Parkinsonism and Related Disorders 66 (2019) 232–236

Contents lists available at ScienceDirect

Parkinsonism and Related Disorders

journal homepage: www.elsevier.com/locate/parkreldis

Short communication

Dystonia as complication of thalamic neurosurgery

Marina Picillo[a,1], Vijayashankar Paramanandam[b,1], Francesca Morgante[c], Musleh Algarni[b], Diana A. Olszewska[d], Renato Puppi Munhoz[b], Tipu Aziz[e], Erlick Pereira[c], Mojgan Hodaie[f], Suneil K. Kalia[f,g], Andres M. Lozano[f,g], Tim Lynch[d,2], Alfonso Fasano[b,g,*,2]

[a] Centre for Neurodegenerative Diseases (CEMAND), Department of Medicine, Surgery and Odontoiatry, Neuroscience Section, University of Salerno, Salerno, Italy
[b] Edmond J. Safra Program in Parkinson's Disease and Morton and Gloria Shulman Movement Disorders Centre, Toronto Western Hospital, UHN, Division of Neurology, University of Toronto, Toronto, Ontario, Canada
[c] Neurosciences Research Centre, Molecular and Clinical Sciences Institute, St George's University of London, London, UK
[d] Centre for Brain Health, Dublin Neurological Institute, National Centre for Deep Brain Stimulation, Mater Misericordiae University Hospital, Dublin, Ireland
[e] Nuffield Department of Clinical Neurosciences, John Radcliffe Hospital, Oxford, UK
[f] Toronto Western Hospital, UHN, Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ontario, Canada
[g] Krembil Brain Institute, Toronto, ON, Canada

ARTICLE INFO

Keywords:
Dystonia
Tremor
DBS
Stimulation
Thalamus

ABSTRACT

Background: Thalamotomy and deep brain stimulation of the ventralis intermedius nucleus are effective symptomatic treatments for tremor, irrespective of the underlying diagnosis.
Methods and results: Herein we describe six tremor patients (2 Parkinson's disease, 1 dystonic tremor, 2 Essential tremor plus dystonia, 1 Essential tremor plus ataxia) who underwent thalamic neurosurgery and acutely or sub-acutely developed dystonia that was permanent in three cases and could not be managed with any adjustments in the stimulation settings. Tremor response was excellent. We argue that thalamic procedures disrupted either or both the cerebello-thalamic and the cortico-striato-pallido-thalamo-cortical loop resulting in an increase of the thalamo-cortical outflow and subsequent change in the clinical picture from tremor to dystonia.
Conclusion: Thalamic neurosurgery might be rarely complicated by dystonia. Why some patients are more prone to develop this adverse event is still unknown and possibly related to intrinsic factors, which certainly need further studies.

1. Introduction

Thalamotomy and deep brain stimulation (DBS) of the ventralis intermedius (Vim) nucleus of the thalamus are effective symptomatic treatments for tremor irrespective of the underlying tremor diagnosis, i.e. essential tremor (ET), Parkinson's disease (PD) and dystonic tremor [1]. The long-term efficacy is good, although loss of benefit can occur due to habituation and/or disease progression [1,2]. The adverse effect profile of both is acceptable overall, particularly for DBS as adjusting stimulation settings can lessen common issues such as balance and speech problems [2].

Here, we describe six patients who underwent thalamic procedures for tremor in three centers and acutely or sub-acutely developed dystonia contralateral to the targeted hemisphere. We also provide possible pathophysiological explanations to explain this interesting and rare phenomenon.

1.1. Case reports

Patient 1. A 50-year-old, right-handed Indian man with a diagnosis of PD complained of left hand tremor and stiffness for 10 years. Due to the disabling and drug-resistant tremor (Video 1, segment 1), he underwent right Vim DBS (3387 lead connected to an Activa SC implantable pulse generator – IPG – by Medtronic, Minneapolis, MN, USA). Post-operative brain MRI confirmed satisfactory electrode location (Fig. 1A). The tremor was abolished immediately after electrode

Abbreviations: BoNT, botulinum neurotoxin; DBS, deep brain stimulation; ET, Essential Tremor; IPG, implantable pulse generator; PD, Parkinson's disease; Vim, ventralis intermedius; STN, subthalamic nucleus; ZI, Zona Incerta

* Corresponding author. University of Toronto, Movement Disorders Centre, Toronto Western Hospital, 399 Bathurst St, 7 Mc412, Toronto, ON, M5T 2S8, Canada.
E-mail addresses: alfonso.fasano@gmail.com, alfonso.fasano@uhn.ca (A. Fasano).

