International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 8; Issue 06 (D); June 2019; Page No.19206-19211
DOI: http://dx.doi.org/10.24327/ijcar.2019.19211.3694

Research Article

NEUROPHYSIOLOGICAL EVALUATION OF BOWEL DYSFUNCTION IN LOWER MOTOR NEURON LESIONS

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A R T I C L E I N F O

Article History:
Received 12th March, 2019
Received in revised form 23rd April, 2019
Accepted 7th May, 2019
Published online 28th June, 2019

A B S T R A C T

Introduction: Fecal incontinence is a distressing condition, often caused by split of the anal sphincter or pelvic floor nerve injury. Constipation constituted additional bowel impairment in patients with neurogenic lesions. Patients suspected to have bowel dysfunction with neurogenic etiology should undergo neurophysiological testing. **Aim of The work:** This work was aimed to assess the electrodiagnostic value of sphincteric electromyography, pudendal nerve terminal motor latency, sacral reflexes, pudendal nerve and somatosensory-evoked potentials in bowel dysfunction. **Patients and Methods:** This study included 25 patients suffering from bowel dysfunction, with Lower motor neuron lesionsselected from Tanta and Alexandria University Hospitals. Diagnosis of the patients based on a full history including boweldysfunction and constipation questionnaires, complete physical and neurological examination andmagnetic resonance imaging.Followed by the electrodiagnostic of sphincteric electromyography, pudendal nerve terminal motor latency, sacral reflexes, and pudendal nerve somatosensory-evoked potentials. **Results:** The sensitivity of motor unit action potential of external anal sphincter parameters in diagnosis of neuropathic lesion include: sensitivity of amplitude 40% , duration 56 %, area 100%, , rise time 100%, phases 88%, denervation 56%.The sensitivity of other parameters in diagnosis of neuropathic lesion as following: bulbocavernosus12%, puborectalis56%, gracilis92%, pudendal nerve terminal motor latencies right 100% &left 88%, reflex the bulbocavernosus12%, ReflexPudendo-anal 72%, Somatosensory evoked potentials of pudendal nerve 28%.**Conclusion:**This study results point to the importance of using a combination of of motor unit action potentialparameters to increase sensitivity for the detection of neuropathic changes in bowel dysfunction

INTRODUCTION

Fecal incontinence is a disturbing condition, often caused by split of the anal sphincter or by injury in pelvic floor nerve.[1]Parturition is considered the most common injury cause to the pudendal nerve and its branches due to a mechanical disruption in muscle fibers or in skeletal muscles innervation. Their sources; "anterior hom cells/ sacral roots" can be damaged due to Conus medullaris or cauda equina injury.[2]

Techniques such as neurophysiological testing to investigate the function of pelvic organ and pelvic floor have been developedto clinically test these entities. The anal sphincter electromyography was first performed in Denmark. [1]

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In recent years, external anal sphincter (EAS) electromyography (EMG) has gained popularity among neurologists and clinical neurophysiologists, as the muscle is innervated by the lower sacral segments. The external anal sphincter (EAS) is readily accessible and examined without too much discomfort, and it is easy to compile arepresentative sample of its motor unit action potentials (MUPs). . [4]

After stimulating bulbocavernosus electrically, the reflex latency is recorded as part of the motor conduction studies. So, after somatosensory introduction to the clinical field, the evoked potentials are recorded, after several repetitive stimulations for pelvic sensory nerve and pudendal nerve.[4]After that, the cortical and nerve root were stimulated electrically and magnetically [5][6] while lately, recording at pelvic floor musculature is used in clinical practic. Moreover, such information may help to delineate the prognosis of the

disease, before considering treatment or during therapeutic follow-up. [5]

Patients & Methods

This study included twenty-five (25) patients, age ranged between 29-58 yrs old, with bowel dysfunction due to cauda equina syndrome, sacral plexus lesions and pudendal nerve neuropathy selected from Tanta and Alexandria University Hospitals.

Patients with upper motor neuron lesions (stroke, multiple sclerosis, multiple system atrophy, Parkinsonism, spondylotic myelopathy, transverse myelitis and spinal cord injury) excluded from the study.

