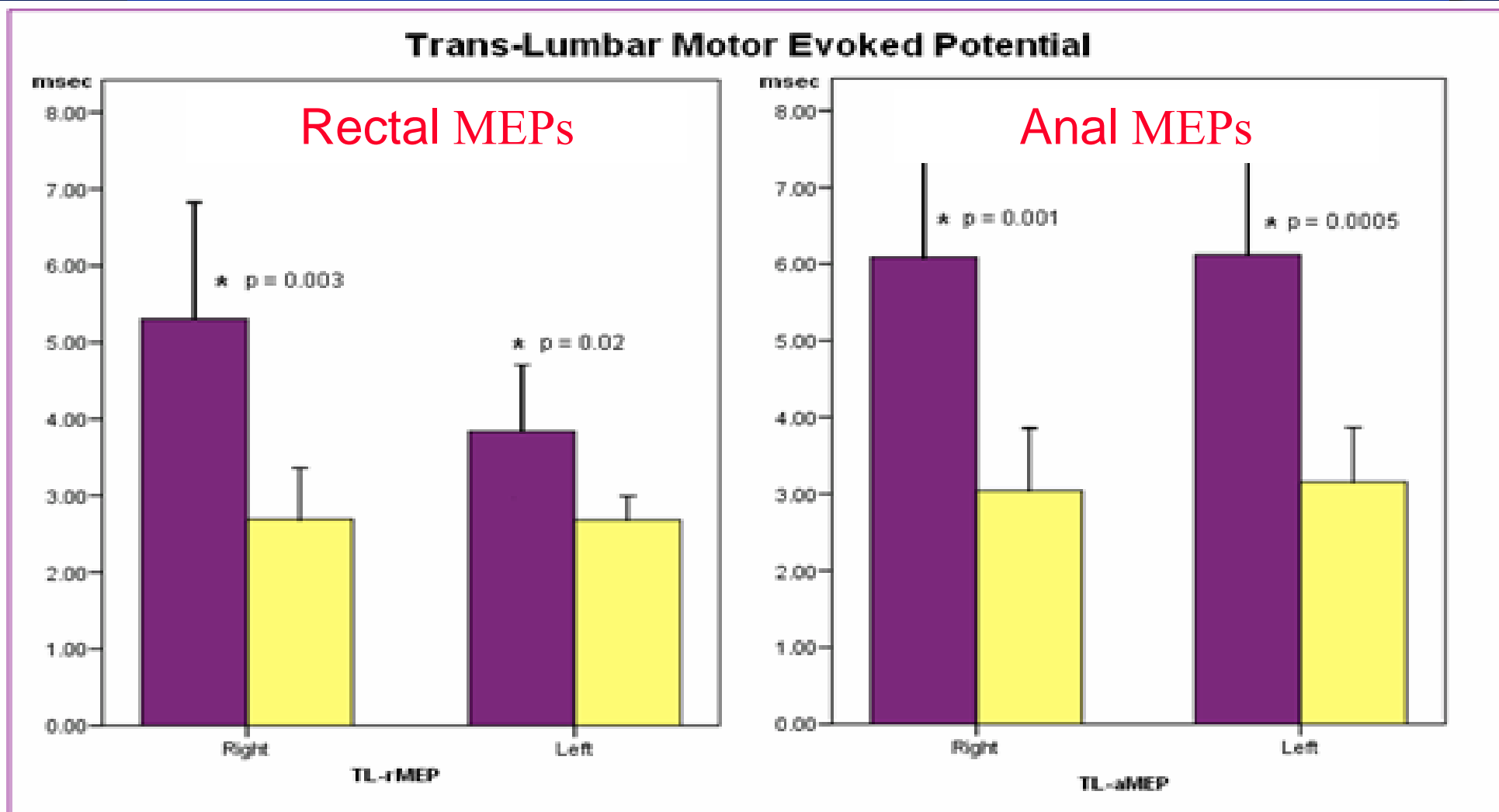
A 60-yr-old trucker sustained back injury from fall, 8 yrs ago and had bony spur removed at L1-L2. Afterwards, he developed passive urinary and fecal incontinence.

Anal ultrasound was normal. Manometry showed weak IAS and EAS, hyposensitive rectum, Type 2 dyssynergia with normal PNTML. Does he have Neuropathy?

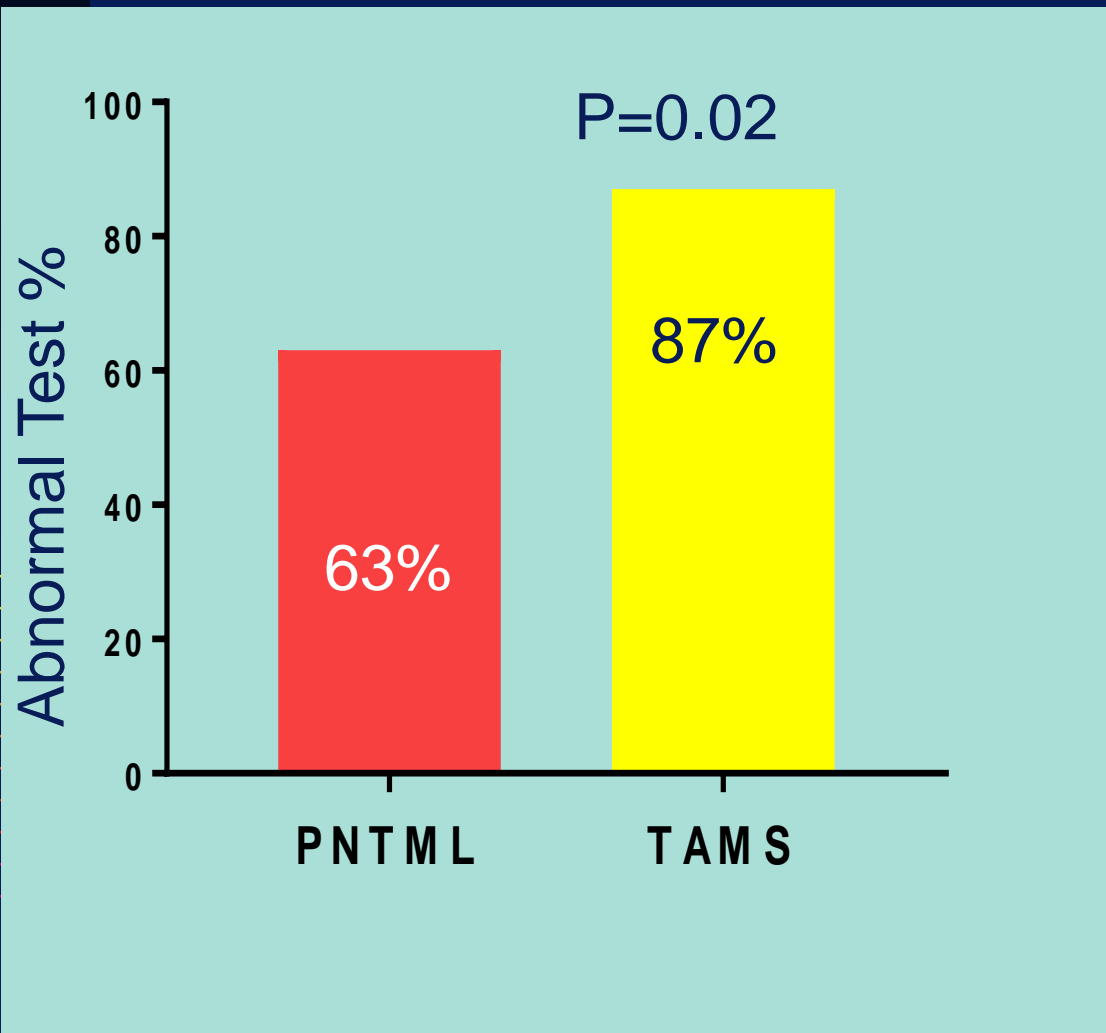
MEP tests revealed that 5 of 8 spino-anal MEPs were abnormal indicating severe neuropathy that was missed by PNTML



Trans-lumbar MEPs: Incontinence vs Controls



Detection of Neuropathy in Fecal Incontinence PNTML vs TAMS, n=30



- Positive agreement = 63%
- Negative agreement = 13%
- Total = 76%
- 24% with Normal PNTML had abnormal TAMS
 - Normal PNTML does not exclude neuropathy
 - PNTML detects distal 1-2” neuropathy, misses proximal
 - PNTML misses rectal neuropathy

Patients with FI have prolonged Translumbosacral Anorectal MEPs latencies

	Controls	FI patients	p
Left lumbar anal	3.29±0.77	5.79±2.30	<0.001
Right lumbar anal	3.39±0.68	6.20±2.40	<0.001
Left sacral anal	2.99±0.68	5.20±1.86	<0.001
Right sacral anal	3.14±0.74	6.20±2.17	<0.001
Left lumbar rectal	2.89±0.68	3.84±1.54	0.007
Right lumbar rectal	3.19±0.74	4.02±1.60	0.006
Left sacral rectal	2.92±0.84	4.58±1.86	<0.001
Right sacral rectal	2.97±0.77	4.77±2.22	<0.001

Neuropathy is patchy in patients with FI

	Left <i>n=50 (%)</i>		Right <i>n=50 (%)</i>	
	<i>Normal</i>	<i>Abnormal</i>	<i>Normal</i>	<i>Abnormal</i>
TL-rMEP	27 (54)	23 (46)	20 (40)	30 (60)
TL-aMEP	17 (34)	33 (66)	29 (38)	31 (62)
TS-rMEP	25 (50)	25 (50)	34 (68)	16 (32)
TS-aMEP	16 (32)	34 (68)	30 (60)	20 (40)

TAMS vs PNTML in Spinal Cord Injury & vs Controls

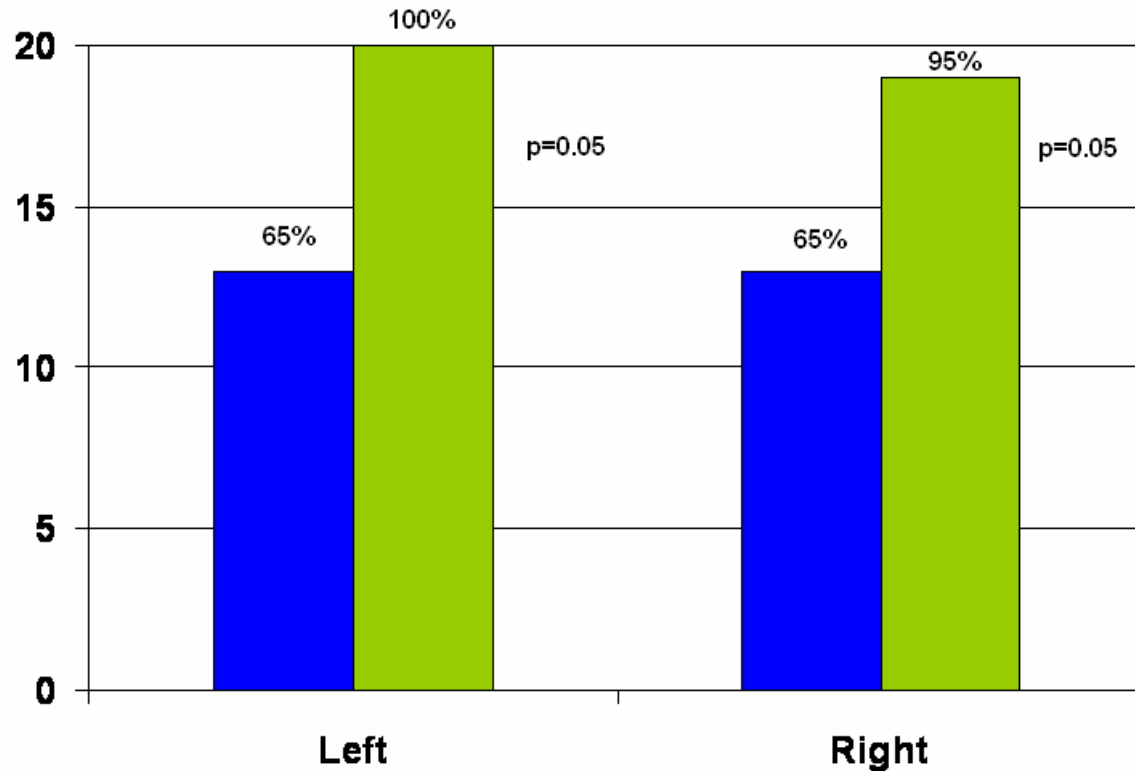
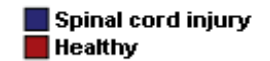
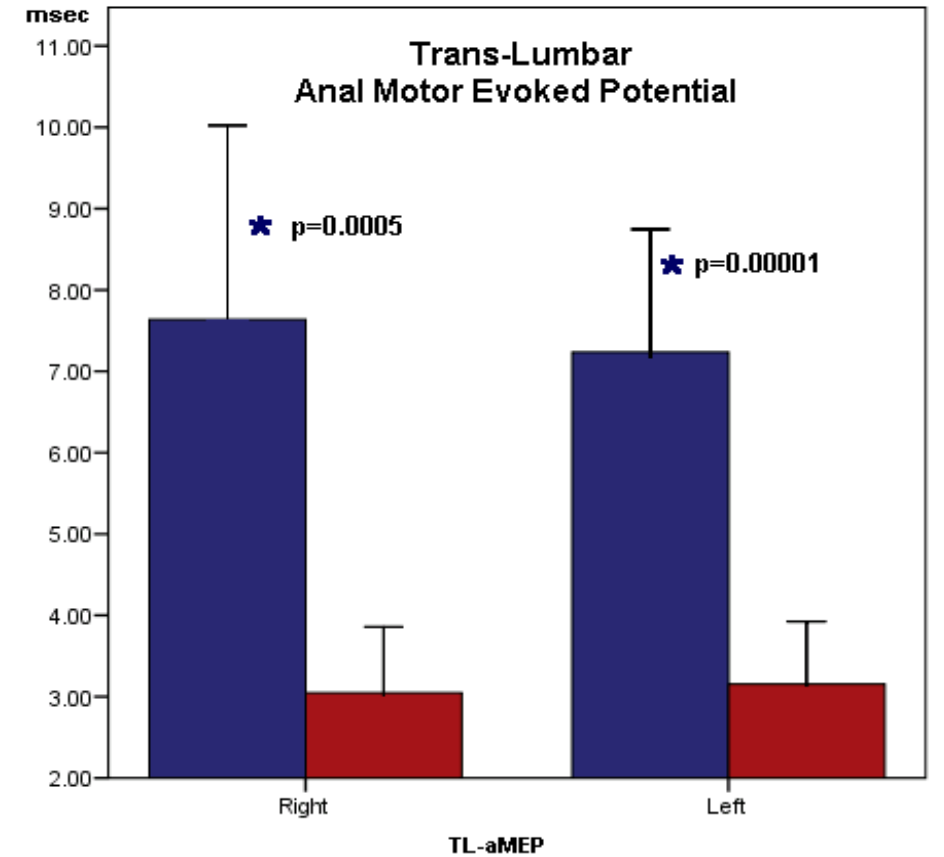
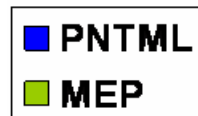


