

# **Comparative study Between The Functional Outcomes Of Neuromodulation And Neuroablation Techniques For Treatment Of Secondary Dystonia**

**Thesis**

Submitted for partial fulfillment of MD Degree in

**Neurosurgery**

By

**Mohamed Abd El-Rahman Moustafa Nada**

M.B., B.Ch., M.Sc

Neurosurgery Specialist

Dar El-Shifa Hospital, Al-Abbasia

**Under Supervision Of**

**PROF. DR. EMAD MOHAMED GHANEM**

Professor of Neurosurgery

Faculty of Medicine

Ain Shams University

**PROF. DR. KHALED MOHAMED EL BAHY**

Professor of Neurosurgery

Faculty of Medicine

Ain Shams University

**ASSIST. PROF. DR. WALID AHMED ABDEL GHANY**

Assistant Professor of Neurosurgery

Faculty of Medicine

Ain Shams University

**ASSIST. PROF. DR. ZEIAD YOSSRY FAYED**

Assistant Professor of Neurosurgery

Faculty of Medicine

Ain Shams University



**Faculty of Medicine  
Ain Shams University**

**2017**

## **Abstract**

### **Background:**

Secondary dystonia are the syndromes that have dystonic symptoms due to brain insult which can be associated with neonatal encephalopathy syndromes, trauma, vascular injury, infections, demyelinations, or hereditary disorders associated with neurodegenerative process. The disability inflicted by dystonia encouraged the development of many neurosurgical procedures in order to improve the quality of life of these patients.

The aim of this study was to compare the outcomes of different Neuroablative and modulation techniques in treatment of secondary dystonia.

### **Patients and methods**

This is a prospective study included 120 patients suffering from intractable secondary dystonia. Ablative techniques included the brain lesioning procedure and combined anterior and posterior lumbar rhizotomy (CAPR). Modulation techniques included deep brain stimulation (DBS) and intrathecal baclofen therapy (ITB). Patients with focal dystonia were included in the Botulinum toxin injection group. Patients with generalized dystonia were included in either of the brain lesioning or the deep brain stimulation, and patients with predominant affection of both lower limbs were included in either of the (CAPR) or the (ITB) groups.

Assessment measures included the evaluation of the muscle tone, range of motion, and the Burke-Fahn-Marsden dystonia rating scale through a follow up period of one year.

### **Results**

Muscle tone was significantly reduced in the ablative techniques and the ITB, but the changes in the DBS group were not significant. The range of motion improved in all groups; the changes were significant in the ablative techniques and the ITB but were not significant in the DBS group. The BFMDRS showed improvement in all groups, the changes were significant in all groups except the DBS group.

### **Conclusion**

Both neuroablative and neuromodulation techniques have the beneficial impact on secondary dystonias especially with stationary neurological pathologies with no significant statistical difference between both techniques. While the neuromodulation techniques had the advantages of being adjustable, titratable, reversible, and can be performed bilaterally.

**Key words:** Dystonia; Neuroablation; Neuromodulation

## ACKNOWLEDGEMENTS

First and foremost, thanks to God who; gave me the ability to complete this work.

---

I would like to express my sincere and deep gratitude, to my **PROF. DR. EMAD MOHAMED GHANEM** (Professor of Neurosurgery, Faculty of Medicine - Ain Shams University) for his kind help, cooperation, and valuable suggestions. It is a great honor to work under his guidance and supervision.

And I would like to express my thanks and appreciation to **PROF. DR. KHALED MOHAMED EL BAHY** (Professor of Neurosurgery, Faculty of medicine - Ain shams university) for his supervision, continuous guidance, cooperation and helpful instructions

And I am very grateful to **DR. WALID AHMED ABD EL-GHANY** (Assistant Professor of Neurosurgery, Faculty of medicine - Ain shams university) for his valuable help and keen interest in the progress and accomplishment of this work.

Also, I would like to thank **DR. ZEIAD YOSSRY FAYED** (Assistant Professor of Neurosurgery, Faculty of medicine - Ain shams university) for his valuable help and keen interest in the progress and accomplishment of this work.