[1] These authors equally contributed to the manuscript as first authors.
[2] These authors equally contributed to the manuscript as senior authors.

https://doi.org/10.1016/j.parkreldis.2019.08.008
Received 9 April 2019; Received in revised form 1 July 2019; Accepted 11 August 2019

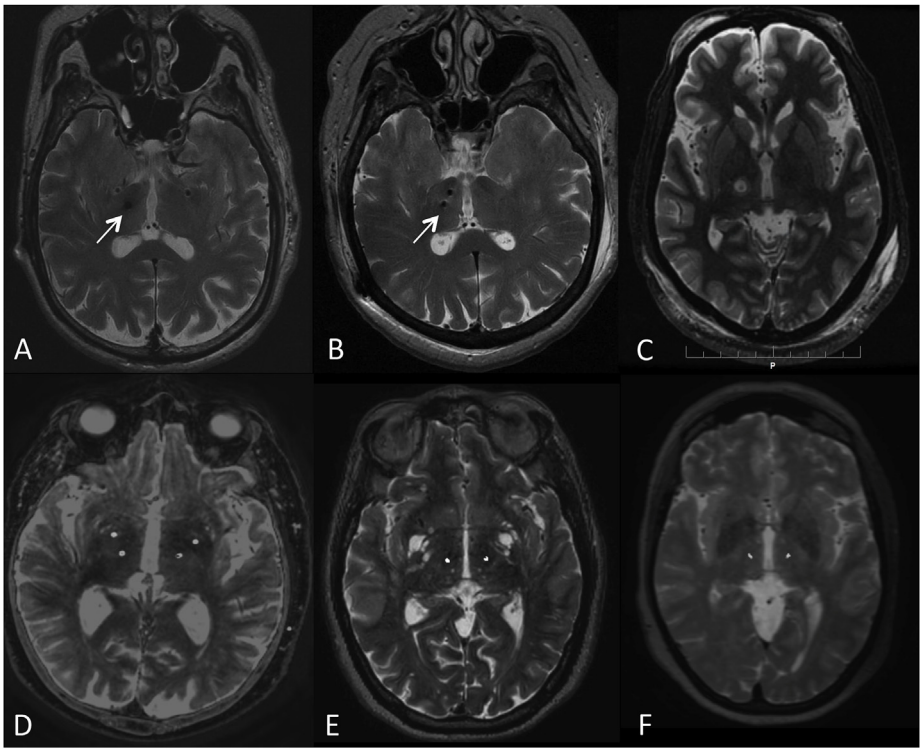

Fig. 1. A) Patient 1's T2w brain MRI showing the thalamic electrode position (white arrow). Later on, the patients underwent bilateral GPi DBS. B) Patient 2's T2w brain MRI showing the thalamic electrode position (white arrow). C) Patient 3's T2w brain MRI showing a right-sided radiofrequency thalamotomy. D) Patient 4's T2w brain MRI showing bilateral Vim DBS as well as bilateral Gpi DBS (white dots). E) Patient 5's T2w brain MRI resonance image with superimposed post-operative CT showing bilateral Vim/ZI DBS at the Vim level (white dots). F) Patient 6's postoperative CT fused to T2w brain MRI image showing bilateral Vim/ZI DBS (white dots).