Fig. 6 Abnormal latencies detected by PNTML and MEP



Error Bars: 95% CI

Patients with SCI have prolonged Translumbosacral Anorectal MEPs latencies

Table 1. Translumbar and transsacral motor-evoked potentials and PNTML values in healthy controls and in subjects with SCI

	Left		<i>P</i>	Right		<i>P</i>
	SCI	Control		SCI	Control	
TL-rMEP, N=37 (ms)	5.3 (3.5, 6.3)	2.7 (2.2,3)	0.01	5.5 (3.1,6.9)	2.6 (2,3.1)	0.002
TL-aMEP, N=38 (ms)	6.7 (5.6,7.8)	3.2 (2.8,5.4)	0.002	7.1 (5.7,8.8)	2.9 (1.5,8.7)	0.0001
TS-rMEP, N=37 (ms)	5.8 (3.2,7.3)	3.0 (2.3,3.6)	0.047	4.9 (3.3,5.6)	3.0 (2.3,3.7)	0.078
TS-aMEP, N=37 (ms)	6.0 (5,7.5)	3.0 (2.2,3.4)	0.0001	5.5 (4,6.4)	3.0 (1,8.2)	0.006
PNTML, N=36 (ms)	3.3 (2,4.5)	1.7 (1.4,1.8)	0.006	2.9 (2.3,3.8)	1.7 (1.3,2.1)	0.009

Abbreviations: CI, confidence interval; PNTML, pudendal nerve terminal motor latency; SCI, spinal cord injury; TL-aMEP, translumbar-anal motor-evoked potential; TL-rMEP, translumbar-rectal motor-evoked potential; TS-aMEP, transsacral-anal motor-evoked potential; TS-rMEP, transsacral-rectal motor-evoked potential.

The values are given as mean (95% CI).

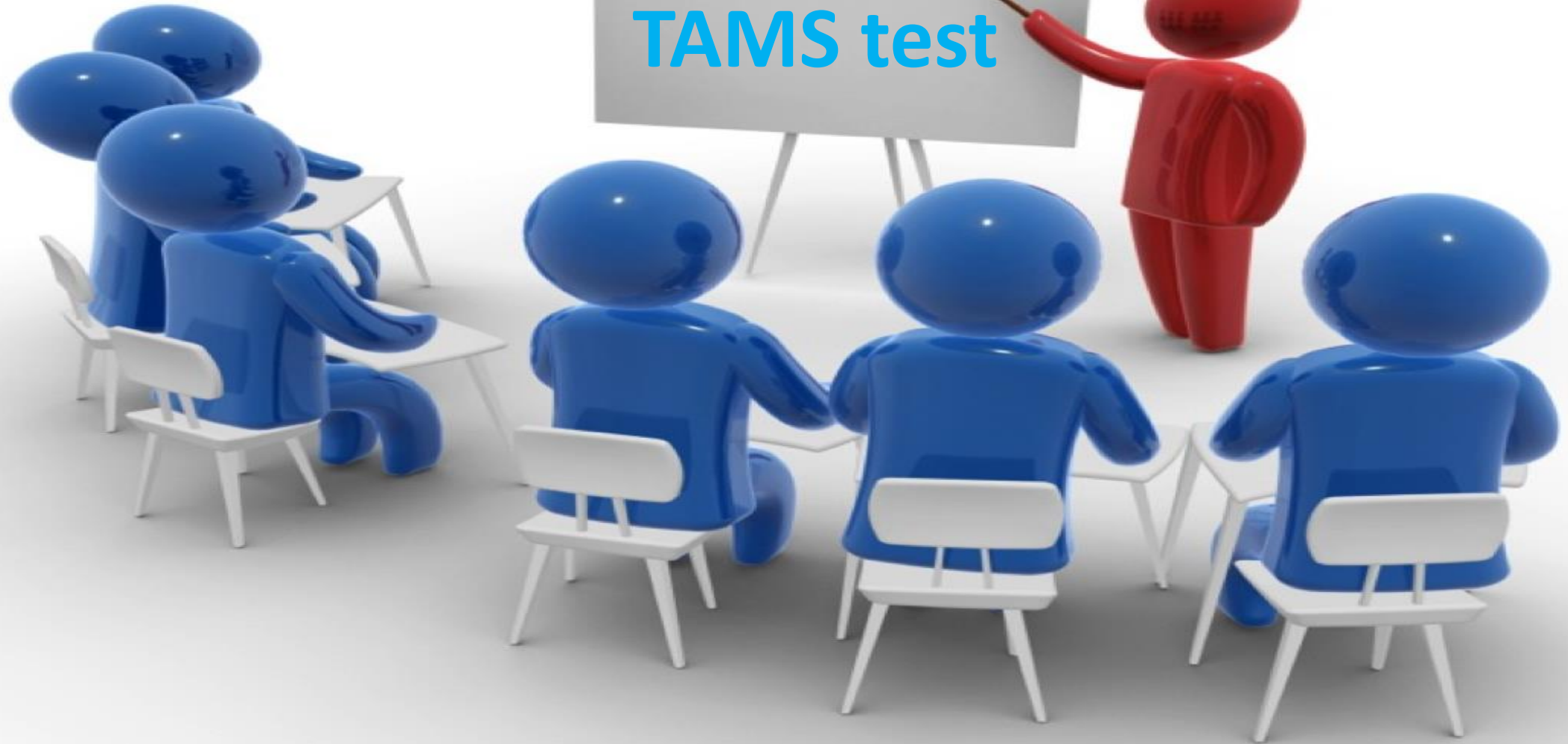
TAMS-Evidence for Clinical & Research Use?

- TAMS is superior to PNTML for detecting **anorectal neuropathy** in patients with **fecal incontinence (FI)**¹ and in **spinal cord injury**²
- TAMS is an **independent predictor** of anorectal physiological dysfunction in **FI** and it was not correlated with muscle damage³
- TAMS reveals neuropathy in 85% of patients with **FI**^{1,4}
- The main locus of neuropathy is the **peripheral spino-anorectal pathways**; the central pathways are intact⁴



1. Rao SS, et al. Dis Colon Rectum 2014;57:645-52.
2. Tantiphlachiva K, et al. Am J Gastroenterol 2011;106:907-14.
3. Patcharatrakul T, Rao S, et al. Gastroenterology 2016;150:S941-942.
4. Xiang X, et al. Clin Gastroenterol Hepatol 2018 (In Press).

Training for TAMS test

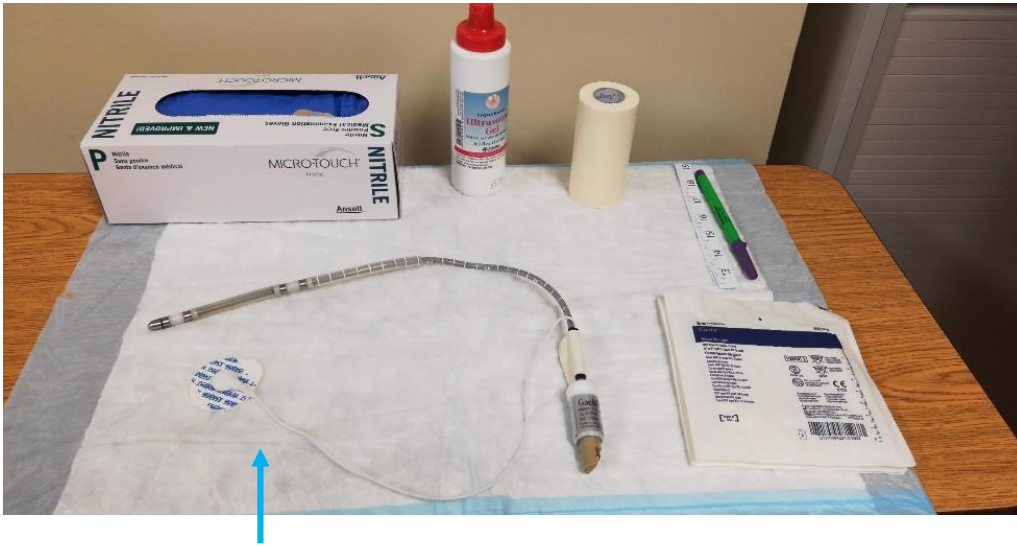


Preparation & Performance of TAMS Test: 5 Steps

- Equipment set up
- Patient Preparation
 - DRE
 - Probe Placement & Reference Electrodes
 - Patient Positioning & Marking
- Magnetic Stimulation & Recording of MEPs
- Measurement of 8 MEPs
- Interpretation & Report



Preparation for TAMS



Connect the conductive adhesive hydrogel with probe



Special moon pants for patient

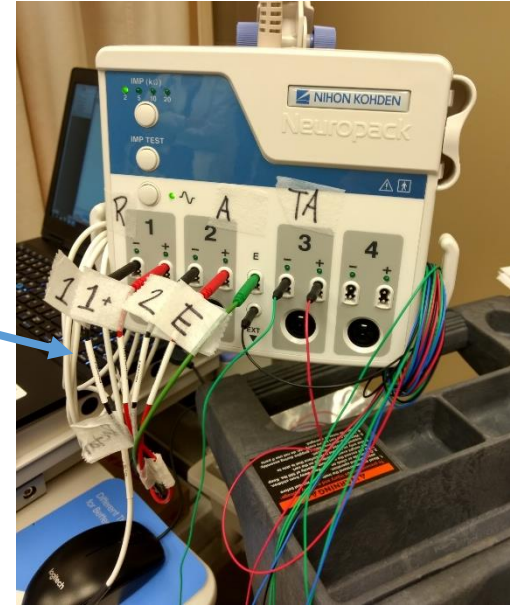
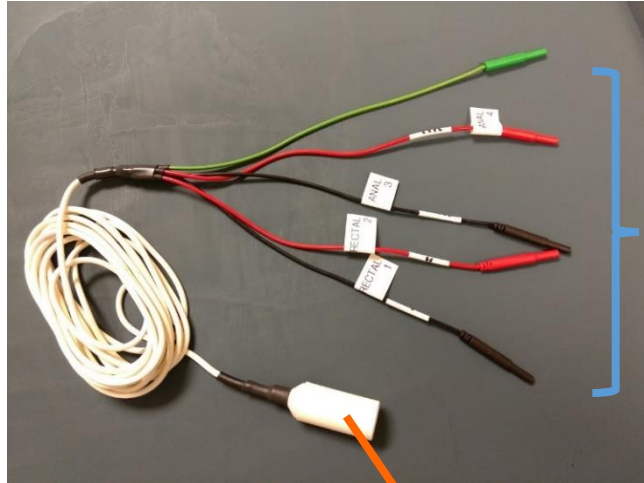


Connect the coil to the machine.