# CONTENTS

Acknowledgements	I
List of figures	III
List of abbreviations	VII
Introduction	1
Aim of the work	5
Anatomical & physiological considerations	7
Pathophysiology of secondary dystonia	24
Clinical aspects of dystonia	30
Assessment measures of dystonia and treatment outcomes	39
Non surgical treatments of dystonia	54
Surgical treatments of dystonia	59
Patients and methods	77
Results	108
Case reports	145
Discussion	155
Summary	172
Conclusion	175
References	177

# List of Figures

Fig. No.	Description	Page
1	A three-dimensional drawing of the basal ganglia and structures around it	8
2	Human basal ganglia shown in a frontal section	10
3	Pathways within the Cortico-basal ganglia loop	11
4	Myelin plate of the left striatum	15
5	Myelin plate in coronal view of the left basal ganglia	17
6	Principal cell masses in the human right thalamus shown in a horizontal section	21
7	An irregular burst discharges recorded in the Vim nucleus shown with the contra-lateral EMG from the forearm flexor and extensor muscles	25
8	The multistep process and summary of the pathophysiology of dystonia	29
9	Phenomenological features of dystonia	33
10	Clinical and etiologic schemes for classification of dystonia	34
11	Expression of dystonia according to body distribution	36
12	T2-weighted axial MRI demonstrates the “face of the giant panda” sign	50
13	FLAIR MRI demonstrating the "eye of the tiger" sign	50
14	FLAIR MRI demonstrating diffuse demyelination in a patient with metachromatic leukodystrophy	51
15	Comparison between Bertrand procedure and Taira's method in cervical denervation	66
16	Sectioning of the anterior and posterior rootlets in patients suffering from mixed dystonia and spasticity	68
17	Demonstration of intrathecal Baclofen pump insertion	70
18	Different types of spinal cord stimulators	72
19	Screenshot of the MER recording system	76
20	Different commercially available DBS systems	77
21	Manual goniometer	83
22	Plain X-rays scanning for deformities	87
23	CT scan for pallidotomies and DBS	87

24	The Leksell stereotactic arc system	90
25	The localizer is attached to the base ring and is ready for imaging	91
26	Leksell Surgiplan software	92
27	Patient positioning and burr holes	94
28	Macro-stimulation and impedance monitoring	94
29	Operative steps during MER	97
30	Fluoroscopic image for verification of the DBS electrodes	98
31	Operative steps during IPG insertion	99
32	Operative steps during CAPR	101
33	The Medtronic NIM Response	101
34	Screenshots of the intra- operative responses of different muscle groups to stimulation	101
35	Patient position during Baclofen pump insertion	104
36	Abdominal incision and facial planes	105
37	The pump in place in the abdominal wall	106
38	Guided techniques for Botulinum toxin-A injection	107
39	Numbers of patients in different etiologies for secondary dystonia	108
40	A girl with a feeding gastrostomy	109
41	Different X-rays demonstrating deformities	111
42	The changes in the mean MAS during the follow up period in group A1	113
43	The changes in the mean ROM during the follow up period in group A1	114
44	The changes in the mean BFM during the follow up period in group A1	115
45	The changes in the mean Barthel index during the follow up period in group A1	116
46	Changes in the spasm frequency scores during the follow up period in group A1	117
47	The changes in the mean MAS during the follow up period in group A2	119
48	The changes in the mean ROM during the follow up period in group A2	120
49	The changes in the mean BFM during the follow up period in group A2	121
50	The change in the mean Barthel index during the follow up period in group A2	122
51	Changes in the spasm frequency scores during the follow up period in group A2	123
52	The changes in the mean MAS during the follow up period in group B1	125

