Gait disorders

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Gait disorders can be tricky
Gait disorders are common

• Abnormalities of gait and balance can be caused by peripheral &/or CNS disorders, from motor weakness & sensory loss, to loss of automaticity, cognitive decline

• Consequences - fear of falling’ and need for assistive devices, resulting in social isolation and reduced activity

• Falls are most common cause for injury related hospital admissions
Outline of this talk

- Classification of gait disorders
- Approach to a patient with gait disorder
- Pathophysiology of higher order gait disorder
- Examples of different forms of gait disorders
- Recognition of particular forms of gait disorders
- Concluding summary
Classification of gait disorders

- *Nervous system complexity level* - lower, middle, and higher level
- *Anatomic lesion location* (i.e. cerebellar, frontal lobe etc.)
- *By etiology* (i.e. vascular disease, degenerative parkinsonism, spinocerebellar ataxias)
- *Clinical phenomenology* (i.e. ataxia, parkinsonism, dyskinesia) - sub-classified as continuous or episodic
Approach in a patient with gait problem

As always good history & physical and neurological exam –

Most importantly

- Watching the gait- stance, cadence, steppage, arm swing, postural reflexes

- Look out for associated features: are there features of parkinsonian, cerebellar, spasticity, or weakness or sensory loss.
Higher level gait disorders

• The term higher-level gait disorders (HLGD) defines a category of balance and gait disorders that are not explained by deficits in strength, tone, sensation, or coordination. HLGD are characterized by various combinations of disequilibrium and impaired locomotion - Nutt 2013

• Various terms used gait apraxia, frontal
• ataxia, marche a petits pas, lower-half parkinsonism, and many more
<table>
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<tr>
<th>Level</th>
<th>Anatomy</th>
<th>Function</th>
<th>Example</th>
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<tbody>
<tr>
<td>Lower</td>
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<tr>
<td>Motor</td>
<td>Motor neuron, muscle</td>
<td>Force</td>
<td>Motor neuropathy</td>
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<tr>
<td>Sensory</td>
<td>Sensory nerve, vestibular nerve, vision</td>
<td>Orientation in environment</td>
<td>Sensory neuropathy</td>
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<td>Middle</td>
<td></td>
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<tr>
<td>Motor</td>
<td>Corticospinal, cerebellum, basal ganglia</td>
<td>Refine force</td>
<td>Myelopathy with spasticity</td>
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<td>Sensory</td>
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<tr>
<td>Higher</td>
<td>Cortex, basal ganglia</td>
<td>Collate and interpret sensory information;</td>
<td>Frontal lobe vascular disease</td>
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<td>select and modify motor programs</td>
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Etiologies of HLGD

• Degenerative disorders,
• Large-vessel strokes,
• Microvascular disease with white matter lesions, and microinfarcts,
• Tumours,
• Hydrocephalus.
Characteristic features of HLGD
Fig. 1. Diagram illustrating basic balance-locomotor circuits. The shaded structures and connections are hypothesized to be affected in
Nonsense mutation in *CFAP43* causes normal-pressure hydrocephalus with ciliary abnormalities


Abstract

**Objective** To identify genes related to normal-pressure hydrocephalus (NPH) in one Japanese family with several members with NPH.

**Methods** We performed whole-exome sequencing (WES) on a Japanese family with multiple individuals with NPH and identified a candidate gene. Then we generated knockout mouse using CRISPR/Cas9 to confirm the effect of the candidate gene on the pathogenesis of hydrocephalus.

**Results** In WES, we identified a loss-of-function variant in *CFAP43* that segregated with the disease. *CFAP43* encoding cilia- and flagella-associated protein is preferentially expressed in the testis. Recent studies have revealed that mutations in this gene cause male infertility owing to morphologic abnormalities of sperm flagella. We knocked out mouse ortholog *Clap43* using CRISPR/Cas9 technology, resulting in *Clap43*-deficient mice that exhibited a hydrocephalus phenotype with morphologic abnormality of motile cilia.

**Conclusion** Our results strongly suggest that *CFAP43* is responsible for morphologic or movement abnormalities of cilia in the brain that result in NPH.
Deconstructing normal pressure hydrocephalus: Ventriculomegaly as early sign of neurodegeneration

Alberto J. Espay MD, MSc, Gustavo A. Da Prat MD, Alok K. Dwivedi PhD ... See all authors