Patients:

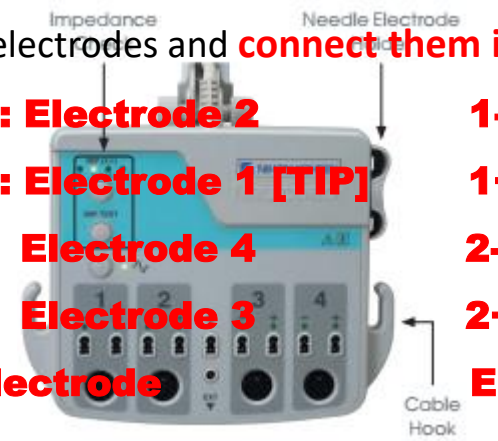
- No specific bowel preparation. Patients advised to move their bowels before coming to lab
- **Digital rectal examination** should be performed
- If stool present in the rectum, enema may be needed

Preparation: Connect probe with N-Kohden



Label the electrodes and **connect them in order.**

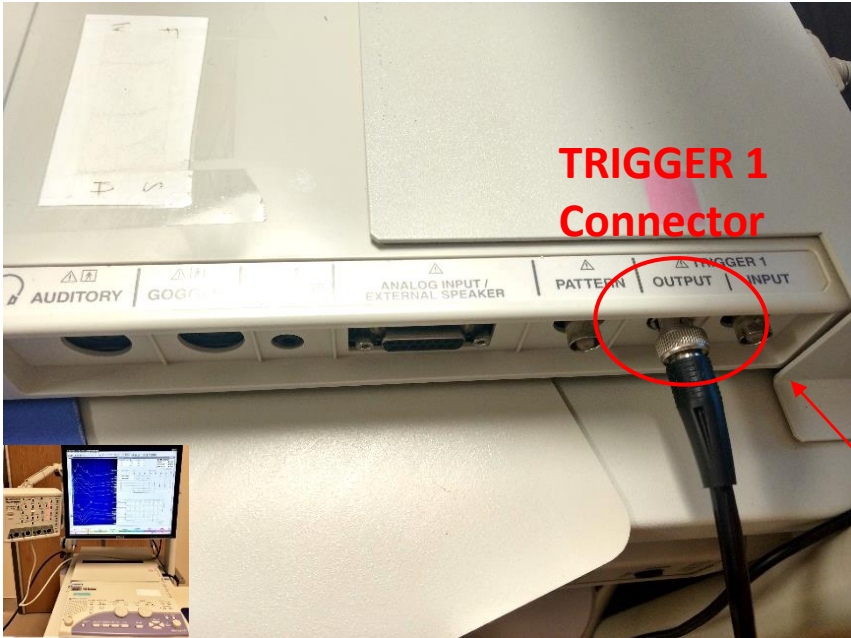
- Rectal 1: Electrode 2** **1-**
- Rectal 2: Electrode 1 [TIP]** **1+**
- Anal 3: Electrode 4** **2-**
- Anal 4: Electrode 3** **2+**
- Green electrode** **E**



The channels depend on the configuration of Nihon Kohden

Transducer: connects the probe with the machine

Preparation: Connect N.Kohden with Magstim



Recording system



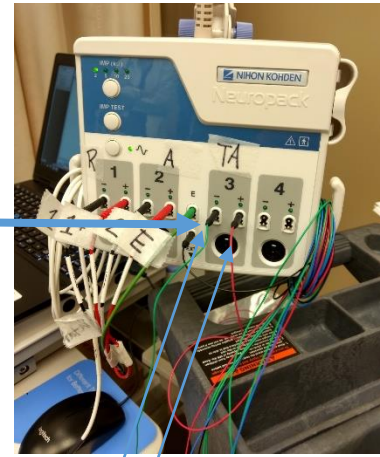
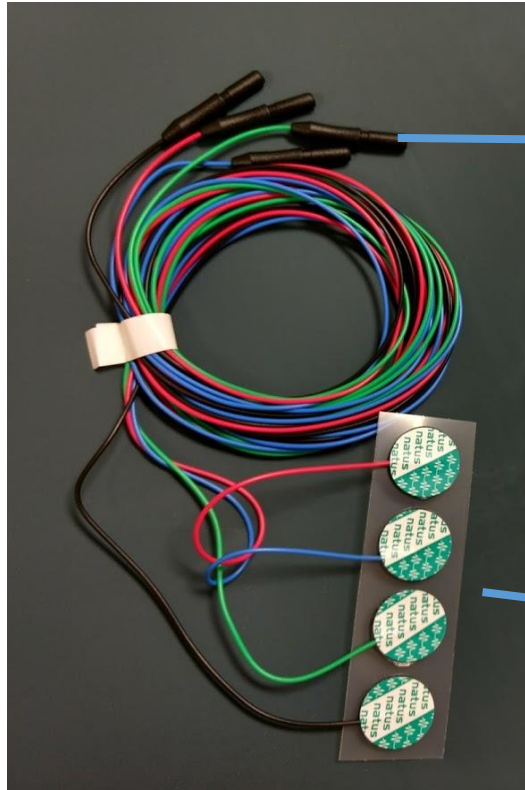
Magstim 200

Stimulator

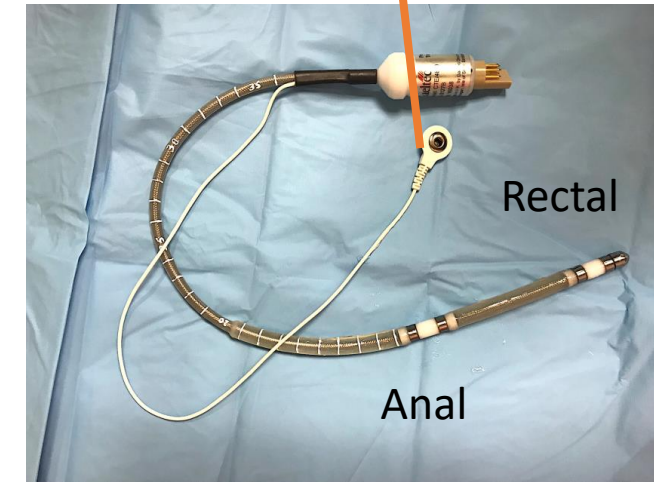
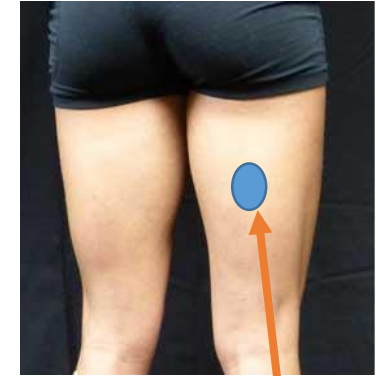
Connect the BNC cable
Marked IN to the Nihon Kohden
TriggerPort on the back of Machine

Connecting

Preparation- Reference Electrodes



Ground reference electrode from probe



3 reference electrodes: connect to the subject's leg to Nihon Kohden

Preparation: Enter patient Info into Recorder

Neurophysiology recorder

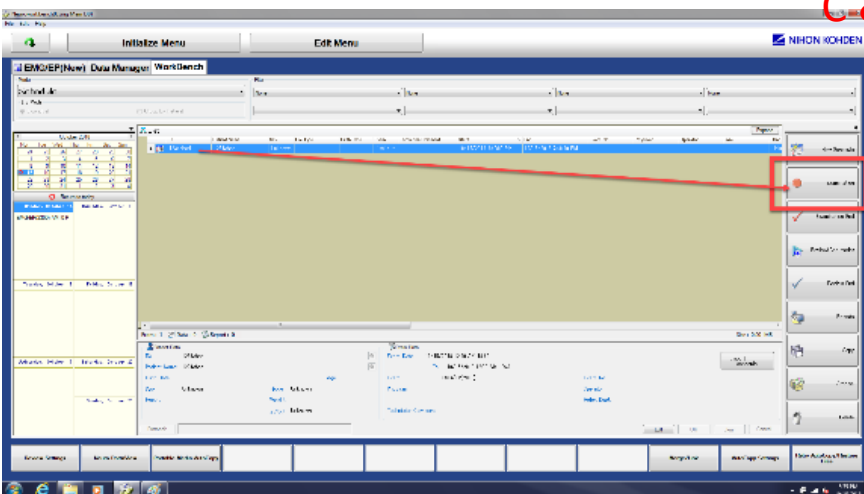
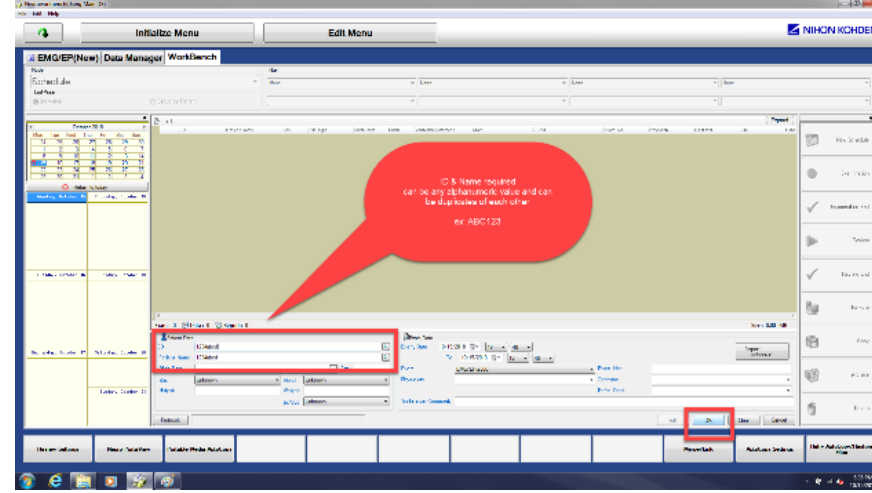
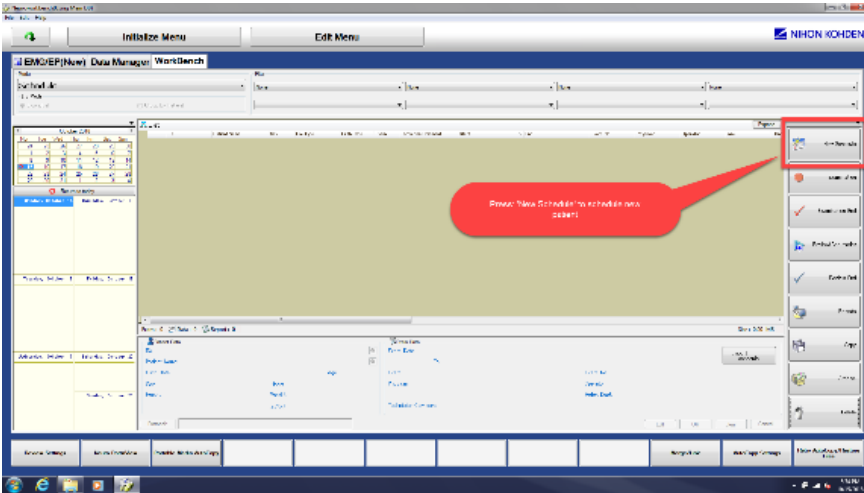
A & B

A-B: Click “New Schedule” and enter ID & Name > ‘OK’

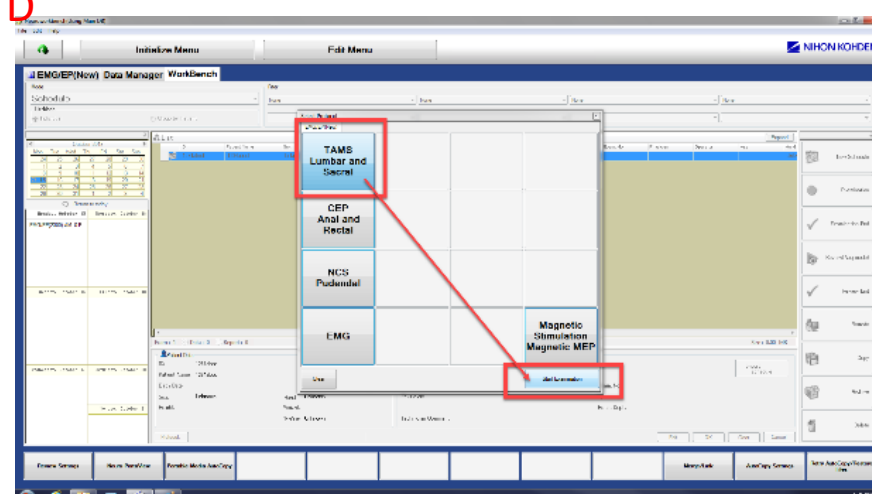
C-D: Click “Examination” > (TAMS Lumbar LT, TAMS Sacral LT, TAMS Lumbar RT, TAMS sacral RT)

to open the record interface.

E: Spin button to set intensity at **10 mA**.