Diagnosis of the patients based on a full history followed by a complete physical and neurological examination, magnetic resonance imaging, Boweldysfunction and constipation questionnaires and electromyography(EMG)

Bowel dysfunction questionnaire[7] include questions covering all aspects of bowel dysfunction; Consistency of feces, anal incontinence frequency, sensation while defecation, associated pain and other possibleissues and constipation

	Frequency				
Type of incontinence	**Never**	**Rarely**	**Sometimes**	**Usually**	**Always**
Flatus	0	1	2	3	4
Liquid stools	0	1	2	3	4
Solid stools	0	1	2	3	4
Wears Pads	0	1	2	3	4
Lifestyle alteration	0	1	2	3	4

0=perfect continence, 20= complete incontinence

Frequency: never =0; rarely = <1/month; sometimes = <1/week, ≥1/month; usually = <1/day ≥1/week; always = ≥1/day

Questions were scored (more pronounced bowel dysfunction scored higher).

- Score= 0: Perfect anal continence
- Score between 1 and 5: Incontinence of flatus and considered mild
- Score between 6 and 10:Liquid stools observed several times per week and considered moderate
- Score between 11 and 20: Observe daily incontinence of liquid/solid stools and considered severe.

Constipation questionnaire[7]

1. Bowel movements frequencies:

0 = 1–2 times in 1 to 2 days, 1 = 2 times a week, 2 = once a week, 3 = > 1 a week

2. Painful evacuation effort, completeness (feeling of incomplete evacuation), abdominal pain:

Never= 0, Rarely= 1, Sometimes= 2, Usually= 3, Always= 4

3. Evacuation Failure per 24 hours:

Never= 0, 1 to 3 times=1, 3 to 6 times= 2

4. history (years of constipation):

0 = 0, 1 =1–5, 2 = 5–10, 3 = 10–20, 4 = >20

5. Assistance (type of assistance):

No assistance=0, Taking stimulating laxatives=1, Enemas/digital assistance=2

Constipation in this study was defined as patients having mild, moderate, and severe scores including constipation, evacuation problems, frequency, and other associated problems.

1. Electromyography(EMG)

It consists of 2 parts: 50 mm long concentric needle (No. 22583), standard with UK, Oxford and the Nihon Kohden EMG system. This EMG system contains 5 Hz-10 kHz standard filter, 200 mV/division gain and 10 mesc/division sweep. [4]The examination is performed after making sure that the patients has a complete empty bladder.

a. External anal sphincter (EAS); 1 cm away from anal orifice, the subcutaneous part(3±6 mm under mucosa) of external anal sphincter muscle was inserted with the needle. Moreover, the needle was inserted 1±3 cm at the anal orifice, 30°-50°angle to the anal canal axis, in order to measure deeper parts in the anal sphincter. [4]
b. Bulbocavernosus muscle; The needle was inserted trans-mucosally and medially to the labia majora in females bulbocavernosus muscle. [3]
c. Urethral Sphincter; in females, and 5 mm from the external urethral meatus, 12 o'clock position electrode was retained into the sphincter of striated urethra. [10]
d. Levatorani (Puborectalis part); the external anal sphincter was attached with a concentric needle 3 to 5 cm deep in the front half. [4]
e. Gracilis; concentric needle was inserted in the distal third of the medial thigh; this muscle is just anterior to the medial hamstring tendon. [10]

2. St. Mark's Hospital Electrode (UK)is used to obtain motor latencies at the Pudendal nervewhere it stimulated by single 0.1 msec stimuli and near the ischial spine at the tip of the finger. At the level of external sphincter, a surface electrode that is placed 8 cm at the base of thefinger, records the motor potentials [3]

3. Sacral reflexes

a. The bulbocavernosus;, to stimulate the dorsal nerve of the penis in male or the clitoris in females, 1 Hz hand-held bipolar stimulating electrode with cathodeapply a 0.1-0.5 msec rectangular pulse.Then, a concentric needle electrode records these pulses after inserting it into the left part and the right part of bulbocavernosus muscles. [8]
b. Pudendo-anal, Clitoro-anal; Surface electrode is placed in penis and clitoris dorsal nerve to electrically stimulate the pudendal nerve.Another concentric needle electrode records these stimuli after its insertion into the leftside and the right side of bulbocavernosus muscles. [8]

4. EEG system is used to record somatosensory evoked potentials (SEP) of pudendal nerve. They are measured from the middle behind the central vertex (2 cm). [9] 0.1 msec, 2- HZ surface electrode is placed at penis and clitoris base to initiate stimulation with three folds intensity than that of the sensory threshold.