insertion in absence of any acute adverse events. However, within a few days the patient developed a sustained dystonia of left hand and foot (Video 1, segment 2). One month post surgery he still had no tremor but the ipsilateral hemidystonia persisted (Video 1, segment 3). No additional neurological signs suggesting damage of the cortico-spinal tracts were observed. Stimulation was started with the most proximal contact in the attempt to reduce dystonia by stimulating the ventral lateral anterior portion of the thalamus, which is closest to ventralis oralis posterior (Vop) nucleus [3]. Finally, stimulation was turned off due to lack of benefit after several unsuccessful programming sessions. Levodopa was discontinued and he became bradykinetic confirming a diagnosis of PD with probable dystonic tremor at onset and hemidystonia triggered by the introduction of the thalamic electrode. A year later, the patient developed generalized levodopa-induced dyskinesias and underwent bilateral DBS of the globus pallidus pars interna (GPi) with significant improvement of dyskinesia and only partial improvement of hemidystonia. Further symptomatic management was also achieved with injections of botulinum neurotoxin (BoNT) in left hand and foot.

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.08.008

Segment 1. Levodopa challenge before surgery. Left hand kinetic tremor is evident OFF medication as well as hypomimia. After a challenge with levodopa 150 mg left hand tremor improves but dystonic posture appears.Segment 2. Video from the Emergency department seven days after surgery showing left hand fixed dystonia (DBS off).Segment 3. First programming session one month after surgery off stimulation and off medication. The patient presents with left hemidystonia with toes curling during walking. Patient has no spasticity, weakness or other pyramidal signs.

Patient 2. A 57-year-old, left-handed, woman with a diagnosis of tremor-dominant PD complained of left hand rest and kinetic tremor for 7 years. Tremor was partially levodopa-responsive but she remained disabled as kinetic tremor affected her dominant side (Video 2, segment 1). Right subthalamic nucleus (STN) DBS (3387 lead connected with an Activa PC IPG) improved tremor but induced left-hand cramping (Video 2, segment 2). Any stimulation reprogramming resulted in further worsening of the dystonia, thus STN stimulation was finally switched off with subsequent worsening of tremor and resolution of spasms. Six years later, she was implanted with right Vim DBS (3387 lead connected with an Activa SC IPG) (Fig. 1B). Vim stimulation was effective on tremor but induced task-specific hand dystonia (Video 2, segment 3). Again stimulation was turned off with resolution of dystonia. After reviewing the clinical history (particularly the lack of bradykinesia and rigidity), the initial diagnosis of PD was reconsidered and dystonic tremor was the final diagnosis. Nuclear imaging of the dopaminergic pathway was not available.

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.08.008

Segment 1. Baseline evaluation before surgery: left hand rest tremor and reduced left arm movements during walking are evident.Segment 2. Right STN DBS effectively controls tremor but induces disabling task-specific cramping with left shoulder elevation.Segment 3. Patient with both Vim and STN DBS stimulation off: left hand rest tremor with no dystonia is shown. After turning right Vim DBS on (case + 2–2.5V/60μs/130Hz) tremor subsides but painful, task-associated dystonia with shoulder elevation is evident. Rest tremor is slightly present in the right hand as well.

Patient 3. A 55-year-old man with tremor-dominant PD with off medication dystonia underwent right-sided radiofrequency thalamotomy due to disabling left hand kinetic tremor (Video 3, segment 1). He had paraplegia due to a previous spinal trauma and given the presence of infected pressure holes, often causing sepsis, DBS was not considered a good option for such a patient.

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.08.008

Segment 1. Levodopa challenge before surgery: left hand kinetic tremor and dystonic posturing as well as hypomimia are evident OFF medication. Levodopa challenge with 150 mg does not improve tremor.Segment 2. Patient is seen after right thalamotomy while on levodopa: he presents left hand dystonia and levodopa-induced dyskinesias involving his trunk and neck.

Tremor improved right after surgery but left arm dystonic posturing slowly developed over a 3-month period (Video 3, segment 2). Brain MRI showed a lesion limited to the Vim thalamus (Fig. 1C). No

additional neurological signs suggesting damage of the cortico-spinal tracts were observed. The patient is currently managed with high doses of BoNT injections with partial benefit, particularly alleviating his pain.

