J Neurol (2005) 252 : 300–306
DOI 10.1007/s00415-005-0641-2

ORIGINAL COMMUNICATION

Nir Giladi
Talia Herman
Irith I. Reider-Groswasser
Tanya Gurevich
Jeffrey M. Hausdorff

Clinical characteristics of elderly patients with a cautious gait of unknown origin

Received: 5 March 2004
Received in revised form: 11 August 2004
Accepted: 16 August 2004
Published online: 23 February 2005

I. I. Reider-Groswasser, MD
Section of Neuro-radiology
Dept. of Imaging
Tel-Aviv Sourasky Medical Center
Tel-Aviv, Israel

N. Giladi, MD · T. Herman, MScPT · I. I. Reider-Groswasser, MD · T. Gurevich, MD · J. M Hausdorff, PhD
Depts. of Physical Therapy, Neurology and Diagnostic Imaging
Sackler Faculty of Medicine
Tel-Aviv University
Tel-Aviv, Israel

J. M Hausdorff, PhD
Division on Aging
Harvard Medical School
Boston (MA), USA

Nir Giladi, MD (✉) · T. Herman, MScPT · T. Gurevich, MD · J. M Hausdorff, PhD
Movement Disorders Unit
Tel-Aviv Sourasky Medical Center
Tel-Aviv, Israel
Tel.: +972-3/697-4912
Fax: +972-3/697-4911
E-Mail: ngiladi@tasmc.health.gov.il

This work was supported in part by NIH grants AG-14100, RR-13622, HD-39838 and AG-08812 and was presented in part at the American Geriatrics Society Annual Meeting, May 2002.

Abstract *Objective* To evaluate and systematically characterize a group of older adults with disturbed gait of unknown origin. *Design* Cross-sectional study. *Setting* Outpatient clinic in a movement disorders unit. *Participants* Twenty-five patients (mean age 78.4 years) with a disturbed gait of unknown origin were compared with twenty-eight age matched "healthy" controls (mean age 78.2). *Measurement* Detailed medical history, geriatric and neurological assessments. *Results* Patients walked more slowly ($P < 0.0001$) and with shorter strides ($P < 0.0001$) compared with controls. Muscle strength was lower, and static and dynamic balance and gait performance were worse among the patients ($P < 0.0001$). The patients also tended to be more depressed ($P < 0.0001$), more anxious ($P < 0.002$), had a greater fear of falling ($P < 0.0001$) and had lower scores on the Mini-Mental State Examination ($P < 0.005$). There was no difference in the frequency of cerebellar or pyramidal signs in the two groups. However, neurological testing revealed that extrapyramidal ($P < 0.0001$) and frontal release signs ($P < 0.0001$) were more common among the patients. Neuroradiological findings were rare among the patients and they did not explain the changes in gait speed or fear of falling. *Conclusions* Older adults with a disturbed gait of unknown origin appear to share common characteristics. They walk more slowly than "healthy" controls with increased unsteadiness and with excessive fear of falling. The extrapyramidal, frontal lobe, and limbic systems apparently play an important role, to different degrees, in what can be viewed as a multisystem neurodegenerative syndrome clearly different from "aging."

Key words gait · disequilibrium · fear of falling · aging

Introduction

About 10–20% of older adults walk without any significant mobility impairment [7, 8, 28]. Among those older adults who do have a gait disturbance, the cause is often easily identifiable and attributable to underlying chronic disease (e. g., Parkinson's disease) [7, 8, 18, 20, 28]. There are, however, many older adults who have an impaired gait that does not appear to be the result of any identifiable cause [32]. In their review of patients attending a neurology clinic, Sudarsky et al. found that the

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cause of the gait disturbance was "unknown", even after neuro-imaging, in about 10–20 percent of the older adults with a disturbed gait [27, 28]. In a study of the "oldest old" (age range 87 to 97 years) in the Netherlands, Bloem et al. observed that about 20 % of those studied had a normal gait, 69 % had a gait disorder due to known disease, and about 11 % of the subjects had an idiopathic "senile gait disorder", i. e., a gait disorder of unknown origin [6].

Various terms have been used to describe the gait changes in older adults that appear to be a result of "aging" including, for example, idiopathic senile gait and cautious gait of the elderly [19]. Using nomenclature based on the hierarchy of the nervous system organization to describe a clinical spectrum of gait disturbances in the elderly, Nutt et al. coined the term "higher-level" gait disorders (HLGD) to refer to an altered gait that is not a result of lower extremity or peripheral dysfunction and can not be attributed to chronic disease or any known lesion in the brain [20, 21].