The EMG results were classified into five categories: Category I: normal, Category II: slight partial EAS lesion, Category III: moderatepartial EAS lesions, Category IV: severepartial EAS

lesions, and Category V: bilateral and complete denervation of all EAS muscles [4]

Statistics: descriptive and analytical statistics were conducted and presented using the mean, standard error, unpaired student t-test, Wilcoxon tests, test for linear correlation coefficient, ANOVA tests for variances, Paired t-test and chi-square test by SPSS version 17.Likelihood-ratio chi-square, Fisher's exact test and the Yates' corrected chi-square are computed for 2x2 tables. Student t-test [Unpaired]:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{SE_1 2 + SE_2 2}}$$

Paired t-test:

$$t = \frac{\overline{X}d}{\sqrt{SE_d}}$$

Sensitivity/true positive rate/recall ratecaculates the actual real positives proportion which are correctly identified Sensitivity= true positives/(true positive + false negative)–Specificity/true negative ratecalculates the negatives proportion which are correctly identified by the test.

- Specificity=true negatives/(true negative + false positives) - False negative - negatively tested result when the disease exist- False positive - positivelydetected when the disease does not exist. [1]

RESULTS

Table 1 Bowel dysfunction questionnaire

		Group
Mild anal incontinence	N	5
	%	20.00
Moderate anal incontinence	N	9
	%	36.00
Severe anal incontinence	N	11
	%	44.00
Total	N	20
	%	100.00

Table 2 Constipation questionnaires

Constipation		Group
Mild	**N**	1
	%	4.00
Moderate	**N**	2
	%	8.00
Total	**N**	3
	%	12.00

Table 3 Comparison between normal cases and cases with bowel dysfunction as regard motor unit action potential parameters of external anal sphincter.

	All cases	*N*	*Mean*	*Std. Deviation*	*p-value*
Amplitude	*Bowel Dysfunction*	*25*	0.6731	0.08097	
	Normal	*14*	0.4714	0.06075	*S*
Duration	*Abnormal*	*25*	7.0692	0.40699	
	Normal	*14*	5.2621	0.63056	*S*
Area	*Abnormal*	*25*	0.6000	0.07303	
	Normal	*14*	0.3950	0.05599	*S*
Thickness	*Abnormal*	*25*	0.8900	0.05568	
	Normal	*14*	0.8436	0.12610	*NS*
Size index	*Abnormal*	*25*	0.5354	0.10556	
	Normal	*14*	0.1843	0.11216	*S*
Phases	*Abnormal*	*25*	3.69	0.751	
	Normal	*14*	3.29	0.469	*NS*
Rise time	*Abnormal*	*25*	0.5500	0.11195	
	Normal	*14*	0.5121	0.41386	*NS*

This table demonstrated that the potentials for motor unit action resulted from the EAS in all dysfunction patients were significantly larger in amplitude, duration, size index and phases.

Table 4 The sensitivity and specificity of the amplitude as one MUAP parameter in diagnosis of external anal sphincter (EAS) neuropathic lesion.

Sensitivity%	**40**
Specificity%	**100**
Positive predictive value%	100
Negative predictive value%	63.6
Overall agreement%	70.4

Table 5 The sensitivity and specificity of the duration as one of motor unit action potential (MUAP) parameter in diagnosis of EAS neuropathic lesion.

Sensitivity%	**56**
Specificity%	**100**
Positive predictive value%	100
Negative predictive value%	70
Overall agreement%	77.8

Table 6 The sensitivity and specificity of area as one MUAP parameter in diagnosis of EAS neuropathic lesion.

			Group		**Total**
			Bowel Dysfunction	**Normal**	
Area	Abnormal	Count	25	14	39
		% within Dysfunction	100%	100.0%	100%
	Total	Count	25	14	39
		% within Dysfunction	100.0%	100.0%	100.0%

Table 7 The sensitivity and specificity of thickness as one MUAP parameter in diagnosis of EAS neuropathic lesion.

Sensitivity%	**48**
Specificity%	92.9
Positive predictive value%	85.7
Negative predictive value%	65
Overall agreement%	70.4

Table 8 The sensitivity and specificity of size index as one MUAP parameter in diagnosis of EAS neuropathic lesion.

Sensitivity%	**72**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	77.8
Overall agreement%	85.2

Table 9 The sensitivity and specificity of phases as one MUAP parameter in diagnosis of EAS neuropathic lesion

Sensitivity%	**88**
Specificity%	71.4
Positive predictive value%	73.3
Negative predictive value%	83.3
Overall agreement%	77.8

Table 10 The sensitivity and specificity of rise timeas one MUAP parameter in diagnosis of EAS neuropathic lesion.