Patient 4. A 76-year-old man with an 8-year history of alcohol-responsive postural and action tremor consistent with ET was referred as a surgical candidate for bilateral Vim DBS. In hindsight, he had very subtle right foot posturing prior to surgery and a possible increased blinking rate (i.e., ET plus dystonic signs) (Video 4, segment 1). After initial improvement, he developed progressive right foot dystonia, neck stiffness with jaw-opening dystonia and blepharospasm over a 1-year period, not alleviated by any stimulation adjustments nor by turning off the stimulation for several minutes (Video 4, segment 2). No additional neurological signs suggesting damage of the cortico-spinal tracts were observed. In view of the persistent tremor and worsening of dystonia, bilateral Gpi DBS was performed at age 81 (Fig. 1D). After intensive programming, his tremor was well controlled with partial improvement of right leg dystonia, dysarthria, oromandibular dystonia and blepharospasm.

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.08.008

Segment 1. Upper limbs postural tremor is shown with worsening in the bat-wing position. Kinetic tremor is also present.Segment 2. Post-operative condition with DBS on (4.5V/90μs/150Hz, 4.4V/90 μs/150Hz) is characterized by laryngeal, jaw and right foot dystonia. An improvement of tremor (left > right) is also noticeable. Left foot drop is secondary to an incidental peroneal nerve palsy.

Patient 5. A 66-year-old man with a 20-year history of action tremor in the upper limbs and a diagnosis of ET underwent bilateral Vim DBS (directional lead 6171 connected to Infinity IPG, Abbott Inc, Plano, TX, USA) (Video 5, segment 1). Prior to surgery, he had very mild dystonic posturing of the right hand characterized by finger extension and wrist flexion, when outstretching the upper limbs (i.e., ET plus dystonic posturing).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.08.008

Segment 1. Upper limbs rest and postural tremor (right > left) is seen during the preoperative assessment.Segment 2. After surgery the patient has a dramatic improvement of tremor with dystonic posturing of right arm (case+ 2(a,b,c)-/2 mA/90 μs/130 Hz)

The most ventral contacts of the electrodes were positioned in the Zona Incerta (ZI) (Fig. 1E). Despite full control of tremor on both sides, dystonic movements in the right arm appeared right after the first programming (Video 5, segment 2) and decreased when the intensity of stimulation on left Vim was reduced from 3.2 to 2.8 mA. At this DBS setting he had satisfactory control of action tremor with mild dystonic movements not interfering with activities.

Patient 6. A 63-year-old woman diagnosed with tremor of the head, vocal cord and limbs (more severe in the upper limbs) obtained excellent tremor control after bilateral Vim/ZI DBS (directional lead 6171 connected to Infinity IPG) (Fig. 1F). Before DBS, she had some difficulty with tandem gait and a slightly wide base when walking (i.e., ET plus ataxic signs). After surgery, prior to turning DBS on, a mild inclination of the head to the left was apparent. The best effect on tremor was obtained with the stimulation of the first (on ZI) and third (on Vim) contact. However, stimulation with the most distal contact in ZI worsened balance. One month following her first DBS programming session, a mild dystonic posturing of both hands was evident with stimulation of both hemipsheres, especially with increased intensity of stimulation (Video 6, segment 1). Significant improvement of dystonic posturing was achieved by using the most distal contacts located in ZI (Video 6, segment 2).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.08.008

Segment 1. Dystonic posturing of the upper limbs (left > right) is evident during Vim stimulation (case+ 3(a,b,c)-/1.8 mA/60μs/130Hz). Segment 2. Improvement of dystonic posturing of the upper limbs with preserved benefit on the tremor is seen with ZI stimulation (case+ 1(a,b,c)-/1.8 mA/60μs/130Hz). Finally the patient was managed with Vim stimulation as her balance was worse with ZI stimulation and she had little disability from the mild dystonic posturing of the hands.

2. Discussion

Despite different clinical presentations, the patients described here share common features: an excellent tremor response after a thalamic procedure, the relatively rapid development or worsening of dystonia after surgery, the presence of subtle to evident dystonic signs before surgery (in all patients but number 6), and non contributory brain MRI.