53	The changes in the mean ROM during the follow up period in group B1	125
54	The changes in the mean BFM during the follow up period in group B1	126
55	The change in the mean Barthel index during the follow up period in group B1	127
56	Changes in the spasm frequency scores during the follow up period in group B1	128
57	The infected burr hole cap and the lead extruded through the scalp	130
58	Marked extensor spasm of the back and neck muscles impeding sitting	130
59	The changes in the mean MAS during the follow up period in group B2	132
60	The changes in the mean ROM during the follow up period in group B2	133
61	The changes in the mean BFM during the follow up period in group B2	134
62	The change in the mean Barthel index during the follow up period in group B2	135
63	Changes in the spasm frequency scores during the follow up period in group B2	135
64	The changes in the mean MAS during the follow up period in group C	138
65	The changes in the mean ROM during the follow up period in group C	139
66	The changes in the mean BFM during the follow up period in group C	140
67	The change in the mean Barthel index during the follow up period in group C	141
68	Changes in the spasm frequency scores during the follow up period in group C	142
69	Follow up CT brain for verification of the lesions site	146
70	Pre and post- operative picture for a child with mixed hypertonic state	149
71	Verification of the position of the device electrodes	151
72	Baclofen pump refilling technique	153
73	Guided injection of Sternocleidomastoid muscle	154

# List of Abbreviations

---

<b>BADS</b>	Barry Albright dystonia scale
<b>BSDI</b>	Blepharospasm disability index
<b>BoNT</b>	Botulinum neurotoxin
<b>BFMDRS</b>	Burke-Fahn-Marsden dystonia rating scale
<b>CP</b>	Cerebral palsy
<b>CD</b>	Cervical dystonia
<b>CAPR</b>	Combined anterior and posterior rhizotomy
<b>CT</b>	Computed tomography
<b>CBD</b>	Corticobasal degeneration
<b>DBS</b>	Deep brain stimulation
<b>DRD</b>	Dopa responsive dystonia
<b>EMG</b>	Electromyography
<b>GABA</b>	Gamma aminobutyric acid
<b>GPe</b>	Globus pallidus externus
<b>GPi</b>	Globus pallidus internus
<b>IPG</b>	Implantable pulse generator
<b>IQ</b>	Intelligence quotient
<b>ITB</b>	Intrathecal Baclofen
<b>MRI</b>	Magnetic resonance imaging
<b>MRCS</b>	Medical research council scale
<b>MAS</b>	Modified Ashworth scale
<b>MSA</b>	Multiple system atrophy
<b>PKAN</b>	Pantothenate kinase-associated neurodegeneration
<b>PSP</b>	Progressive supranuclear palsy
<b>RF</b>	Radiofrequency
<b>ROM</b>	Range of motion
<b>SEP</b>	Somatosensory evoked potentials
<b>SCS</b>	Spinal cord stimulator
<b>SCM</b>	Sternocleidomastoid muscle
<b>SNe</b>	Substantia nigra pars compacta
<b>SNr</b>	Substantia nigra pars reticulata
<b>STN</b>	Subthalamic nucleus
<b>TWSTRS</b>	Toronto Western spasmodic torticollis rating scale
<b>TMS</b>	Transcranial magnetic stimulation
<b>TENS</b>	Transcutaneous electrical stimulation



<b>UDRS</b>	Unified dystonia rating scale
<b>Vim</b>	Ventralis intermedius nucleus of the thalamus
<b>Voa</b>	Ventralis oralis anterior nucleus of the thalamus
<b>Vop</b>	Ventralis oralis posterior nucleus of the thalamus

---

## Introduction

---

Dystonia is the syndrome of sustained involuntary muscular contraction, causing twisting or repetitive movements or abnormal postures. Dystonia was first described by Gowers' in 1888, when it was named "tetanoid chorea". Destarac used the term "torticollis spasmodique" for description of cervical dystonia. The word "dystonia" was first used by Oppenheim in 1911 by using the term "dystonia musculorum deformans" (**Kanovsky et al., 2015**).

David Marsden attributed the syndrome to a disorder of functioning of the basal ganglia (**Marsden and Rothwell, 1987**), there is a hypothesis that dystonia is the "normal" motor action which is accompanied by abnormal co-contraction of antagonists, and by defective reciprocal inhibition in the other muscle groups. As a result, there is a dystonic pattern or dystonic movement appearing as a result of that abnormal muscle activity (**Albanese et al., 2013<sup>a</sup>**).

Dystonia is observed in different clinical conditions and can be classified according to the etiology to:

- **Primary:** with genetic defects, without gross morphological changes or any other associated symptoms.
- **Dystonia plus syndromes:** appears in association with parkinsonism or myoclonus, due to certain genetic or metabolic defects.