Despite the fairly common occurrence of this phenomenon and its association with reduced quality of life and future morbidity and mortality [6, 28, 29, 31, 33], the clinical characteristics of these patients are largely unknown. In their original study [20, 21], Nutt et al. proposed definitions for sub-types of HLGD in the eldery, based on a small group of patients; however, the differences between those sub-groups are not without ambiguity and may simply be related to severity. Subtle white matter changes and frontal atrophy of unknown origin have been reported in older adults with idiopathic disequilibrium and poor mobility [3, 4, 17, 32, 33]. Bloem et al. suggested that sub-clinical, perhaps cerebrovascular disease is the underlying cause [6] and Fife et al. proposed that vestibular function may be involved [15]. In general, however, this phenomenon has not been well characterized and diagnostic criteria have not been proposed or evaluated. It has not been determined whether this gait disorder of the elderly is a result of a normal psychological and motor response to an objective functional deterioration, or a neurological syndrome with specific clinical, radiological and possibly pathological features. It is unclear if the changes in gait are the product of a primary neuronal degeneration, or if they are secondary to vascular changes. Before diagnostic criteria can be established and appropriate treatment plans prescribed, a better understanding of this phenomenon is needed.

The purpose of the present study was to address some of these issues by systematically characterizing a group of older adults with disturbed gait of unknown cause. Specifically, we hypothesized that elderly patients with this condition may share a common pathology. To test this hypothesis, we evaluated in detail the clinical features and neuroradiological characteristics of a group of older adults with gait disturbances of unknown origin and compared their findings with an age-matched control group. Our findings suggest that there are several common clinical features among those older adults with gait disturbances of "unknown" cause that may produce the observed alterations in mobility.

Methods

Subjects

Twenty-five older adults who came to the Movement Disorders Unit at the Tel Aviv Sourasky Medical Center for evaluation of walking difficulties were studied. All patients were mobile and walked independently at the time of assessment and all underwent an orthopedic and a thorough general and neurological examination.

Patients were excluded if the cause of their gait disorder could be identified. Thus, for example, patients with a history of clinically established stroke, Parkinson's disease (PD), or other diagnosed neurodegenerative disorder, and patients with pain during walking, intermittent claudication, rest tremor or pronounced bradykinesia were excluded. Patients who were taking anti-parkinsonian or antispastic medications, or had known orthostatic hypotension were excluded as well. We also excluded patients with clinically significant or known visual, peripheral, or vestibular disturbances as well as patients with orthopedic disturbances. Patients with a history of Meniere's syndrome, benign paroxysmal positional vertigo, hearing loss or any history of vestibular neuritis were excluded. Patients with dementia according to DSM IV criteria [1], history of psychiatric disease, or historical use of dopamine receptor blocking agents (antipsychotic medications) were also excluded. In addition, we excluded patients with a history of traumatic head injury and loss of consciousness. Patients with any focal brain lesion other than a single lacunar infarct were excluded. We specifically excluded any patient with mild, moderate or severe ventricular enlargement on CT of the brain if he/she also had cognitive decline or urinary incontinence, in order to exclude patients with possible normal pressure hydrocephalus (NPH). No patient had CSF drainage because none was suspected to have NPH based on the clinical picture.

To briefly summarize, all patients had self-reported walking difficulties that prompted them to seek medical advice. A movement disorders specialist (NG) confirmed the existence of an abnormal gait by watching the patient walk. No specific disorder could be diagnosed as a cause for the patients' complaint prior to this study. The observed gait abnormalities could not be attributed to any specific or well-characterized disease or medical condition after a general medical workup. We did not exclude or specifically include patients with a history of falls; patients with and without a history of falls were included as long as they met the inclusion and exclusion criteria.

The patient population was compared with twenty-eight aged-matched "healthy" controls. Control subjects were recruited from the community (n = 24) and from a nearby elderly housing facility. Subjects were included if they had no complaints about balance and gait and were observed to have a normal gait pattern. Subjects were included if they were not aware of any walking difficulties, if they had no obvious clinical impairment, and did not have significant cognitive decline (Mini-Mental State Examination, MMSE > 24). Subjects were excluded if they had any neurological disorder or any significant clinical history likely to affect their gait (e. g., stroke).

Subjects who met the inclusion and exclusion criteria provided informed written consent. The study was approved by the human studies committee of the Tel Aviv Sourasky Medical Center.