In patient 1 the tremor completely and permanently resolved with right Vim lead insertion but left hemidystonia occurred. In patient 2 focal dystonia was induced by Vim stimulation and, despite intensive reprogramming satisfactory control of tremor without dystonia was impossible. Patient 3 developed permanent dystonia as a result of radiofrequency thalamotomy. Patient 4 progressively developed generalized disabling dystonia after bilateral Vim DBS that required Gpi DBS as rescue therapy. Patients 5 and 6 presented with mild to moderate dystonia after Vim DBS, manageable with changes in stimulation settings (reduction of amplitude of stimulation in case 5 and switch from Vim to ZI stimulation in case 6).

There are few patients reported who presented with a thalamic-induced or aggravated dystonia. Sydow and colleagues reported four ET patients who developed stimulation-induced dystonia during a Vim DBS programming session [4]. Hedera et al. described two dystonic patients whose limb dystonia worsened following unilateral Vim DBS [5]. Similarly to our patients 5 and 6, in these patients optimizing DBS settings resolved the dystonia. By contrast, there are no reported cases of permanent dystonia triggered by lead insertion or thalamotomy (like our patients 1, 3 and 4). We are aware of similar other unpublished cases (personal communication of Prof. Deuschl in Kiel, Germany and Prof. Krack in Grenoble, France).

Both focal and hemidystonia have been described after isolated lesions involving the postero-lateral portion of the thalamus in previously healthy individuals [6]. The pathogenesis of thalamic dystonia is not completely known but may result from dysfunction of the cerebello-thalamic pathway. Alternatively, a disruption of the cortico-striato-pallido-thalamo-cortical loop may disinhibit the ventrolateral nucleus producing increasing thalamo-cortical drive [6].

The role of the cerebellum in the pathophysiology of dystonia is the focus of recent research [7]. Argyelan et al. demonstrated a reduced integrity of cerebello-thalamo-cortical fiber tracts, likely developmental in origin, in both manifesting and clinically non-manifesting *TOR1A* mutation carriers [8]. In these subjects, reductions in cerebello-thalamic connectivity correlated with increased motor activation responses, consistent with loss of inhibition at the cortical level [8].

Although all our patients had an action tremor, they had different clinical presentations (Table 1). In hindsight, patients 1 had dystonic tremor followed by PD, while patient 2 had dystonic tremor mistaken for PD. Patient 3 had tremor-dominant PD also characterized by off medication dystonia. Patient 4's presentation was consistent with long-lasting ET plus soft dystonic signs. Patient 5's diagnosis is consistent with ET plus dystonic posturing, while patient 6 presented with ET plus ataxic features [9].

We argue that dystonia can be a rare and disabling complication of thalamic surgery and it is probably more frequent in patients with pre-existing dystonic features. Similarly to observations in post-stroke patients, thalamic procedures can disrupt either or both the cerebello-thalamic and the cortico-striato-pallido-thalamo-cortical loop resulting in an increased thalamo-cortical outflow causing a different movement disorders [6]. The effect may be specific to the thalamus, as switching the stimulation from Vim to ZI in patient 6 improved the dystonia. As highlighted by Argyelan et al. our patients might have been predisposed to development of dystonia after Vim DBS because of intrinsic unknown

Table 1
Pre- and post-operative patients features.

Patient	Diagnosis	Centre	Procedure	Coordinates (ACPC space)	Outcome and management
1	Dystonic tremor followed by PD	TWH	Right Vim DBS	X: 14 MCP, Y: 7 MCP/+7 PCP, Z:1 MCP	Permanent left hemidystonia managed with BoNT and bilateral Gpi DBS
2	Dystonic tremor mistaken for PD	TWH	Right Vim DBS	X: 15 MCP, Y: 7 MCP/+6 PCP, Z:MCP	Stimulation-induced task-specific left hand dystonia
3	Tremor-dominant PD with off medication dystonia	TWH	Right radiofrequency thalamotomy	X: 14 MCP, Y: 8 MCP/+5 PCP, Z: +1 MCP	Permanent left arm dystonia managed with BoNT
4	ET plus dystonic signs	JRH	Bilateral Vim DBS	NA	Permanent generalized dystonia partially responsive to bilateral Gpi DBS
5	ET plus dystonic signs	SGH	Bilateral Vim (and ZI) DBS	VIM: X:12 MCP, Y: 4 MCP, Z: 0 MCP	Stimulation-induced right arm dystonia managed with programming (reduction of amplitude of stimulation)
6	ET plus ataxic signs	SGH	Bilateral Vim (and ZI) DBS	VIM: X:12 MCP, Y: 4 MCP, Z: 0 MCP	Stimulation-induced upper limbs dystonia managed with programming (switch to ZI stimulation)