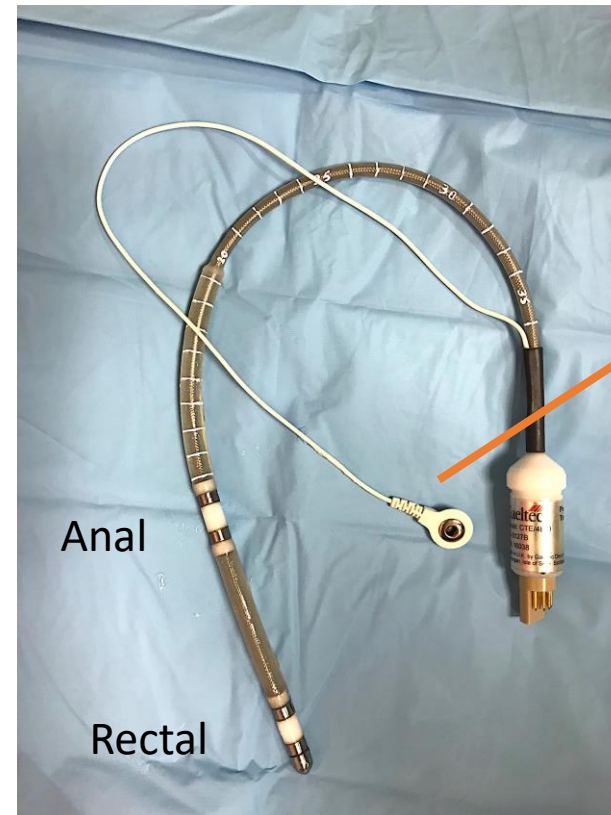


C & D

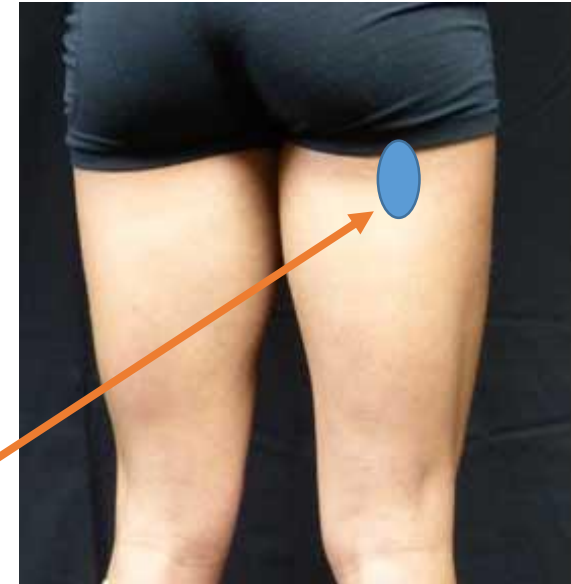


E

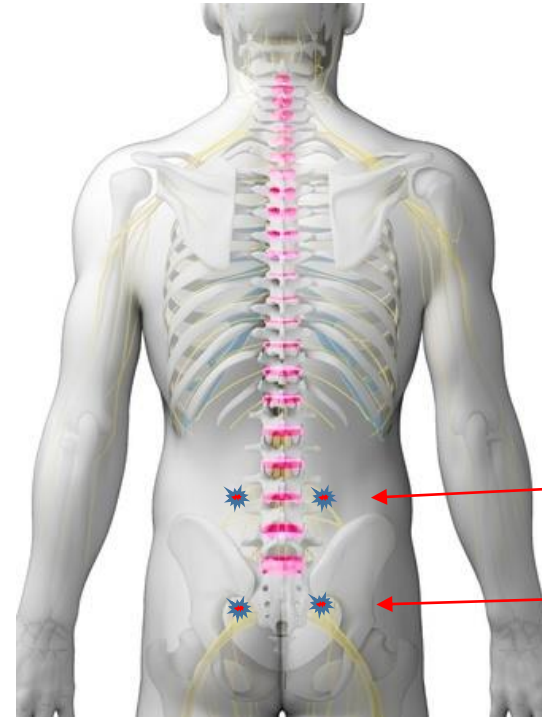
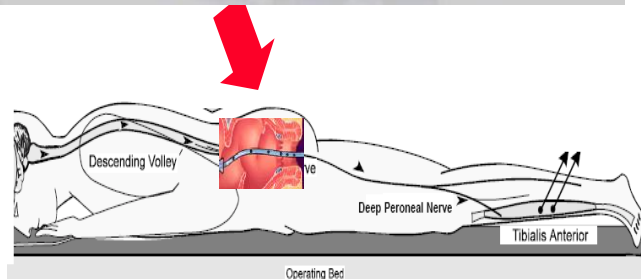
Probe Placement in Left lateral Position



Ground reference
electrode from probe



Place Patient in Prone Position & Mark the Lumbar and Sacral Sites for Stimulation



Lumbar plexus

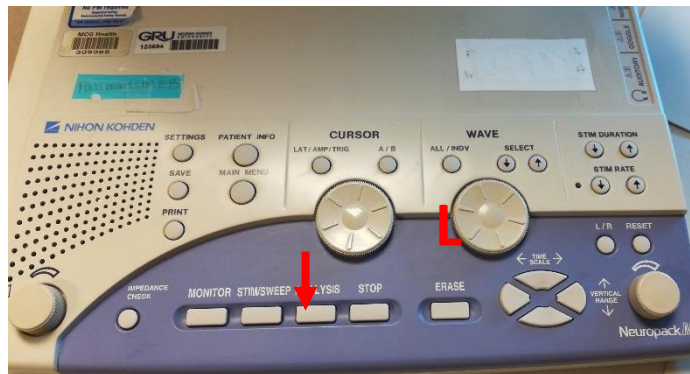
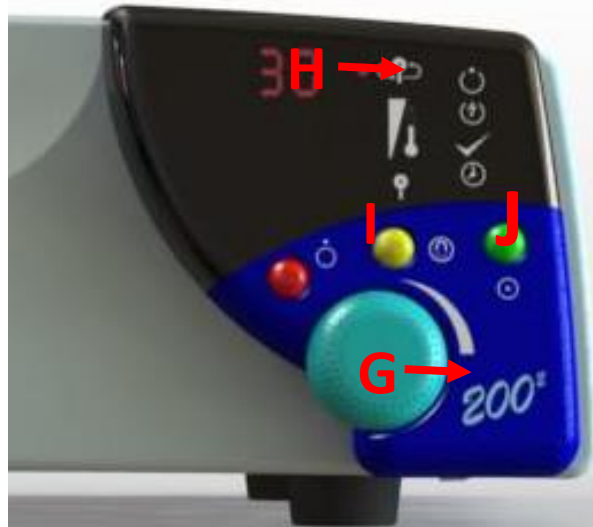
Sacral plexus

Patient is positioned in the prone position.

Lumbar plexus: L2, L3 lumbar vertebra, 3-4 cm lateral to the mid-spine,

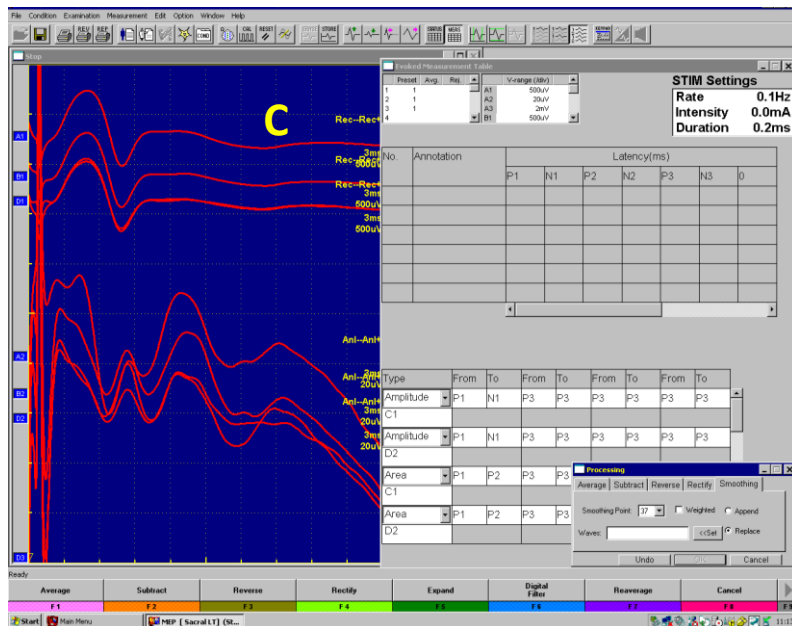
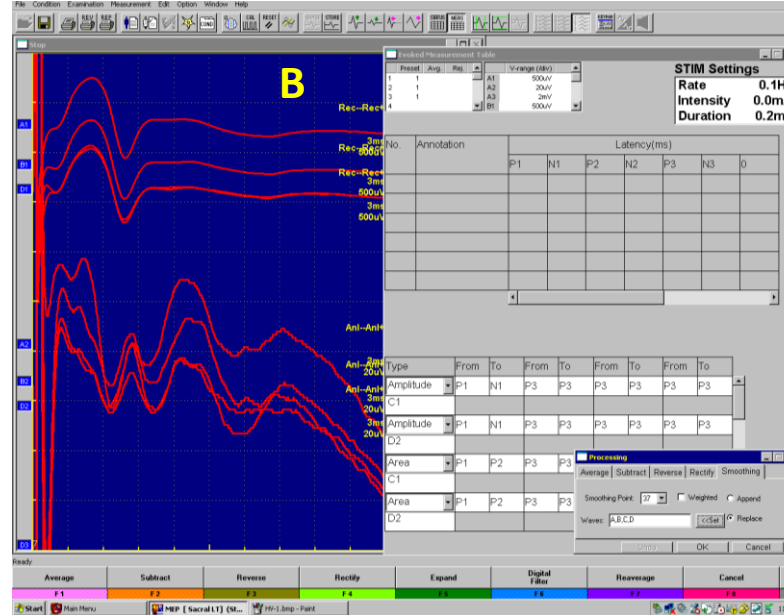
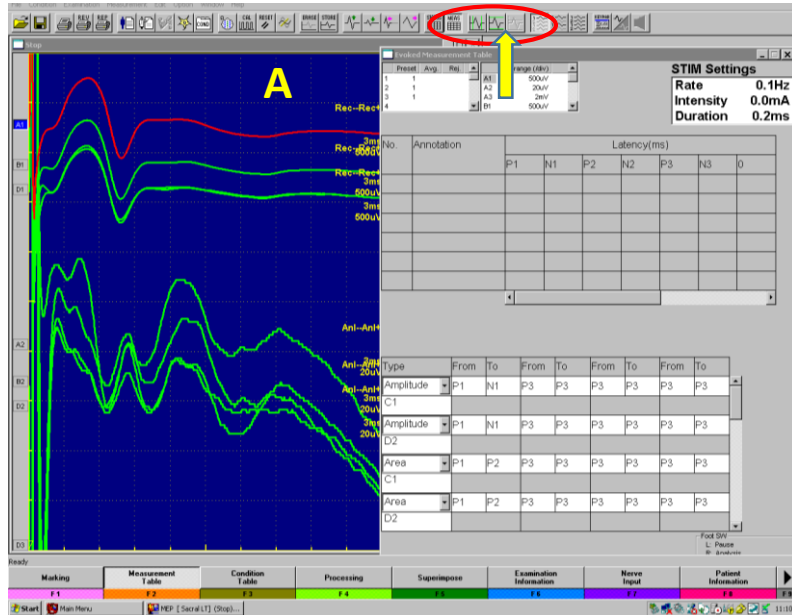
Sacral plexus: S2, S3 sacral vertebra. 3-4 cm lateral to the mid line,

Performing the TAMS test



- Spin button **G** to set intensity at 30 %, then click button **I and then J to familiarize patient with magnet stimulation**
- After the coil is placed on the upper arm, press button **K and L** (ANALYSIS) simultaneously to give stimulation in order to educate the subject about the magnetic stimulation feeling.
- Next, place the coil on the back over the left lumbar mark. Set intensity to **50%**. Move coil by a few mm each time and likewise increase the magnetic intensity gradually by 5-10% up to a maximum of 100% intensity to obtain an optimal MEP response
- Optimal response is at least **10 μ V in amplitude**
- At least **5 optimal responses** are recorded from each site before moving on to the next 3 sites and the procedure is repeated

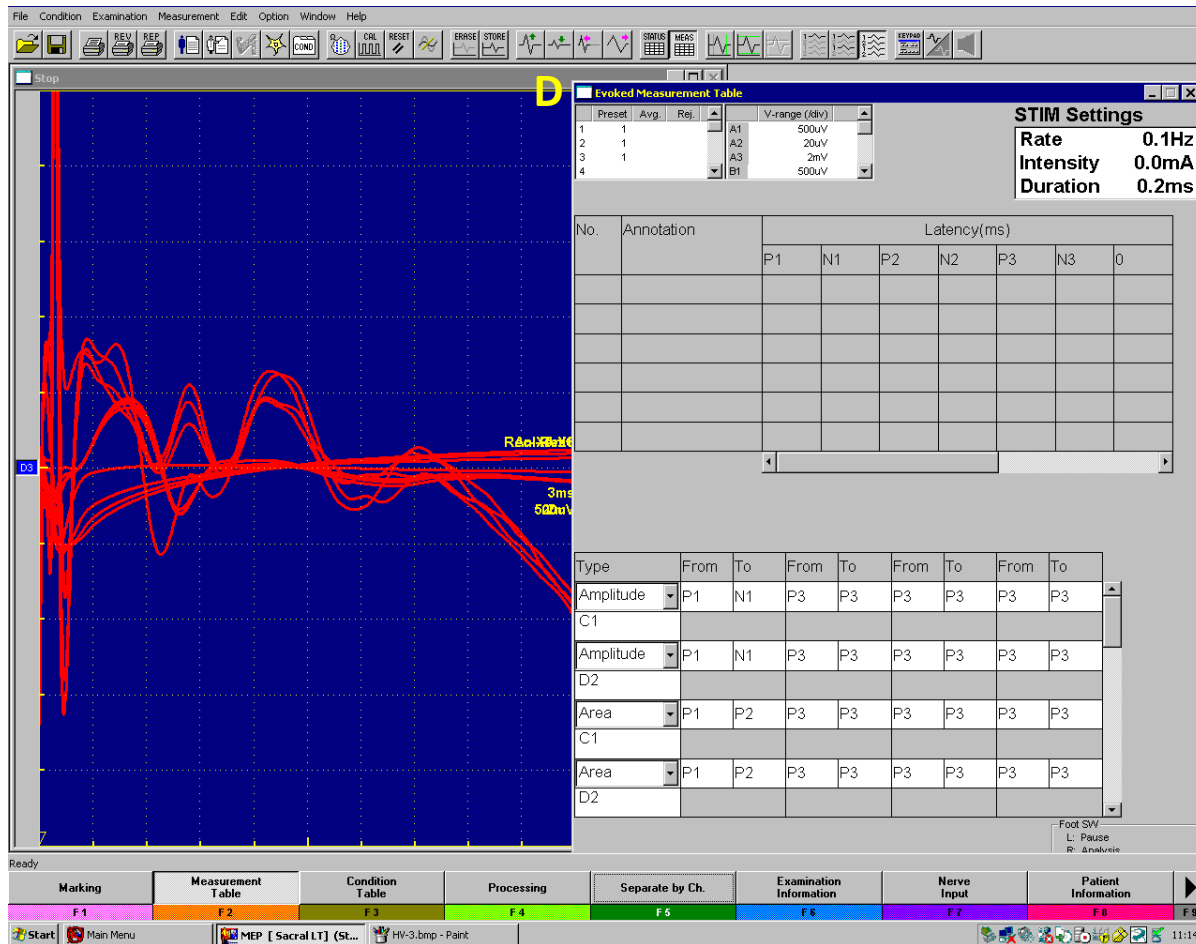
Measurements and Interpretation of MEP



A-C: Click “**process**”, then click “**smoothing**” to smooth the line (If needed)