- **Secondary:** with identifiable causes, morphological changes, and/or additional symptoms (**Albanese et al., 2011**).

Secondary dystonia are the syndromes that have dystonic symptoms due to brain insult associated with: neonatal encephalopathy syndromes, infections, demyelinations, trauma, vascular injury, or hereditary disorders associated with neurodegenerative process (**Jankovic, 2004**).

Correct diagnosis and categorization of dystonia is critical before deciding the modality of treatment (**Albanese et al., 2006**).

Dystonia also can be classified according to the body involvement as:

- Focal dystonia: involving a single body region;
- Multifocal dystonia: involving multiple non contiguous body regions;
- Segmental dystonia: involving contiguous body regions;
- Generalized dystonia: involving the whole body.

Some treatments are more effective in certain types of dystonias. For example, pharmacological treatment is usually the first course of action in the early childhood-onset dystonia. The first drug to try in early-onset dystonia is usually levodopa, although; only 5% of early-onset dystonias are dopa-responsive (DRD) (**Khan and Fernandez, 2015**).

Several medications were used for the treatment of dystonia. These include dopaminergic agents, muscle relaxants, antidopaminergic agents, and anticholinergic drugs.

With the introduction of chemodenervation and the increasing experience of its use in dystonia, botulinum toxin injections are now the treatment of choice for focal and segmental dystonias.

Stereotactic brain lesioning procedures had variable outcomes with respect to the etiology and distribution of dystonia, and with respect to the site of the lesion whether in the thalamus or in the pallidum. By the 1980s, ablative brain surgery for dystonia had widely fallen out of favor and was not widely practiced (**Cersosimo et al., 2008**).

Deep brain stimulation (DBS) is a viable treatment for patients with primary dystonia and also for a small number of patients with secondary dystonias. Proper patient selection is the key to favorable responses after DBS surgery. Patients who are refractory to conservative measures, including medications and botulinum toxin injections are potential candidates (**Rezai et al., 2008**).

Intrathecal baclofen (ITB) is a treatment modality which has been used since the mid 1980's. It is titratable, reversible and produces levels higher than the oral dose facilitating the use of smaller doses per day (**Verroti et al., 2006**).

Peripheral surgical procedures have also been used for focal dystonias. These include: myotomies, rhizotomies, and/or peripheral neurotomies.

Combined anterior and posterior rhizotomy (CAPR) has the potentials to improve severe dystonia affecting the upper or lower extremities in patients with concomitant spasticity. Ventral rhizotomy was expected to help not only secondary dystonia but hereditary degenerative dystonia as well (**Abdel Ghany et al., 2016**) & (**Albright et al., 2001**).

Ventral rhizotomies appeared to be effective in the treatment of dystonia in the extremities, and could be done either in the lumbar region, the cervical region, or both (**Albright and Kabara, 2007**).

It becomes obvious that there is a need to assess the treatment we are rendering to the patient. Treatment and assessment of outcomes occurs on four levels: assessing the technical outcome, functional outcome, cost-effectiveness of the treatment, and patient satisfaction.

As we deal with patients with dystonia, the surgeon needs a strong anatomic, physiologic and pharmacologic background, rigorous methods to assess the disorders, and to work in a multidisciplinary team.

This branch of functional neurosurgery has developed extensively, leading to an arsenal of contemporary methods that could improve many disabling situations.

## **Aim of the study:**

---

1. Compare between the functional outcomes of the neuromodulation and neuroablation techniques for treatment of secondary dystonia.
2. Review the literature about the up-to-date in definitions, etiology, pathophysiological mechanisms and ongoing morbidities of dystonia and the current dystonia rating scales.
3. Outline the standard electrophysiological and physical assessment modalities.

# Review of literature

---

## **Chapter I:**

Anatomical and physiological considerations

## **Chapter II:**

Pathophysiology of dystonia

## **Chapter III:**

Clinical aspects of dystonia

## **Chapter IV:**

Assessment measures and rating scales

## **Chapter V:**

Non surgical treatments of dystonia

## **Chapter VI:**

Surgical treatments of dystonia