Sensitivity%	**100**
Specificity%	42.9
Positive predictive value%	61.9
Negative predictive value%	100
Overall agreement%	70.4

Table 11 The sensitivity and specificity of interference pattern (IP) of EAS in diagnosis of pudendal nerve neuropathy

Sensitivity%	**72**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	77.8
Overall agreement%	85.2

Table 12 The sensitivity and specificity of EAS Denervation in diagnosis of neuropathy

Sensitivity%	**56**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	70
Overall agreement%	77.8

Table 13 The sensitivity and specificity bulbocavernous (BC) EMG in diagnosis of neuropathy

Sensitivity%	**12**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	53.8
Overall agreement%	55.6

Table 14 The sensitivity and specificity of urotheric sphincter (Us) EMG in diagnosis of neuropathy

			Group		**Total**
			Bowel Dysfunction	**Normal**	
Us EMG	Normal	Count	25	14	39
		% within Dysfunction	100	100	100
Total		Count	25	14	39
		% within Dysfunction	100.0	100.0%	100.0%

Table 15 The sensitivity and specificity of puborectalis (PR) EMG in diagnosis of neuropathy

Sensitivity%	**56**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	70
Overall agreement%	77.8

Table 16 The sensitivity and specificity ofgracilis EMG Category in diagnosis of neuropathy

Sensitivity%	**92%**
Specificity%	100%
Positive predictive value%	100%
Negative predictive value%	93.3%
Overall agreement%	96.3%

Table 17 The sensitivity and specificity of pudendal nerve terminal motor latencies right side in diagnosis of neuropathy.

Sensitivity%	**100**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	100
Overall agreement%	100

Table 18 The sensitivity and specificity of pudendal nerve terminal motor latencies Left side in diagnosis of pudendal nerve neuropathy.

Sensitivity%	**88**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	93.3
Overall agreement%	96.3

Table 19 The sensitivity and specificity of The bulbocavernosus reflex [BCR] in diagnosis of pudendal nerve neuropathy

Sensitivity%	**12**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	53.8
Overall agreement%	55.6

Table 20 The sensitivity and specificity of Pudendo-anal reflex [PAR] in diagnosis of pudendal nerve neuropathy

Sensitivity%	**72**
Specificity%	71.4
Positive predictive value%	69.2
Negative predictive value%	71.4
Overall agreement%	70.4

Table 21 The sensitivity and specificity of somatosensory evoked potentials (SSEP) of pudendal nerve

Sensitivity%	**28**
Specificity%	100
Positive predictive value%	100
Negative predictive value%	58.3
Overall agreement%	63

DISCUSSION

Fecal incontinence is a distressing condition, often caused by anal sphincter split or injury in pelvic floor nerve. [1]Constipation constituted additional bowel functiondisturbance in patients having neurogenic lesions. Constipation can be explained numerous mechanisms, and denervation of parasympathetic nerves that hinders colon transit is one of them[11].

Neurological examination of both lower limbs was performed in our study in all patients. 92% of patients had completely normal findings on clinical examination. Significantly reduced motor power in lower limbs was in 8% of patients. Faecal and urine incontinences was much reported in patients having Cauda Equina lesions in comparison to reporting faecalincontinence alone in the same group.

This study displays that the EAS of patients who suffer from bowel dysfunction, show evidence of denervation/ re-innervation, when compared with normative data. (Table 3). Motor unit action potentials were significantly larger than motor unit potentials of normal in the following parameters (area, amplitude, duration, size index and phases).There was significant perfect normal, complete EAS interference pattern.

These findings closely match the pathophysiological consequences of any nerve injury and repair. After the occurrence of partial nerve injury, the fiber muscles started to regain their lost functions by the help of adjacentaxons that innervate them again. These regenerated fibers gain more fibers and thus get enlarged nerve cells. As a result, the process of denervation and re-innervation produces longer, larger and complex waves in terms of duration, amplitude and appearance, respectively.. [12]

"Interference pattern" is created as a result of summation and cancellation of multiple motor units potentials during muscle contraction (continence). For greater contraction, it is required to employ more and larger motor units as illustrated in Henneman's principle· [13]Consequently, these larger units increase the amplitude and the number of produced signals in certain period of time (polarity/sec). In case nerve injury happened, less motor units are involved in creating more force

for muscle contraction. Thus, in cases of nerve injury, the "interference pattern" will be "reduced".