All coordinates are provided in mm.
Abbreviations: BoNT: botulinum neurotoxin; DBS: Deep Brain Stimulation; ET: Essential tremor; Gpi: globus pallidus pars interna; JRH: John Radcliffe Hospital, Oxford, UK; MCP: mid commissural point; NA: not available; PCP: posterior commissural point; PD: Parkinson's disease; SGH: St George's Hospital, London, UK; TWH: Toronto Western Hospital; Vim: ventralis intermedius; ZI: Zona Incerta; X: left lateral; Y: anterior; Z: ventral.

factors [8].

Indeed, the main challenge to our hypothesis that thalamic surgery either triggered or unmasked dystonia in our patients is that thalamic procedures are an effective and safe treatment for dystonic tremor [10]. Our observation that thalamic procedures themselves can cause dystonia is therefore important, but puzzling.

Our report has practical implications. Vim DBS and thalamotomy are considered as effective, symptomatic treatments for tremor irrespective of the underlying diagnosis. Our patients had a negative outcome after thalamic procedures with permanent dystonia in patients 1, 3 and 4 possibly because of altered neural circuits that led to a switch from tremor to dystonia. It is possible that this phenomenon may be more prevalent but underreported in the literature because of the known publication bias of not reporting negative outcomes. Therefore some tremulous patients may not benefit from thalamic procedures because of risk of developing or aggravation of pre-existing dystonia and may be considered for other surgical targets (i.e., GPi, the thalamic ventralis oralis anterior and posterior or STN) [11]. The description of other similar cases may shed light on the intrinsic factors associated with that risk. To date, there are no randomized prospective trials comparing Vim and GPi in dystonic tremor, in our patients Vim was chosen in such patients because tremor was the most disabling symptom, in keeping with previous observation in dystonia patients carrying both Vim and GPi electrodes [5].

There are a number of limitations with our paper including differences in neurosurgical procedures between centers, the lack of neuroimaging investigating the dopaminergic pathways in patient 2, and the variable inter-rater reliability of the detection of soft neurological signs using videos [12]. Finally, thalamic surgery clearly led to the dystonia in patients 1, 3 and 4, however for remaining patients alternative hypotheses should be made. In fact, we cannot exclude the possibility of cortico-spinal side effect due to the spread of current in cases with stimulation-induced dystonia (patients 2, 5 and 6).

In conclusions, we have reported six patients who developed dystonia after thalamic procedures for tremor, complication that was permanent in three of them, a circumstance never reported before. Indeed, such new phenomenon appears to be rare as we were able to collect six cases in three large DBS centers. However, we suspect that this unexplained adverse event may be more prevalent as it probably is underreported in the literature. It is likely that thalamic procedures altered neural circuits resulting in unexpected dystonia in our patients. Further studies are warranted to clarify the intrinsic factors possibly predicting the development of dystonia after thalamic procedures.

Conflicts of interest

None.

Contributorship

1. Research project: A. Conception, B. Organization, C. Execution;
2. Manuscript Preparation: A. Writing of the first draft, B. Review and Critique;

MP: 1B, 1C, 2A
VP: 1C, 2A
FM: 1C,2B
MA: 1C,2B
DAO: 1C,2B
RPM: 1C, 2B
TA: 2B
EP: 2B
MH: 2B
SK: 1C, 2B
AML: 2B
TL: 1B, 2B

AF: 1A, 1B, 2B.