Clinical evaluation and assessments

The evaluation comprised a detailed medical history and a complete, structured neurological examination. This included the evaluation of

eye movement and horizontal saccade, light touch, and sense of position of toes (dorsal column function) and the motor part (part III) of the Unified Parkinson's Disease Rating Scale (UPDRS) [14]. In addition, the MMSE [16], the Geriatric Depression Scale (GDS) [35] and Spielberger's State-Trait Anxiety Inventory [26] were administered to assess mental state. The Charlson's co-morbidity index was used to quantify the number of chronic conditions and general health status [9]. In addition, we checked for nystagmus as well as the subjective feeling of positional vertigo while moving rapidly from a supine to sitting position in order to identify patients with marked vestibular dysfunction. In 23 patients, neuro-imaging (CT or MRI) was performed. Two more patients were recommended to have CT of the brain but because of technical matters it was not performed. A neuroradiologist who was blinded to all other measures quantified the presence and degree of enlarged lateral ventricles and/or leokoaraiosis, on a scale of 0 to3 (0-absent,1-mild, 2-moderate, 3-severe) and the presence and number of lacunar infarcts.

Because a self report of fear of falling based on the response to a single yes/no question has been shown to be inaccurate, the Activities-specific Balance Confidence Scale (ABC) [24] was used to assess the level of fear of falling. The ability to perform activities of daily living was evaluated using the Barthel ADL index [10].

Muscle strength was assessed at the quadriceps and calf muscles using a hand held digital dynamometer [2]. Functional mobility and balance were assessed using Tinneti's Balance and Mobility Assessment [30], the Functional Reach Test (mean of 3 trials in cm) [12], and the Timed Up and Go (TUaG) test [23]. In addition, the gait assessment included observational gait analysis to evaluate walking features and patterns using previously described methods [34]. Subjects walked for 2 minutes in a 25 meter-long, 2 meter-wide hallway. In addition, gait speed and stride length were evaluated by measuring the time and number of strides to walk 10 meters. The average of 3 walking trials was used.

To quantitatively evaluate and compare different neurological systems, we developed pyramidal, extrapyramidal, frontal and balance indices. For the pyramidal index, we included four parameters (yes/no): 1) presence of extensor plantar reflexes (e. g., Babinski sign), 2) presence of clonus in the ankle, 3) increased muscle tone (spasticity), and 4) increased tendon reflexes (hyper-reflexia). The pyramidal index was considered positive if the subject had either a positive Babinski sign or clonus (or both), or if the subject had both spasticity and hyper-reflexia. For the extrapyramidal index, items 22, 23, 24, 25, 26, 30, 31 of the motor part (III) of the UPDRS were summed. The frontal index was considered to be positive if subjects had at least 2 of the following 4 signs: Meyerson sign (glabellar reflex), Snout reflex, Palmo-Mental reflex or Facilitory Paratonia [5]. Cerebellar function was assessed by asking the subject to stand with the feet together for 5 seconds with eyes open and then eyes closed, performing diadochokinesis, finger to nose, and heel to shin tests. It was considered positive if any of these tests was abnormal.

We also developed a balance index, based on six different parameters that assess static and dynamic balance. The index included four continuous scores: the TUaG, Tinetti's balance assessment, functional reach, and the pull test (item # 30 on the UPDRS), and two categorical variables: the ability to perform tandem standing for at least five seconds and tandem walking for at least ten steps. To transform the continuous variables into a single dichotomous variable, cut-off points for each test were calculated in a post-hoc fashion such that for each parameter the cut-off point minimized the overlap between the two groups of subjects. For the TUaG test, 12 seconds or less were considered normal. For Tinetti's balance score both 15 and 16 were considered normal. For the pull test, scores less than 2 were considered normal. For the functional reach test, scores of 24.6 cm or more were considered normal. Each "abnormal" test received 1 point so the balance index ranged between 0 and 6 (0 = normal, 6 = severe balance difficulty).

Statistical analysis

The comparison between the 2 groups (patients and controls) was performed using the Student *t* test when the dependent variables were normally distributed, and using the Mann-Whitney test for non-parametric variables. For categorical variables, comparisons between the two groups were performed using the chi square test. The degree of association between continuous variables was quantified using Pearson's correlation coefficient. Statistical analysis was performed using SPSS for Windows (version 10.0).