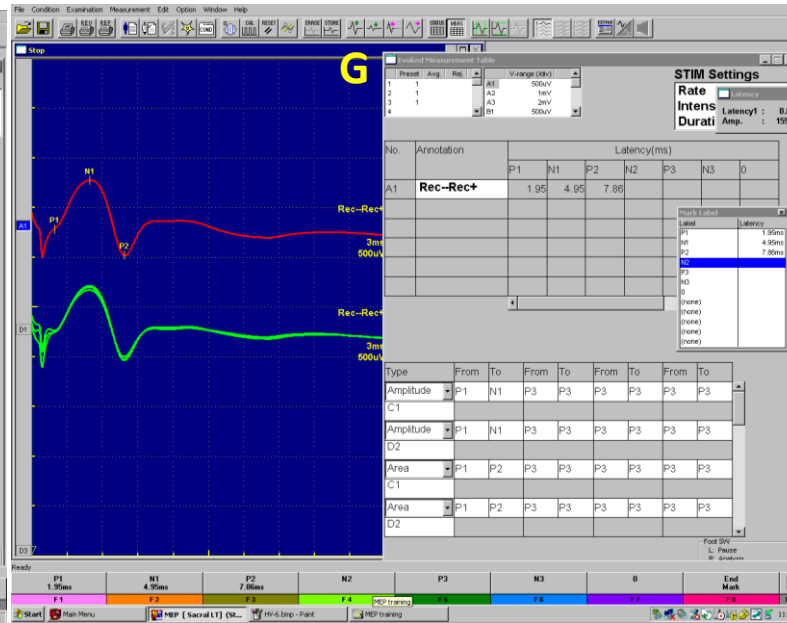
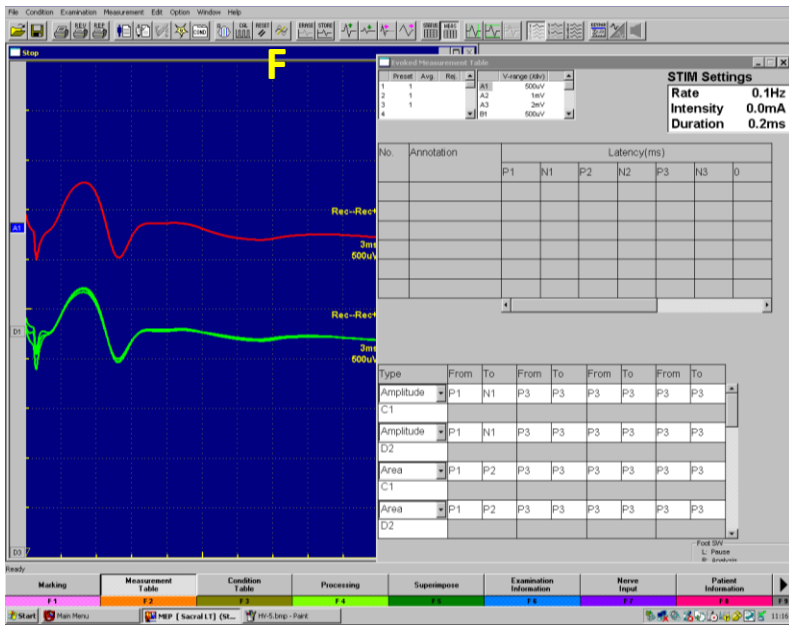
The arrowhead shows “**single**” “**group**” “**all**” buttons which could be used to choose the desired lines.

Measurements and Interpretation of MEP

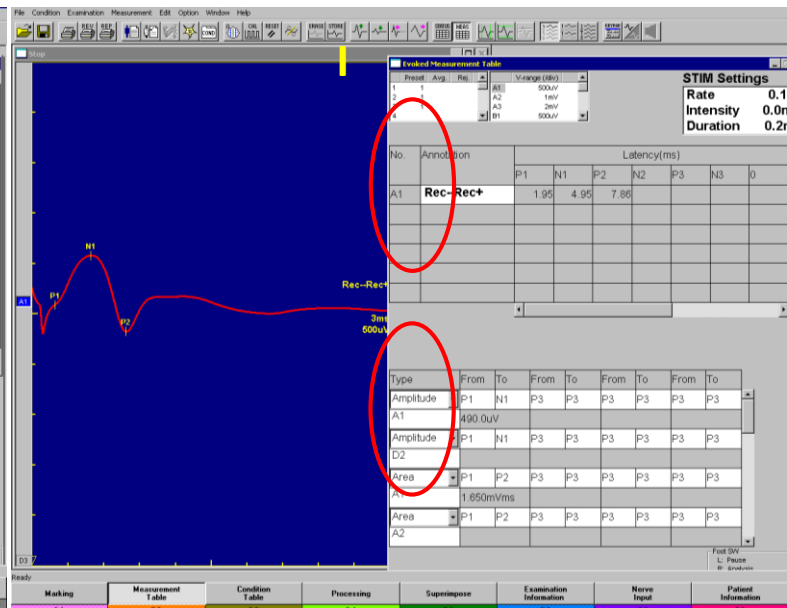
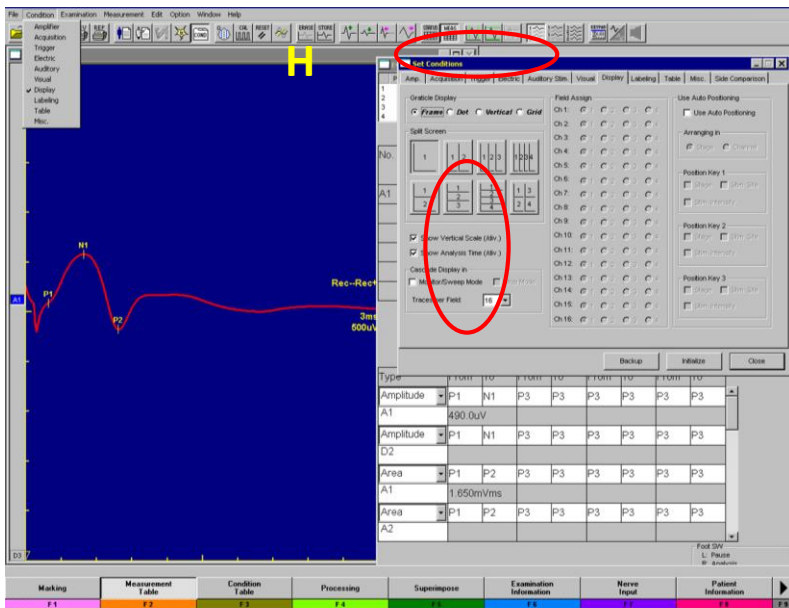


D-E : Click **“superimpose”**, then click **“separated by Ch.”**

Measurements and Interpretation of MEP



F-G: Use “single” “group” “all” button to choose the desired line, click “marking” to mark it and then click “End mark” when done marking.



H: Click “display” to change the background, if needed.

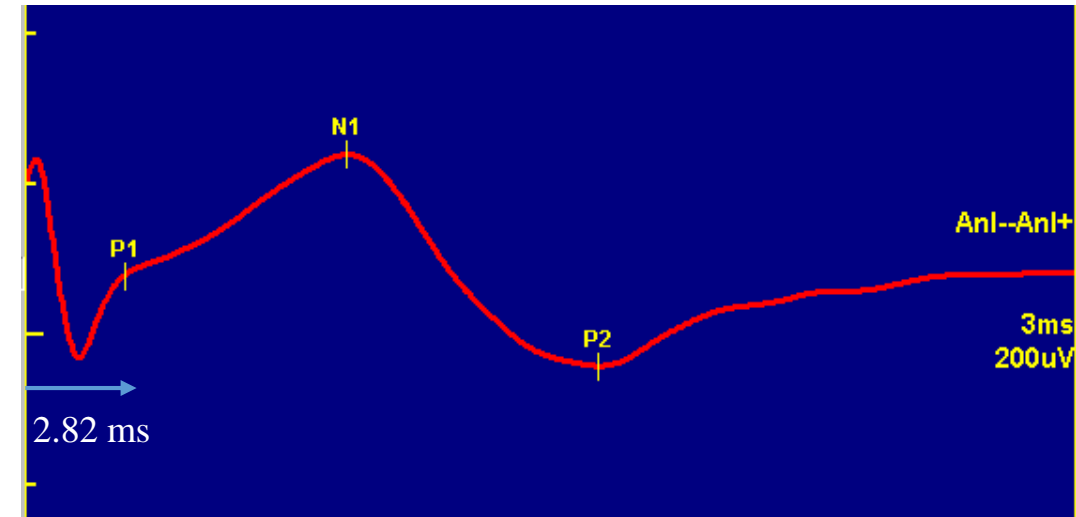
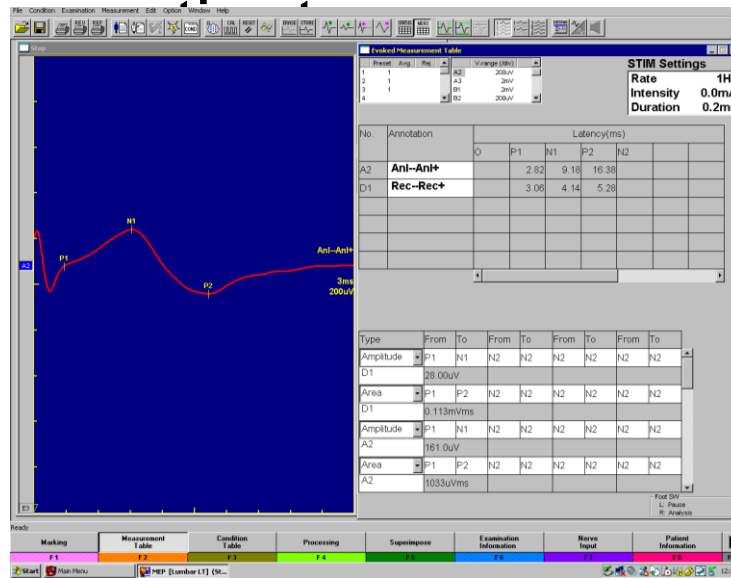
I: Get the amplitude and AUC (area under a curve).

Measurements and Interpretation of MEP

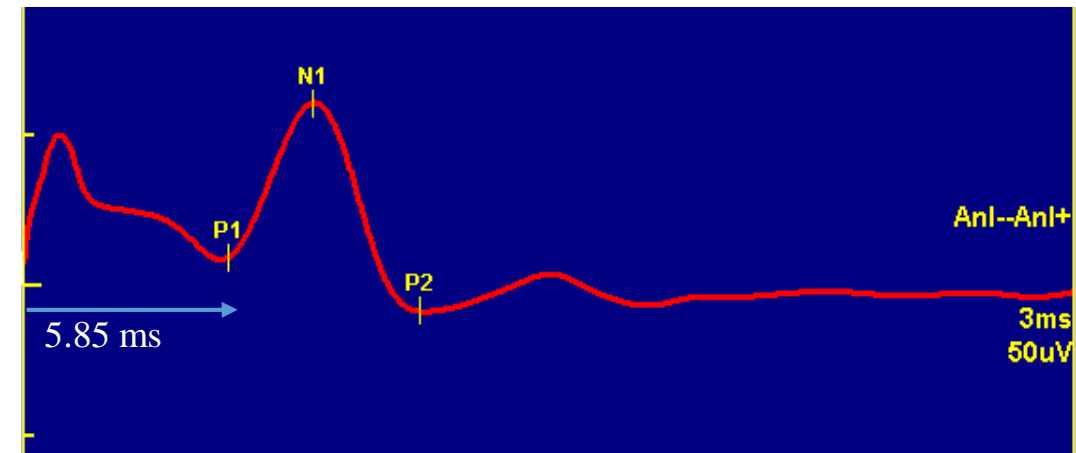
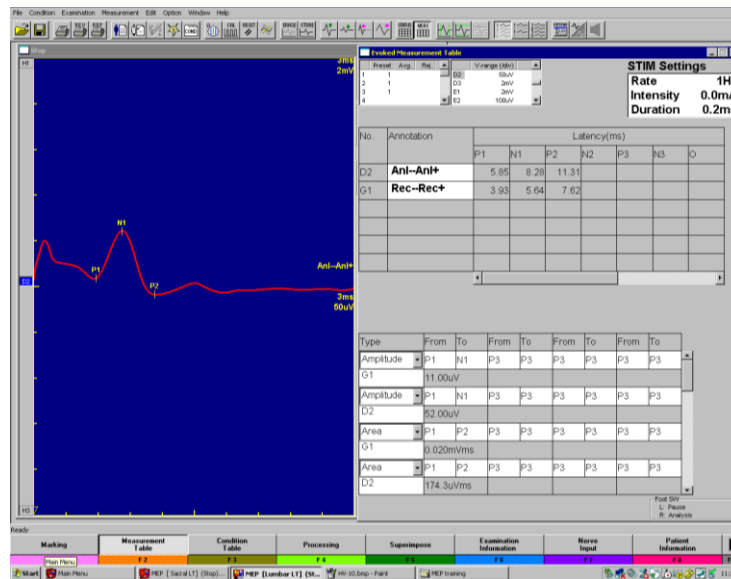
- It is not necessary to measure each one of the MEP responses or average the best response.
- Choose the optimal response (closest to normal or shortest latency) to do the measurement, by selecting the best responses and overlaying them.
- The **first and most prominent negative or positive** deflection will be designated as the MEP response.
- Patients will be classified as having neuropathy **if ≥ 1 of 8 latencies are abnormal.**