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Abstract

Idiopathic normal pressure hydrocephalus (NPH) remains both oversuspected on clinical grounds and underconfirmed when based on immediate and sustained response to cerebrospinal fluid diversion. Poor long-term postshunt benefits and findings of neurodegenerative pathology in most patients with adequate follow-up suggest that hydrocephalic disorders appearing in late adulthood may often result from initially unapparent parenchymal abnormalities. We critically review the NPH literature, highlighting the near universal lack of blinding and controls, absence of specific clinical, imaging, or pathological features, and ongoing dependence for diagnostic confirmation on variable cutoffs of gait response to bedside fluid-drainage testing. We also summarize our long-term institutional experience, in which postshunt benefits in patients with initial diagnosis of idiopathic NPH persist in only 32% of patients at 36 months, with known revised diagnosis in over 25% (Alzheimer's disease, dementia with Lewy bodies, and progressive supranuclear palsy). We postulate that previously reported NPH cases with “dual” pathology (i.e., developing a “second” disorder) more likely represent ventriculomegalic presentations of selected neurodegenerative disorders in which benefits from shunting may be short-lived, with a consequently unfavorable risk-benefit ratio. Ann Neurol 2017;82:503–513
Mid level
Freezing and cycling
The “bicycle sign” for atypical parkinsonism

Differentiation of Parkinson’s disease from atypical parkinsonism is important clinically, for adequate patient counselling, and scientifically, to ascertain proper inclusion in clinical trials. The differential diagnosis remains challenging, even with current clinical insights and modern ancillary investigations. Here, we suggest that the answer to one simple question—“Can you still ride a bicycle?”—offers good diagnostic value for separating Parkinson’s disease from atypical parkinsonism.

We did a prospective observational study in 156 consecutive patients with parkinsonism, but without a definitive diagnosis. At baseline, patients received a structured interview, comprehensive neurological assessment, and cerebral MRI. The interview included a standard question about whether, when, and why cycling had become impossible. The gold standard was the diagnosis after 3 years, which was based on the clinical follow-up including repeat neurological examination, response to treatment, and MRI. All assessments were done by a single, experienced examiner. All patients gave informed consent, as approved by the local ethics committee.

Before their first disease manifestation, 111 patients rode a bicycle (table). 45 went on to develop a gold-standard diagnosis of Parkinson’s disease and 66 a form of atypical parkinsonism. At the time of inclusion (median disease duration 30 months), 34 of the 66 patients with atypical parkinsonism had stopped cycling, as opposed to only two of the 45 patients with Parkinson’s disease (sensitivity 52%, specificity 96%; AUC 0.74, 95% CI 0.64–0.83). The loss of cycling abilities was present for all forms of atypical parkinsonism. Regression analysis revealed no significant effect of age, parkinsonism, or ataxia on the ability to cycle, suggesting that this was an independent marker of atypical parkinsonism.

We suggest that loss of the ability to cycle after disease onset might serve as a new red flag, signaling the presence of atypical parkinsonism. The diagnostic value of the “bicycle sign” was good. Its presence was highly specific for the diagnosis of atypical parkinsonism. This observation does not stand alone. Patients with Parkinson’s disease have few balance problems moving sideways, their gait is typically narrow-based, their tandem gait is usually normal, and they can show a remarkable ability to ride a bicycle. Cycling requires a highly coordinated interplay between balance, coordination, and rhythmic pedaling of the legs. This skilled task is probably sensitive to subtle problems with balance or coordination caused by the more extensive extranigral pathology in atypical parkinsonism. Simply asking about cycling abilities could be added to the list of red flags that can assist clinicians in their early differential diagnosis of parkinsonism.

This work was supported financially by a research grant from the Information and Parkinson Fund. We declare that we have no conflicts of interest.
Trunkal and gait ataxia
Spastacin gene mutation gait
Some particular gait disorders
Bouncy leg gait of post anoxic myoclonus
Lordotic gait
In stiff person syndrome
Clinical Practice

A video review of the diagnosis of psychogenic gait: Appendix and commentary

Michael W. Hayes FRACP, Shanti Graham BSc, Peter Heldorf, Gregory de Moore FRANZCP, John G. L. Morris DM (Oxon), FRACP

First published: 25 January 2001

Abstract

The gait and other clinical features of 22 patients presenting to our hospital over the last 10 years are shown on video. In 12 patients, a diagnosis of psychogenic gait was made; in the remainder, the gait abnormality was the result of a neurologic disease. Psychogenic gait is compared and contrasted with “organic” gait. In one patient, the psychogenic gait occurred in the setting of a neurologic disease. The “traditional” approach to psychogenic gait, attempting to exclude underlying neurologic and psychiatric disease and seeking evidence for primary and secondary gain, was found to be of limited value. More useful were the features of the gait itself, in particular, exaggerated effort, extreme slowness, variability throughout the day, unusual or uneconomic postures, collapses, convulsive tremors, and distractibility; certain aspects of the history were also helpful. A list of comments is provided. The diagnosis of psychogenic gait, particularly in the elderly, remains fraught with hazard, and a balance has to be sought between subjecting an anxious patient to needless investigations and yet not losing sight of the fact that the patient may be elaborating on symptoms of genuine disease. The bizarre gait of some neurologic disorders, particularly dystonia and chorea, may be a pitfall for the unwary.
Psychogenic Movement Disorders: Gait Is a Give-Away!