Funding statement

This work was not supported by a specific funding source.

Conflict of interest related to research covered in this article

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Full financial disclosures

MP – grant from the Michael J Fox Foundation for Parkinson's research; VP, MA, RPM, EP, TA, DO have nothing to disclose; SK – speaker honoraria Medtronic; TL – Advisory Boards An2H, Honoraria UCB pharma, grants from the Michael J. Fox Foundation, Health research Board Ireland, JPND European grant; AF – Consultansies: UCB pharma, Medtronic, Boston Scientific, Abbvie, Advisory Boards: Abbvie, Sunovion, Boston Scientific, Medtronic, Honoraria: UCB pharma, Medtronic, Boston Scientific, Abbvie, Ipsen, Chiesi, Sunovion, Grants: Michael J. Fox Foundation, University of Toronto.

Acknowledgements

We are grateful to Yu-Yan Poon, RN and Alejandro Valencia, NP for having recorded some of the videos at Toronto Western Hospital.

References

[1] M. Picillo, A.M. Lozano, N. Kou, R.P. Munhoz, A. Fasano, Programming deep brain stimulation for tremor and dystonia: the Toronto western hospital algorithms, Brain Stimul 9 (2016) 438–452.
[2] R.G. Cury, V. Fraix, A. Castrioto, M.A. Pérez Fernández, P. Krack, S. Chabardes, et al., Thalamic deep brain stimulation for tremor in Parkinson disease, essential tremor, and dystonia, Neurology 89 (2017) 1416–1423.
[3] K.A. Pauls, S. Hammesfahr, E. Moro, A.P. Moore, E. Binder, F. El Majdoub, et al., Deep brain stimulation in the ventrolateral thalamus/subthalamic area in dystonia with head tremor, Mov. Disord. 29 (2014) 953–959.
[4] O. Sydow, S. Thobois, F. Alesch, J.D. Speelman, Multicentre European study of thalamic stimulation in essential tremor: a six year follow up, J. Neurol. Neurosurg. Psychiatry 74 (2003) 1387–1391.
[5] P. Hedera, F.T. Phibbs, R. Dolhun, P.D. Charles, P.E. Konrad, J.S. Neimat, et al., Surgical targets for dystonic tremor: considerations between the globus pallidus and ventral intermediate thalamic nucleus, Park. Relat. Disord. 19 (2013) 684–686.
[6] C.D. Marsden, J.A. Obeso, J.J. Zarranz, A.E. Lang, The anatomical basis of symptomatic hemidystonia, Brain 108 (1985) 463–483.
[7] A. Malone, M. Manto, C. Hass, Dissecting the links between cerebellum and dystonia, Cerebellum 13 (6) (2014) 666–668.
[8] M. Argyelan, M. Carbon, M. Niethammer, A.M. Ulug, H.U. Voss, S.B. Bressman, et al., Cerebellothalamocortical connectivity regulates penetrance in dystonia, J. Neurosci. 29 (2009) 9740–9747.
[9] K.P. Bhatia, P. Bain, N. Bajaj, R.J. Elble, M. Hallett, E.D. Louis, et al., Tremor task force of the international Parkinson and movement disorder society, consensus statement on the classification of tremors. From the task force on tremor of the international Parkinson and movement disorder society, Mov. Disord. 33 (2018) 75–87.
[10] A. Fasano, F. Bove, A.E. Lang, The treatment of dystonic tremor: a systematic review, J. Neurol. Neurosurg. Psychiatry 85 (2014) 759–769.
[11] A. Patel, W. Deeb, M.S. Okun, Deep brain stimulation management of essential tremor with dystonic features, Tremor Other Hyperkinet Mov (N Y) 8 (2018) 557.
[12] C. Fearon, A.J. Espay, A.E. Lang, T. Lynch, D. Martino, F. Morgante, N.P. Quinn, M. Vidailhet, A. Fasano, Soft signs in movement disorders: friends or foes? J. Neurol. Neurosurg. Psychiatry 90 (8) (2019 Aug) 961–962 pii: jnnp-2018-318455.