Anal MEPs after TSMS in a healthy control and a FI

Healthy control



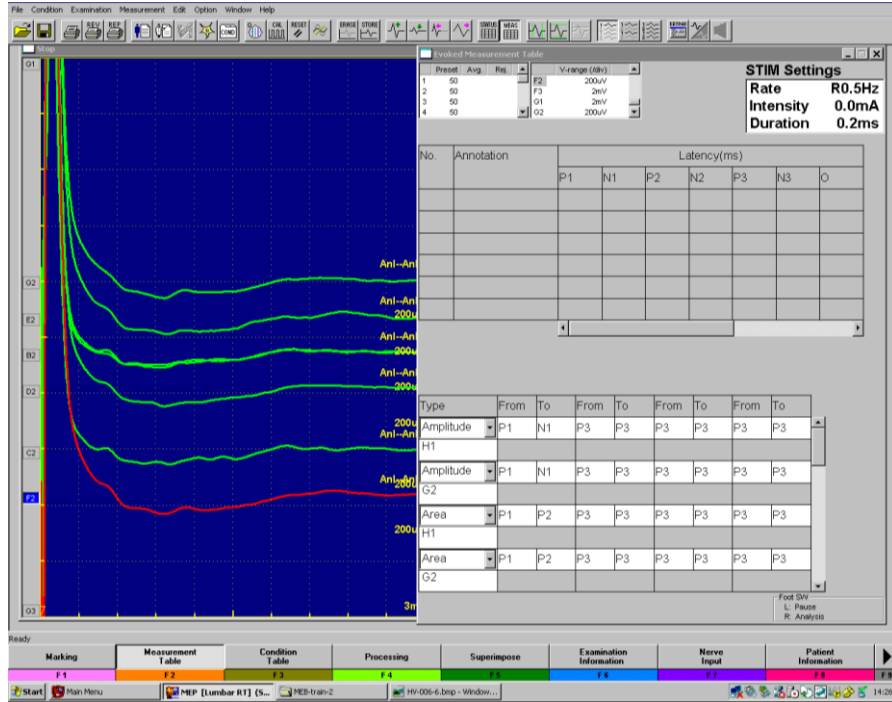
FI patient



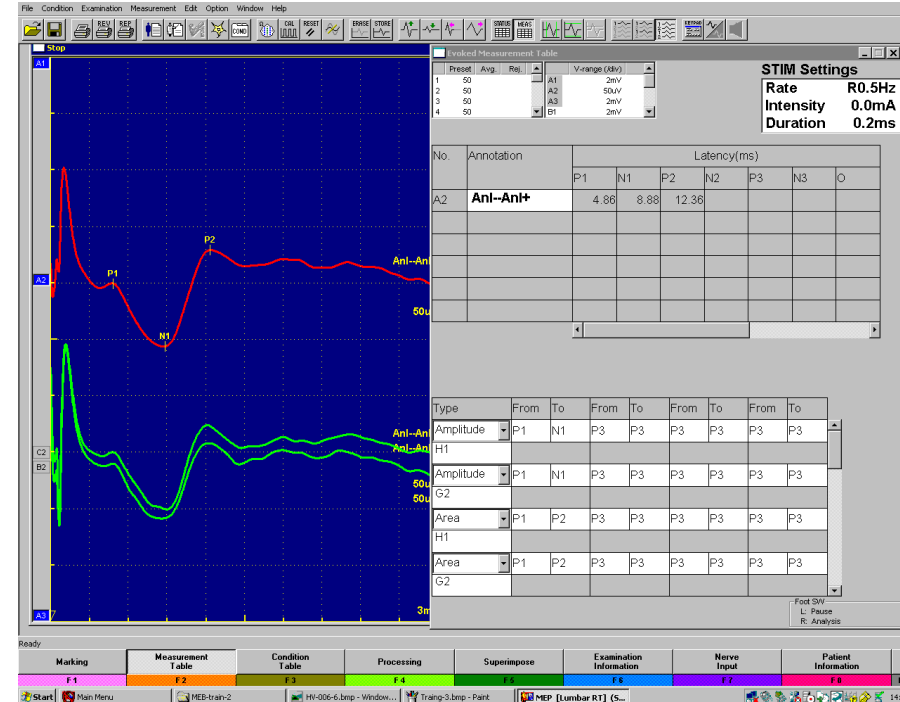


Troubleshooting: Probe slipped after insertion

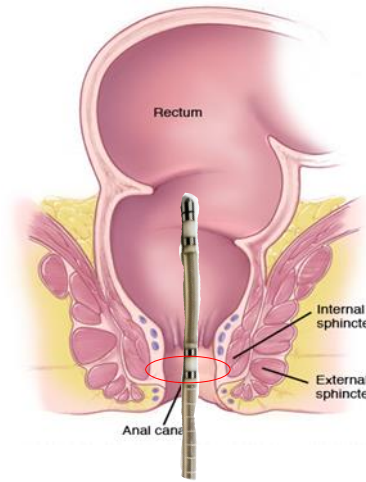
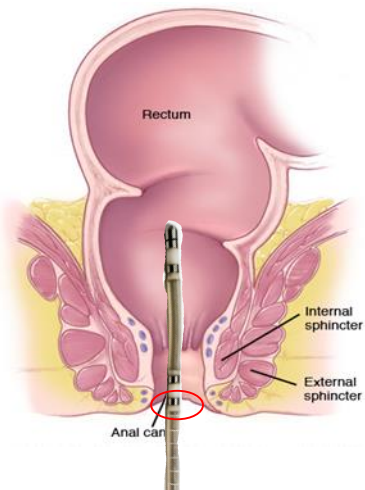
Signals from the same subject and the same site before and after adjusting the probe.



Before the probe was adjusted.