Bettina Balint, MD,1,2,* Lisa M.L. van Wissen, MD,3 Kailash P. Bhatia, MD,2 Bas R. Bloem, MD, PhD2

Abstract: The aim of this article is to point out that an incongruity of gait disorder (either in relation to the presenting movement disorder or incongruity with any type of organic gait disorder) is a useful clue in diagnosing psychogenic movement disorders. To illustrate this, we present a case series of patients with various types of psychogenic movement disorders (rest tremor, myoclonus, dystonia, and chorea). Incongruity of the walking pattern with the presenting movement disorder was a revealing diagnostic clue in all cases. “Incongruity” is currently a main plank in the diagnosis of psychogenic conditions. Our series emphasizes that incongruity of the gait pattern may be the most important sign in a patient where it is otherwise difficult to establish whether the movement disorder is congruous or incongruous with an organic disorder.
Video – gait is a give away
Episodic gait disorders
Man with dystonic foot – who walks backwards better than forwards
Episodic gait disorders: The dancing lady

- This lady would get these episodes after walking or exerting – Marsden diagnosed her as possible functional – somatization

- Later her son developed epilepsy at a young age – there was no other family history
Criss-cross gait
A clue to glucose transporter type 1 deficiency syndrome

Francesca Magrinelli, MD, Eoin Mulroy, MD, FRACP, Susanne A. Schneider, MD, PhD, Anna Latorre, MD, PhD, Giulia Di Lazzaro, MD, Anita Hennig, MD, Stephanie Grünewald, MD, PhD, Darryl C. De Vivo, MD, and Kailash P. Bhatia, MD, DM, FRCP

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Figure Overview of the pathogenesis, phenotypes, diagnosis, and treatment of glucose transporter type 1 deficiency syndrome (Glut1 DS)

Glucose transporter type 1 deficiency syndrome (Glut1 DS) is a rare treatable neurodevelopmental disorder caused by monogenic or, more rarely, biallelic pathogenic variants in the SLC2A1 gene which encodes Glut1.

Pathogenesis Glut1 is a glucose transporter mainly localized in brain capillary endothelial cells and their ensheathing astrocytic end-feet. Here, it plays a critical role in cerebral glucose delivery, being responsible both for glucose transport from the bloodstream into the extracellular cleft between the endothelium and astrocyte and then again for glucose transport from the extracellular cleft into astrocytes. Genetically-determined defects in Glut1 result in impaired glucose uptake by brain tissues.

Clinical picture (1) The clinical spectrum of Glut1 DS includes milder phenotypes which generally fall into one of three categories:
- Epilepsy
- Movement disorders, in particular paroxysmal exercise-induced dyskinesia (attacks of chorea and dystonia affecting mainly the lower limbs)
- Cognitive/behavioral disturbances. These presentations may have onset both in childhood and adulthood, and may occur either in isolation or as a mixed syndrome.

Diagnosis One or both of the following criteria:
1. CSF glucose <3.33 mmol/L on fasting lumbar puncture with normal blood glucose (CSF/blood glucose ratio < 0.4)
2. Monogenic pathogenic variants in Glut1

Neurology 2020
The Criss–Cross gait is a hint to GLUT-1 deficiency

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
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<tbody>
<tr>
<td><strong>Current age</strong></td>
<td>54</td>
<td>25</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td>White British</td>
<td>White British</td>
</tr>
<tr>
<td><strong>Age of onset</strong></td>
<td>6 years</td>
<td>5 years</td>
</tr>
<tr>
<td><strong>Clinical picture</strong></td>
<td>• PED (episodes of toe curling, foot dystonia, limb choreoathetosis)</td>
<td>• PED (episodes of foot dystonia, jerky choreiform movements in his limbs)</td>
</tr>
<tr>
<td><strong>Family history</strong></td>
<td>Father possibly affected (retrospectively) &lt;br&gt; Son affected</td>
<td>Father affected</td>
</tr>
<tr>
<td><strong>CSF analysis</strong></td>
<td>Not performed</td>
<td>CSF glucose = 34.2 mg/dL &lt;br&gt; (Blood glucose = 122.4 mg/dL) &lt;br&gt; CSF/blood glucose ratio = 0.28</td>
</tr>
</tbody>
</table>
Concluding commentary

• Studying gait is one of the most important aspects of the clinical examination in a movement disorders patient to help with the diagnosis and note the systems involved

• Gait disorders can be classified in different forms

• Important to note the associated features

• Important to recognise particular forms of gaits

• Management depends on the particular form but efforts to prevent falls, strengthening and balance rehabilitation is crucial