Results

Demographic and General Health Characteristics

As summarized in Table 1, the patient and control groups were similar with respect to age, gender, weight and height. The Charlson co-morbidity index was low (0 = healthy) and similar in both groups, but incontinence and sleep disturbances were more common among the patients. As shown in Table 2, vascular risk factors were not significantly different in the two groups.

Table 1 Demographic and general health characteristics*

	Patients (n = 25)	Controls (n = 28)	P-Value
Age (years)	78.2 ± 5.0	78.4 ± 5.6	0.846
Women (% of group)	17 (68%)	19 (67.9%)	1.000
Right hand dominance	24 (96%)	27 (96.4%)	1.000
Height (cm)	161.0 ± 8.7	162.7 ± 10.0	0.520
Weight (Kg)	66.4 ± 12.9	66.3 ± 10.0	0.964
Charlson co-morbidity index	0.8 ± 1.1	0.6 ± 1.0	0.427
Incontinence	19 (76%)	6 (21.4%)	< 0.001
Sleep disturbances	14 (56%)	5 (17.8%)	< 0.01

* Entries are mean ± SD or n (% of subjects)

Table 2 Vascular risk factors

	Patients (n = 25)	Controls (n = 28)	P-Value
Hypertension	16 (64%)	15 (54%)	0.578
CABG	4 (16%)	1 (3.6%)	0.176
Ischemic Heart Disease	7 (29.2%)	3 (3.6%)	0.157
PVD	1 (4%)	0	0.472
Diabetes:			
Yes	5 (20%)	6 (21.4%)	1.000
No	20 (80%)	22 (78.6%)	
Current smokers	0	0	NS
Non- smokers	13 (52%)	18 (64%)	
Past-smoking up to 10 yrs ago	4 (16%)	0	
Past smoking over 20 yrs ago	8 (32%)	10 (36%)	

CABG Coronary Artery Bypass Graft; *PVD* Peripheral Vascular Disease
Entries are n (% of subjects)

Neuroimaging findings

Twenty-three patients (out of 25) had neuroimaging reports (CT/MRI or both). Four patients (17 %) had a single lacunar infarct: one patient had a lacune in the lentiform and 3 patients in the corona radiata. Six patients (26 %) had leukoaraiosis; 5 patients had mild leukoaraiosis and one had more severe and diffused type. Fourteen patients (60 %) (6 who had a CT and MRI) had no lacunae or leukoaraiosis. Three patients had mildly enlarged lateral ventricles, 5 patients had moderate enlargement, and one had marked enlargement. All those patients with enlarged lateral ventricles also exhibited cortical atrophy, thus making the radiological diagnosis of NPH very unlikely. There was no correlation between the neuroradiological findings and the degree of fear of falling (ABC score) or gait speed.

Cognitive function and mental health

Patients had significantly higher scores (11.9 ± 4.7 vs. 5.3 ± 3.6; $P < 0.0001$) on the Geriatric Depression Scale (GDS) and on the State-Trait Anxiety Inventory (20 ± 5.4 vs. 15.5 ± 4.5; $P = 0.002$). The mean MMSE was 26.6 ± 3.4 for the study group and 28.8 ± 1.2 for the control group ($P = 0.005$).

Neuro-motor function

There was no difference between the groups with respect to the pyramidal index. Six subjects in the study group and four control subjects had a positive pyramidal index (P = 0.488). Three control subjects had polykynetic reflex at the Achilles' tendon and one had a unilateral equivocal plantar response. We observed significantly higher scores on the motor portion of the UPDRS among the study group (17.2 ± 7.3) compared with the control group (4.3 ± 2.6) ($P < 0.001$). In addition, we observed significant weakness ($P < 0.001$) in both quadriceps and calf muscles among the study group, when we compared the right leg of patients (147 ± 52 N) and controls (219 ± 58 N), the left leg, or summed the strength in the left and right legs ($P < 0.001$). Ten patients and 12 controls had limited upward gaze ($P = 0.85$), as is often observed in healthy elderly adults [22]. No patient or control had nystagmus or slowing of saccade velocities. Mild downward gaze limitation was observed in one patient. In a 2 year follow up period, this patient did not develop Progressive Supranuclear Palsy (PSP). No subjects (both groups) had cerebellar abnormalities or sensory deficits. Signs of impaired frontal lobe function were significantly more frequent among the patients (Table 3).