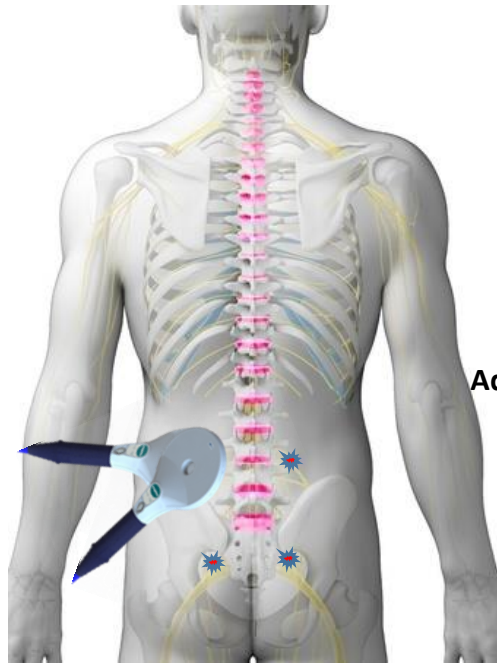


Adjusted the probe and did the TAMS again

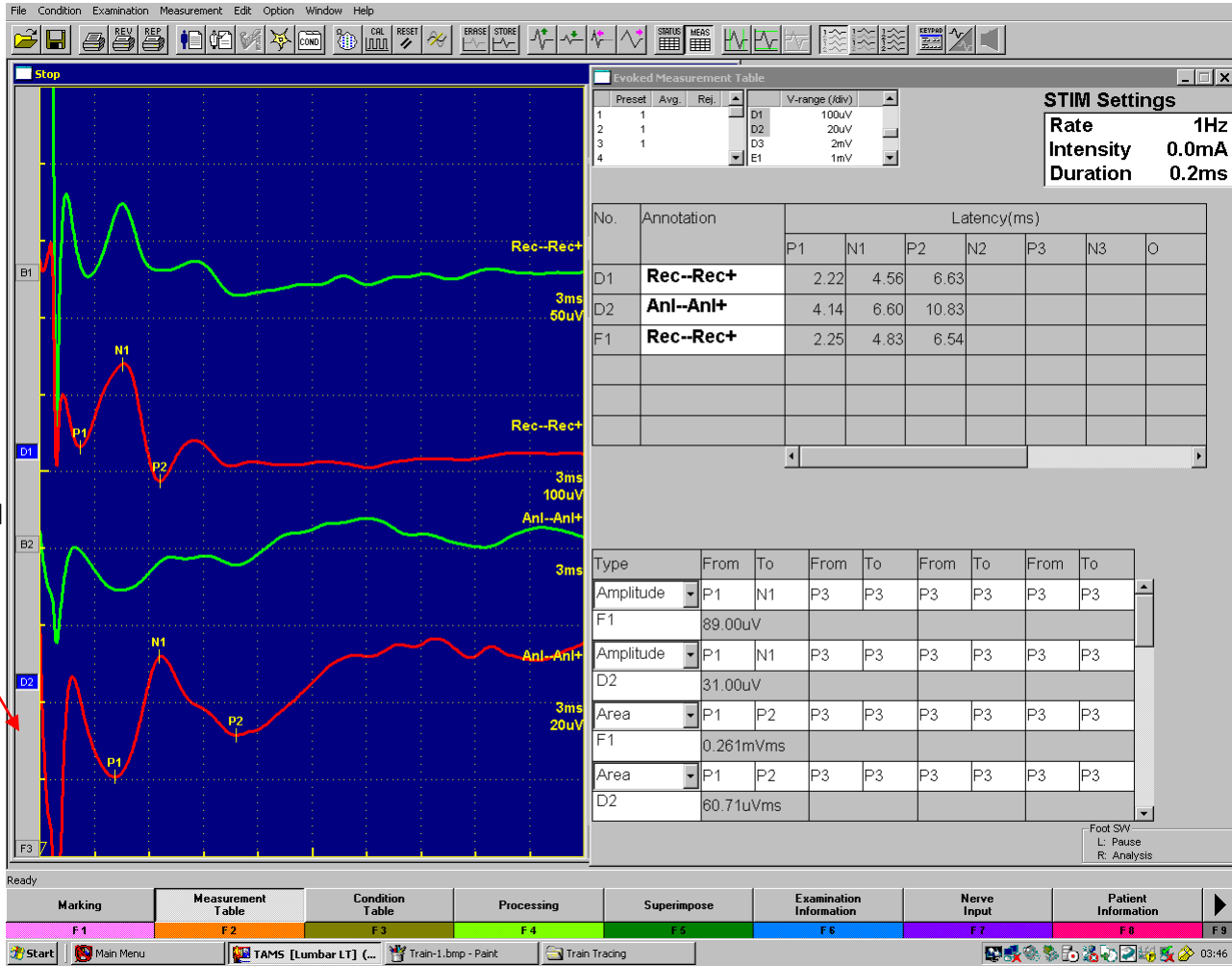




Troubleshooting: Coil positioning



Adjust the coil

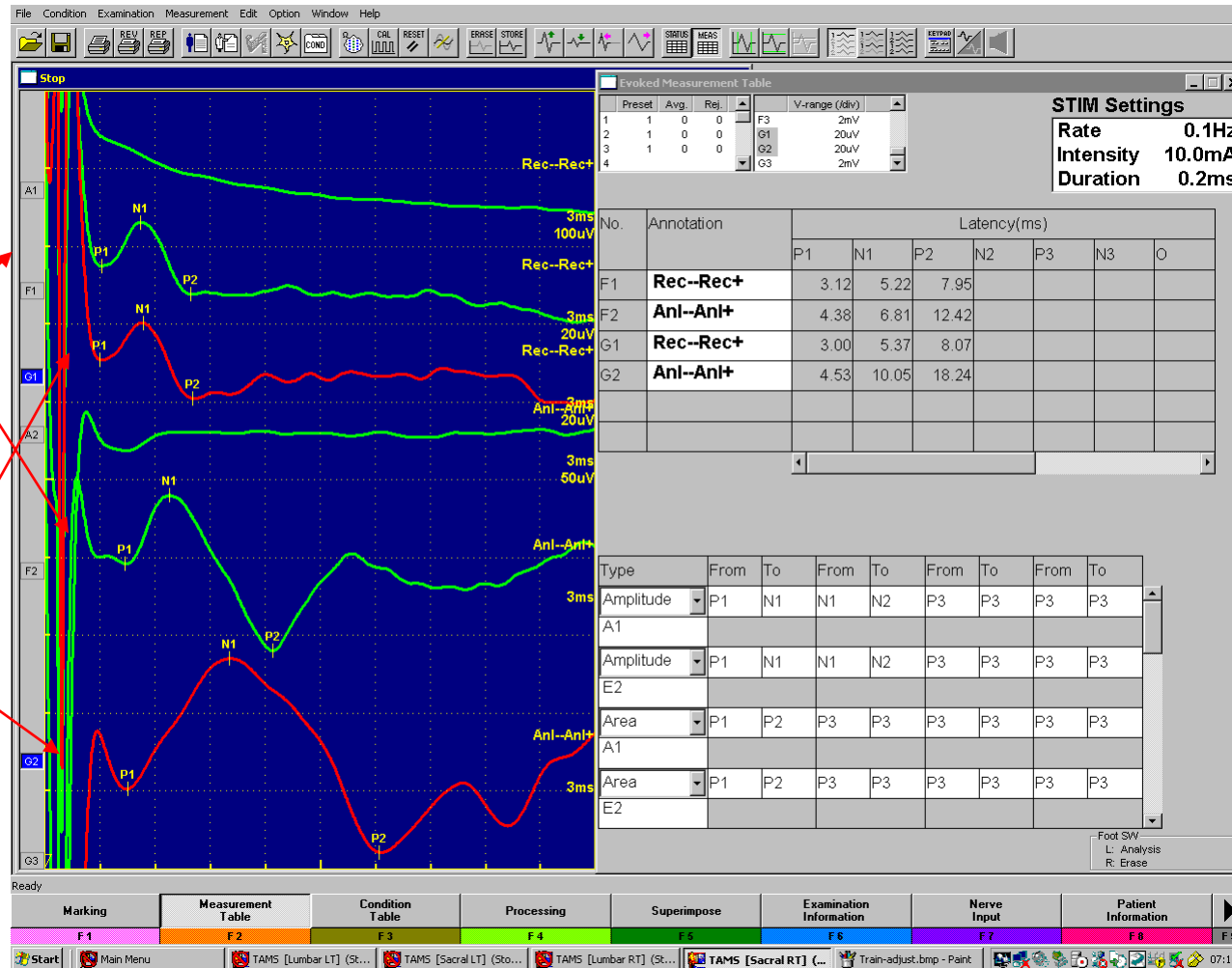




Trouble shooting: Bone or Poor electrode contact

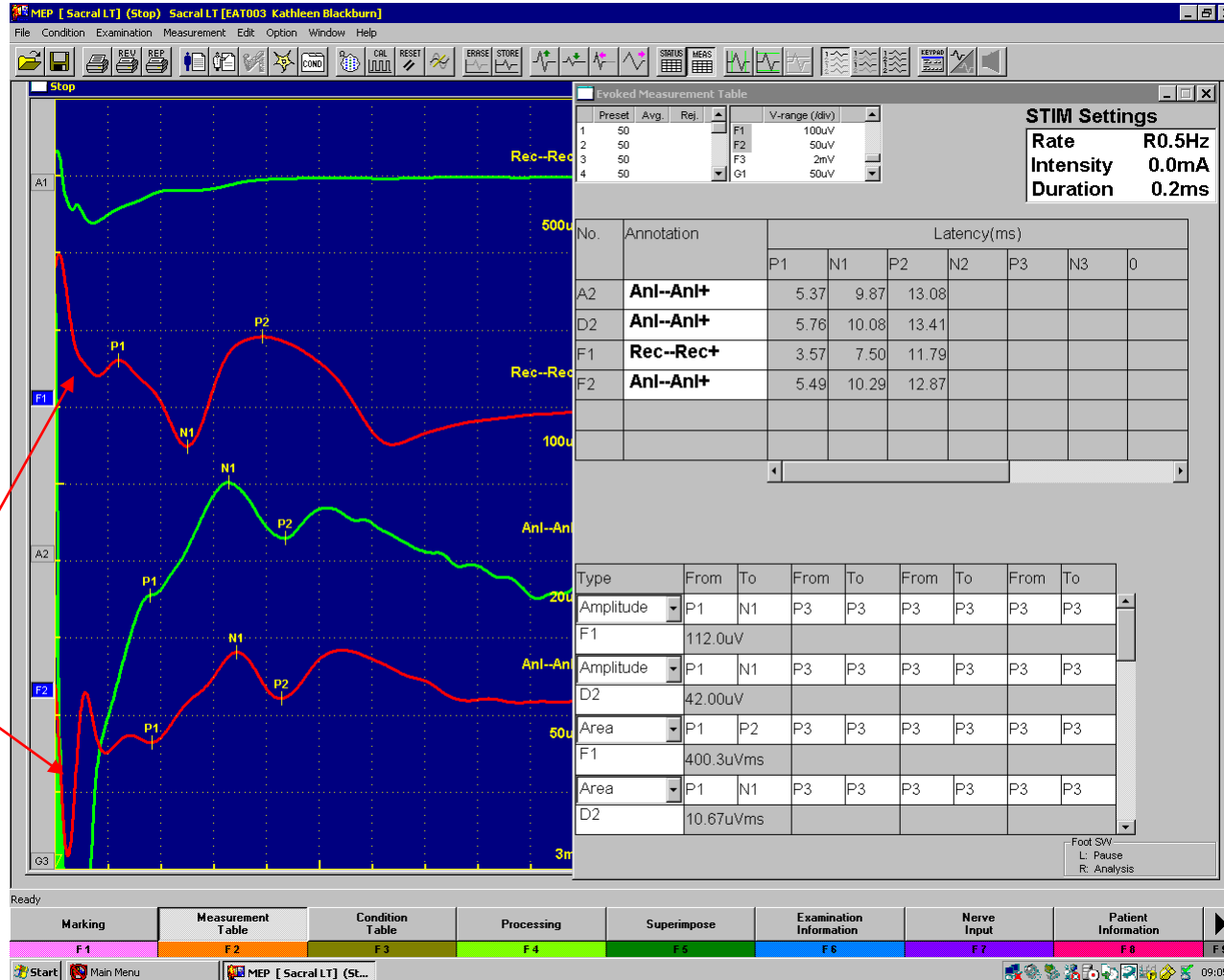
P: Without penetration (bony point)
S: change coil orientation

P: Weak sphincters
S: Use augmentation, such as squeeze.

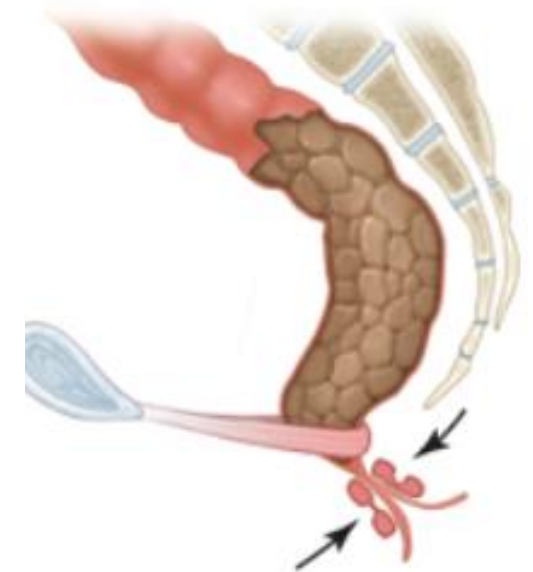


Troubleshooting: Stool in the rectum

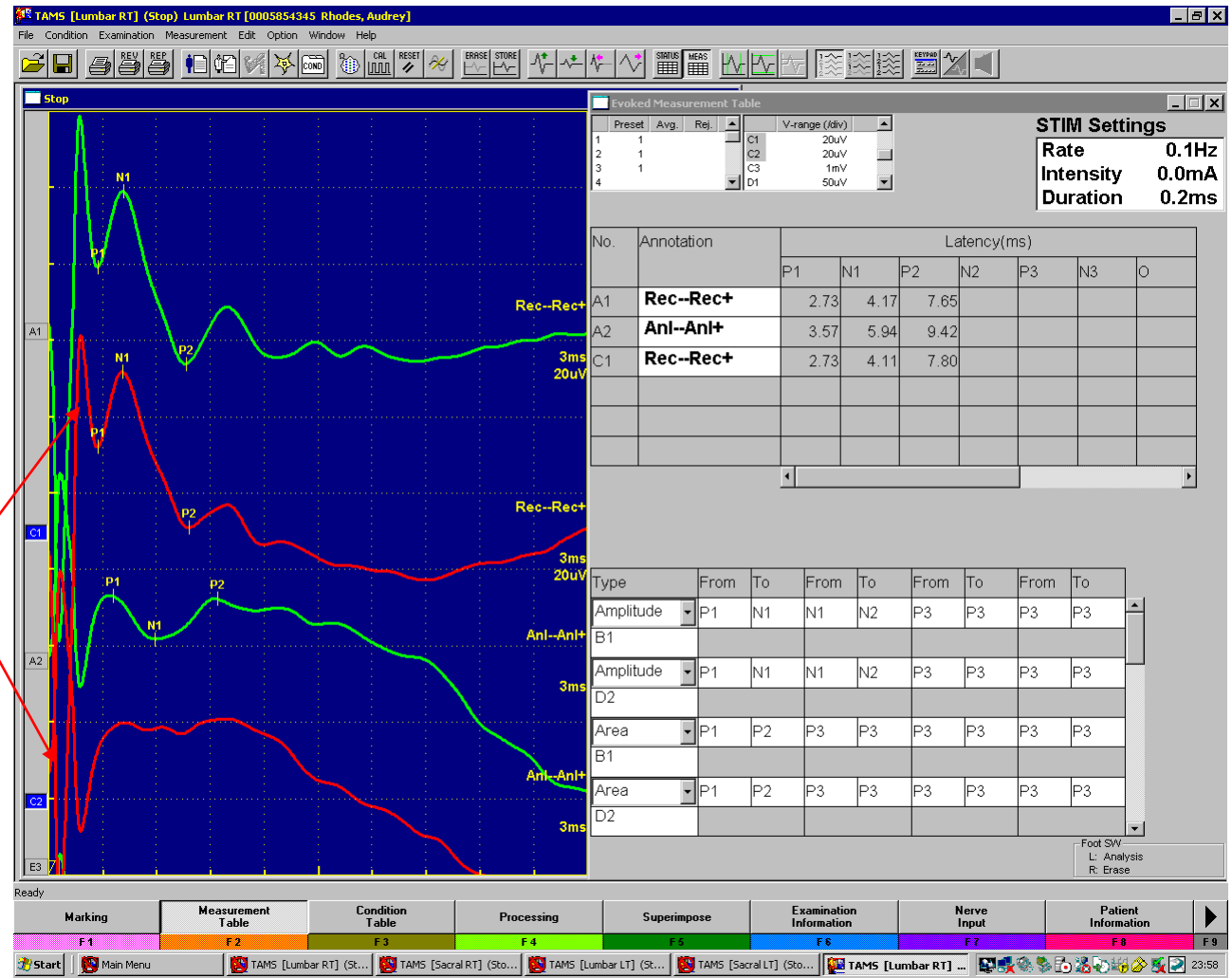
Anal response present but no rectal; Also could be contact



S: Remove the stool.

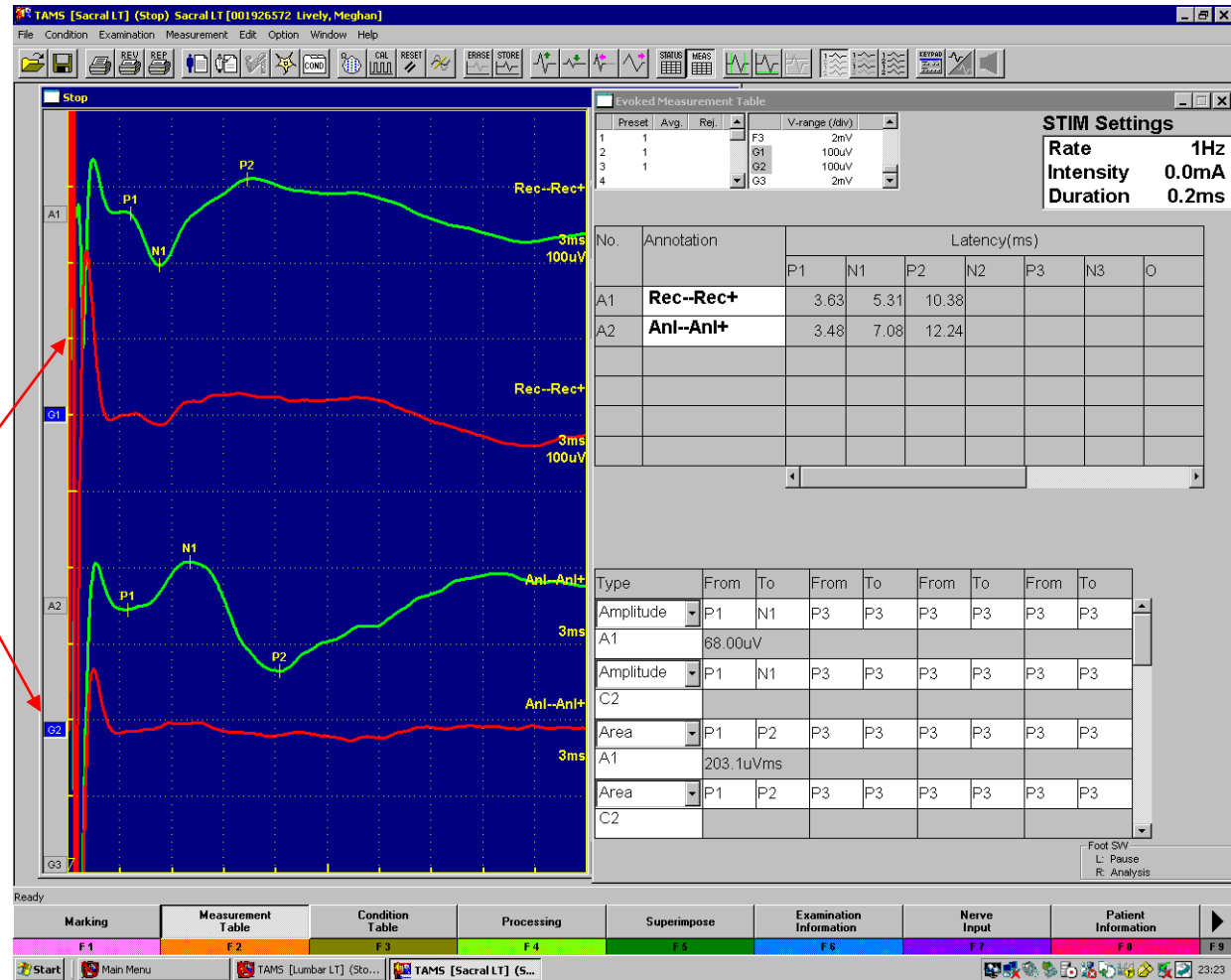


If the probe is displaced,
What will happen?