Re-innervation could be higher in motor units with higher threshold, as suggested by Podnar et al.[14] This means that those require larger force to be activated. Our study resultsare equivalent to this suggestion. Analysis to these higher threshold units, which are required in sufficient voluntary contraction, can be done using the interference pattern technique.

In the present study, mean values were used to compare the diagnostic sensitivity of MUP parameters and the normative data. [15]Using mean values area (100%), rise time (100%) , number of phases (88%) and size index (72%), records maximum sensitivityamong MUP parameters to identify neuropathic muscles (Table 6-8-9-10). The results ofduration (56%), thickness (48%)and amplitude(40) are less sensitive, while area showed highest sensitivity amongthe measured MUP parameters. These results matchother previous study's findings [16], however they differ from the results of Sonoo and Stålberg's study[16]who foundthe sensitivity of thickness was much higher than in this study.

In this study, sensitivity of pudendal nerve terminal motor latencies (PNTML) right (RT) side in diagnosis of pudendal nerve neuropathy was 100% for Rt side and 88 % of Lt side(Table 17,18).

PNTML was shown in this study to be able to illustrate how neurogenic fecal incontinence occurs. However, recently it is reported that PNTML is insufficient to use it alone as electro-diagnosis means in this case. [17,18,19], and the present study supports this report through the obtained results. Moreover, patients with fecal incontinence can undergo systematic examination by PNTML in order to define any neurogenic lesion.

To assess sacral reflex arc integrity, researchers have measured the latencies of bulbocavernosus reflex (BCR) and pudendo-anal reflex (PAR). Any damage in S2-S4 segments of sacral spinal cord or any damage in its afferent and efferent connections may lead to prolonged BCR PAR latencies. [20,21,22,23] However, researchers are required to the added values in clinical practice for patients with pelvic floor and sphincter disorders.[24]

In this study, Overall, sensitivity of bulbocavernosus reflex (BCR) in diagnosis of pudendal nerve neuropathy was 12% and for pudendo-anal reflex (PAR) was 72 % (Table 18, 19). Additional diagnostic data provided by sacral reflex testing makes it in advantage to other used approaches.[]

The value added y the sacral reflex testing suggested to be due to central reflex conduction at the sacral spinal cord as per Podnar[25]. This test is sensitivede-synchronization of the afferent reflexes that are allowed to disperse in the spinal cord, in comparison with the sensory testing. The test also advantaged on other means because it can detect de-synchronization due to minor damagesin sensory nerve fibers coming from the lower sacral region.

Literatures shows how extensive Sacral reflexes have been studied. Many laboratories used sacral reflex testing on daily bases to measure S2–S4 reflex arc integrity in an objective manner. Several data have been published for the sake of comparability. Although this test is easy to be performed and widely used, it lacks the sensitivity towards partial axonal lesions[3]because they are affected by several controllable or non-controllable factors such as dependency on peripheral pathways conduction and on interneuronal system to transmit signals. [3]

To measure the conduction in larger fibers that connect sacral innervated entities and with the parietal sensory cortex, pudendal somatosensory evoked potentials were measured.In our studythe sensitivity of somatosensory evoked potentials (SSEP) of pudendal was 28% with combined dysfunction, these findings are contradictory with Eardley, et al[26] who said that pudendal SEPs were advocated in patients with combined neurogenic bladder and bowel dysfunction.

Summary

- Injuries in pelvic floor nerve can now be measured objectively and rapidly using the "multiple motor unit action potential" analysis.
- To detect EAS neuropathic changes, it is recommended to use MUP parameters combined, in order to increase testing sensitivity when it is compared with that of the individual MUP parameters that did not exceeded of 85%.
- Electrodiagnosis of neurogenic bowel dysfunction by means of Pudendal nerve terminal motor latency measurement alone is insufficient.
- To measure the conduction at peripheral nerves, sacral reflex testing is recommended as an alternate method and as supplementary test with EMG examination of pelvic floor muscles in patients with suspected neuropathic lesion.

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How to cite this article:

Hamdy A. Khallaf *et al* (2019) 'Neurophysiological Evaluation of Bowel Dysfunction in Lower Motor Neuron Lesions Tenggara', *International Journal of Current Advanced Research,* 08(06), pp. 19206-19211.
DOI: http://dx.doi.org/10.24327/ijcar.2019.19211.3694

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