Table 3 The presence of frontal signs

	Patients (n = 25)	Controls (n = 28)	P-Value
Palmomental reflex	20 (80 %)	15 (53.6 %)	0.080
Meyrson reflex	20 (80 %)	12 (42.9 %)	0.011
Snout reflex	13 (52 %)	7 (25 %)	0.053
Facilitory paratonia	19 (76 %)	7 (25 %)	< 0.0001
Positive Frontal Index	22 (88 %)	10 (35.7 %)	< 0.0001

Entries are n (% of subjects)

Balance, gait and functional performance

Balance and postural control measures are summarized in Table 4. Falls were more common among the patients. For all measures, balance was significantly worse among the patients. We note that 96 % of the patients had a balance index score of 4 or above, while 96 % of the subjects in the control group had a score of 2 or less. As shown in Table 5, many features of walking were significantly worse in the patient group.

Factors associated with fear of falling

Among the patients there was a wide range in the degree of fear of falling (mean ABC score 60.3 ± 22.8 %; range: 1–88). The ABC score was *not* associated with fall status, number of falls in the last year ($P = 0.93$), general anxiety level ($P = 0.54$) or with the balance index ($P = 0.35$). In contrast, the ABC score was associated with age

Table 4 Balance and postural control measures

	Patients (n = 25)	Controls (n = 28)	P-Value
ABC (%)	60.3 ± 22.8	94.6 ± 6.4	< 0.0001
No. of falls over the last month	0.16 ± 0.4	0	0.043
No. of falls over the last year	2.0 ± 2.2	0.1 ± 0.3	< 0.0001
Functional Reach (mean of 3 trials)	21.6 ± 5.0	33.6 ± 4.6	< 0.0001
Pull test (0–4) (UPDRS Item # 30)	1.6 ± 0.7	0.4 ± 0.5	< 0.0001
TUaG (sec)	18.1 ± 7.8	8.1 ± 1.3	< 0.0001
Tinetti's balance test	10.1 ± 3.1	15.5 ± 0.5	< 0.0001
Tinetti's gait test	7.92 ± 1.80	11.96 ± 0.19	< 0.0001
Balance Index	5.0 ± 1.0	0.6 ± 0.9	< 0.0001
Tandem stand			
Able	1 (4 %)	20 (71.4 %)	< 0.0001
Unable	24 (96 %)	8 (28.6 %)	
Tandem walk			
Able	0	20 (71.4 %)	< 0.0001
Unable	25 (100 %)	8 (28.6 %)	

ABC Activities-specific Balance Confidence scale. Note, a lower score on the ABC reflects greater fear of falling; *TUaG* Timed Up and Go; *UPDRS* Unified Parkinson's Disease Rating Scale

Table 5a Clinical gait characteristics

	Patients (n = 25)	Controls (n = 28)	P-Value
Use of walking aids: Cane	8 (32%)	0	< 0.0001
Increased or variable walking base	18 (72%)	0	< 0.0001
Excessive knee flexion while walking	8 (32%)	1 (3.6%)	0.009
Decreased arm swing	17 (68%)	4 (14.3%)	< 0.0001
Start hesitation	3 (12%)	0	0.098
Turning hesitation	5 (20%)	0	0.019
Festination	2 (8%)	0	0.218
Short steps	18 (72%)	0	< 0.0001

Entries are n (% of subjects)

Table 5b Spatio-temporal gait parameters

	Patients (n = 25)	Controls (n = 28)	P-Value
Stride length (m)	0.84 ± 0.20	1.27 ± 0.17	< 0.0001
Gait velocity (m/sec)	0.73 ± 0.21	1.24 ± 0.17	< 0.0001

Entries are mean ± SD

(r = –0.49, $P < 0.04$), depression (r = –0.49, $P < 0.01$), functional status as measured by the Barthel ADL Index (r = 0.48, $P < 0.015$), the extrapyramidal index (r = –0.64, $P < 0.001$), and gait changes (e. g., gait speed r = 0.61, $P < 0.002$).

Discussion

Our findings indicate that this group of patients clearly had mental, extrapyramidal, frontal-lobe and postural control disturbances. In contrast, we did not find any significant pyramidal dysfunction, sensory or cerebellar abnormalities. These observations suggest that in addition to the abnormal walking features, an inclusion criterion, this group of older adults with a gait disturbance of unknown origin has a form of a multi-system disorder.

Other factors should be ruled out when considering this disorder. Factors such as vascular problems, metabolic disturbances or history of trauma do not explain the development of the disease. It is not clear whether the muscle weakness we observed is part of the mild extrapyramidal syndrome [37] which contributes to the gait and postural disturbances, or the result of disuse due to decreased activity. Based on the selective degeneration of some neuronal systems and not others, we suggest the possibility that this is a primary neurodegenerative syndrome.