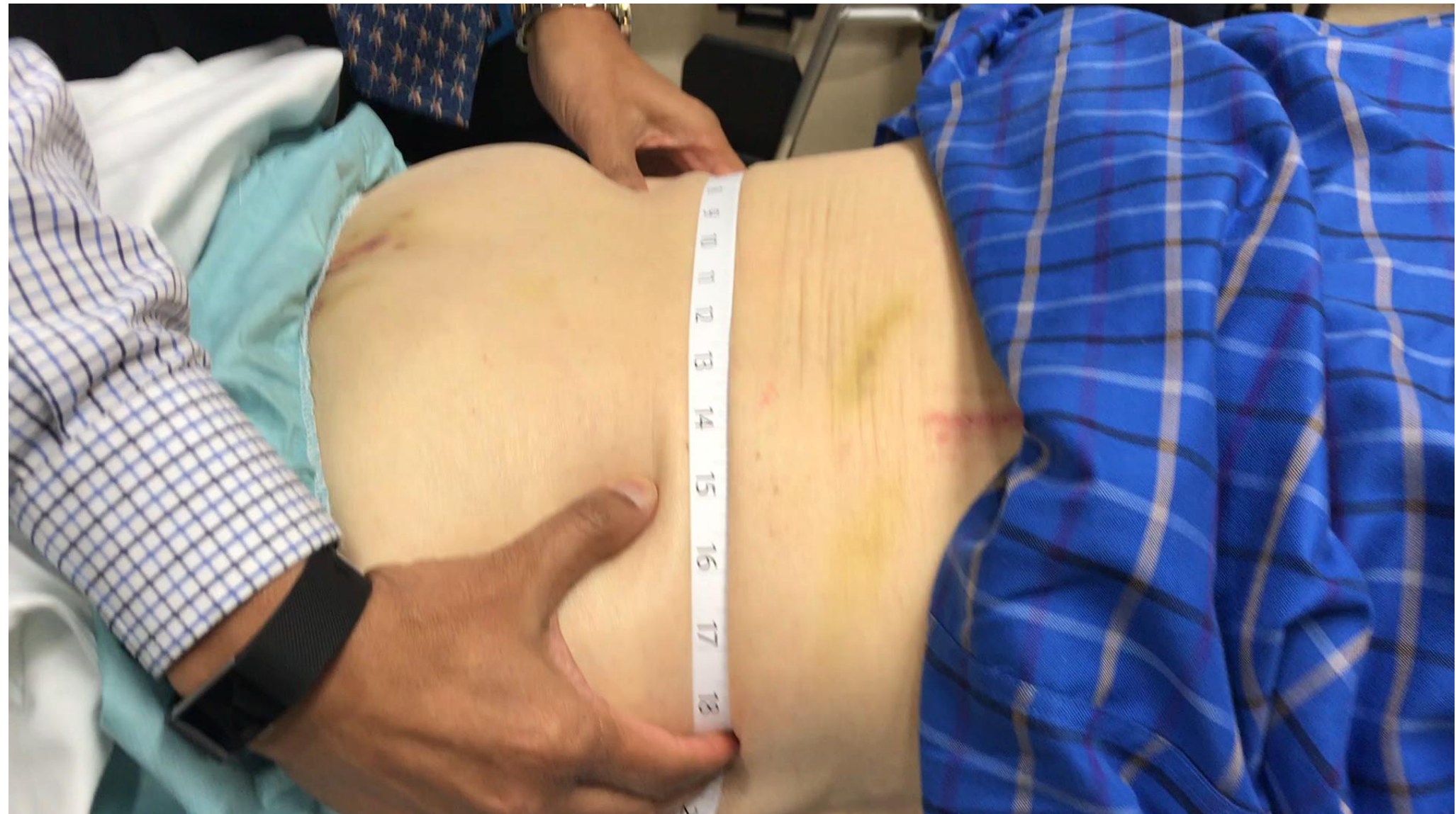


Question and Answer

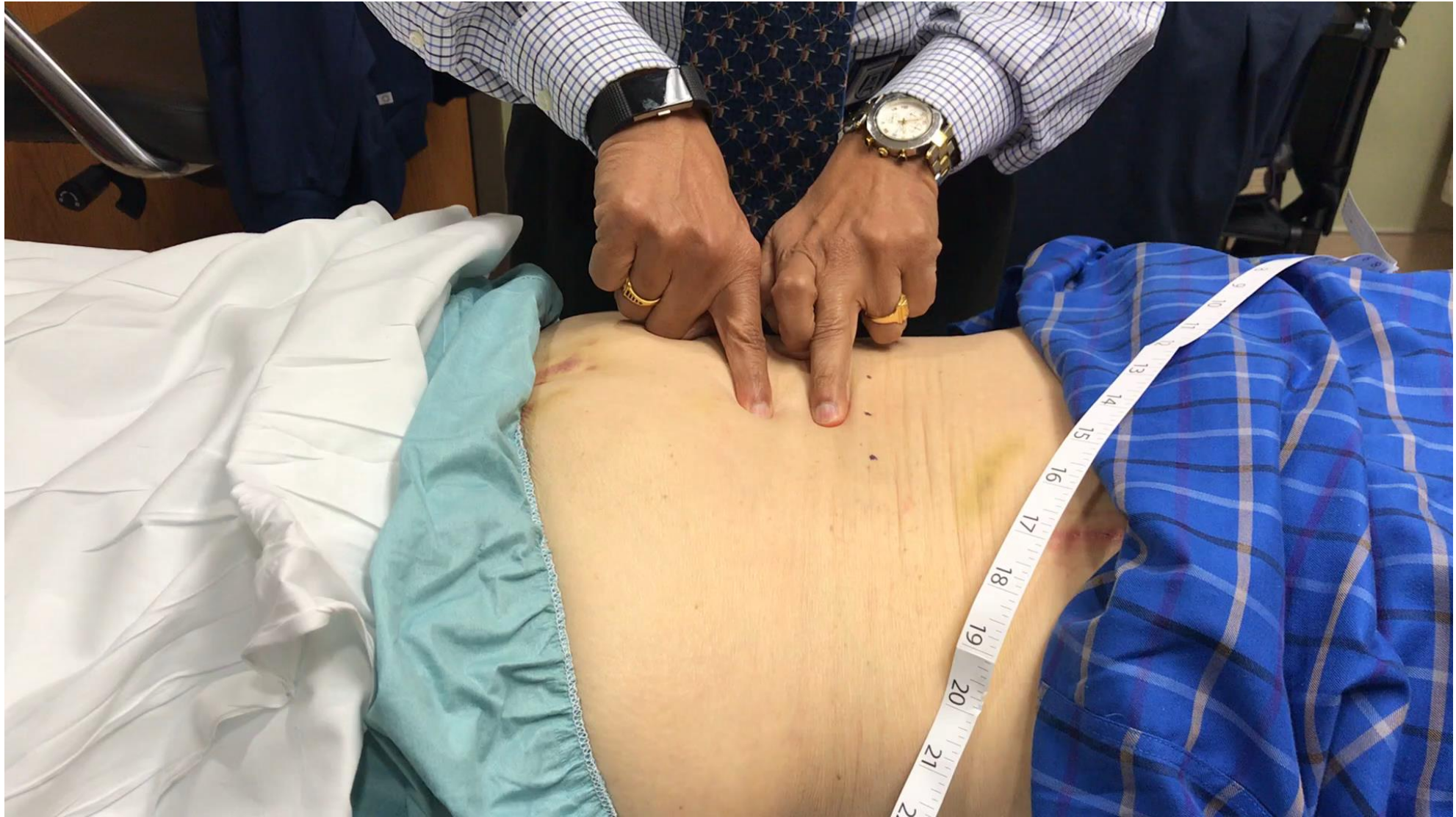
If reference electrodes are disconnected, What will happen?



Video-Demonstration-Surface Marking

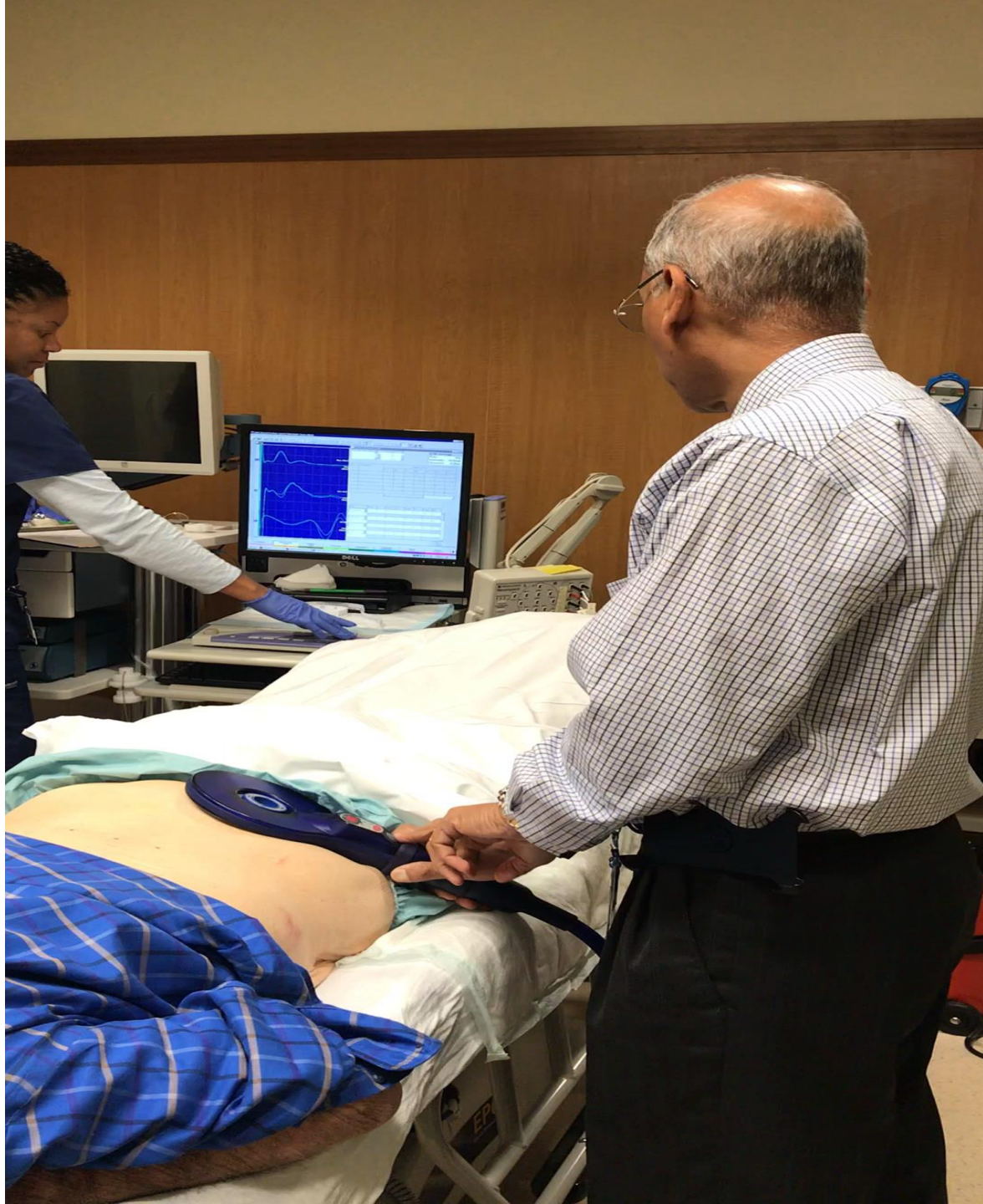


Identifying Lumbar & Sacral intervertebral space



Patient Education





Summary Of Pitfalls with TAMS recording/Measurement

Connectors/
reference
electrodes

Weak sphincter
Augmentation

Obesity



Probe
Slipped

Stimulation
intensity

Stool in
rectum

Coil
location



Spine surgery

???
Call Dr Rao
Pray

Back injury

TAMS Test Interpretation & Report

Translumbar Anorectal Magnetic Stimulation (TAMS) — MEP study

Left Lumbar MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Left Lumbo-Rectal					
Left Lumbo-Anal					

Left Sacral MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Left Sacro-Rectal					
Left Sacro-Anal					

Right Lumbar MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Right Lumbo-Rectal					
Right Lumbo-Anal					

Right Sacral MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Right Sacro-Rectal					
Right Sacro-Anal					

Entered into Medidata by: Staff Initials: _____	Date: Day ___ / Month ___ / Year ___
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TAMS Test Interpretation & Report

Translumbosacral Anorectal Magnetic Stimulation (TAMS) — MEP study

Left Lumbar MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Left Lumbo-Rectal	65	5.2	25	124	Abnormal
Left Lumbo-Anal	65	4.4	67	198	Normal

Left Sacral MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Left Sacro-Rectal	60	6.1	45	212	Abnormal
Left Sacro-Anal	60	5.9	56	176	Abnormal

Right Lumbar MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Right Lumbo-Rectal	70	3.8	92	289	Normal
Right Lumbo-Anal	70	6.3	43	98	Abnormal

Right Sacral MEPs					
Anatomic Location	Intensity %	Latency (msec)	Amplitude (microvolts)	AUC (μ Vmsec)	Notes
Right Sacro-Rectal	70	3.5	78	192	Normal
Right Sacro-Anal	80	5.7	23	87	Abnormal

Entered into Medidata by: Staff Initials: _____

Date: ___/___/___
Day / Month / Year

TAMS Test Conclusions

- Anorectal neuropathy is a common finding in F.Incontinence
- TAMS is a novel neurophysiological test that assesses anorectal Neuropathy
- It is Objective, Reproducible and has well developed normative data
- Test takes about 30 minutes to Perform & Interpret
- Significant evidence supports its clinical utility in FI and SCI
- Equipment and Testing Pitfalls should be avoided and/or overcome
- Meticulous care when acquiring information ensures accuracy
- Mastering any test/technique requires skill & there is a learning curve

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Transcranial Magnetic Stimulation



Reza Jalinus

Ian Freston

Tony Barker