This syndrome is highly governed by postural insecurity and affective changes in the form of anxiety, fear of falling, depression and mild cognitive changes. The combination of the above picture and the indirect signs of frontal lobe dysfunction [3], partial urinary incontinence and the lack of cerebellar symptoms leads us to speculate that the degeneration mainly involves the limbic, pre-frontal lobe network, and the anterior striatum. The lack of pronounced cognitive deterioration or parkinsonism and the presence of partial urinary incontinence in a high percentage of the patients, without other autonomic disturbances, suggest that this may be a predominantly white matter disorder. Frontal ataxia has been associated with vascular changes of the frontal subcortical regions [11]. We could not completely exclude some vascular contribution to the clinical picture; however, the neuro-imaging findings suggesting vascular changes were mild and infrequent and it seems, therefore, that they are not likely to be related to the observed changes in mobility. The imaging studies available were not performed according to a uniform protocol and therefore the comparison relates to gross findings.

Based on the results of the present study, we propose the existence of a neurodegenerative disorder that involves mainly the frontal lobes and its sub-cortical white matter. Its main features are disequilibrium with postural instability, exaggerated fear of falling, and general anxiety. Extrapyramidal features and cognitive changes are also present but not dominant in this syndrome. This syndrome was considered part of the Higher Level Gait Disorders (HLGD), as suggested by Nutt [21]. The current group of patients could be classified among those with a "cautious gait" of unknown origin (CGUO) or a HLGD. Based on the results of the present study, Table 6 summarizes putative common clinical features of these patients.

Frequently, patients with CGUO are misdiagnosed as suffering from Parkinson's disease based on their slowed gait and the presence of "rigidity". As a result, many patients receive a levodopa trial, usually with no response. A good and long lasting response to levodopa should be an exclusion criterion for the diagnosis of CGUO. All of the patients in the present study did not have PD.

Table 6 Typical features of patients with Cautious Gait of Unknown Origin

Cardinal features:
- Cautious gait with functional disturbances in mobility
- Significant fear of falling (e. g., ABC score < 85 %)
- Abnormal postural responses (e. g., pathological pull test, low Tinetti score)

Secondary features:
- Partial incontinence
- Mild to moderate extrapyramidal signs (rest tremor is rare)
- Mild cognitive decline
- Frontal release signs

Exclusion features:
- Documented vestibular dysfunction
- Positive response to levodopa
- Early dementia
- Cerebellar disturbances

Three atypical parkinsonian syndromes should be considered in the differential diagnosis: Progressive Supranuclear Palsy (PSP), normal pressure hydrocephalus (NPH) and vascular parkinsonism. The early appearance of postural instability is a common feature of PSP as is the involvement of the frontal lobe and the lack of response to levodopa [25]. Normal downward gaze in all but one of the patients and the lack of axial rigidity do not support the diagnosis of PSP in any of the patients. However, only a post-mortem examination can definitively exclude the diagnosis of PSP or vascular PSP, since PSP is a heterogeneous syndrome [13].

CGUO might be the early stage of NPH [36]. However, we did not find a single subject who could meet the clinical and radiological criteria for NPH. Nonetheless, we can not exclude the possibility that in the future some of these patients will degenerate further and meet those criteria. Follow up studies are needed to clarify the possible association between CGUO and NPH.

Other much less likely diagnoses like proximal myopathy and vitamin B12 deficiency should also be taken into consideration in future studies. We did not perform EMG testing in any of our subjects because any detected weakness was mild and, in our opinion, it could not adequately explain the observed disturbances, especially not the frontal features and other signs and symptoms. Future studies should perform additional diagnostic testing to account for all of these less likely diagnoses.

We suggest that the disequilibrium in this syndrome is of central (hemispheral) origin. However, based on this study one cannot completely rule out the contribution of the vestibular system to the disequilibrium. None of the patients had true vertigo, or Meniere-like episodes and disequilibrium was not associated with head movements or changes in position. Future studies should more completely assess the vestibular contribution to this syndrome.

In summary, we describe a neurodegenerative, multisystem gait syndrome with disequilibrium and fear of falling. We hypothesize that this is a disorder of frontal subcortical white matter and as a result can be viewed as a form of a disconnecting syndrome. Future studies are needed to determine the risk factors for this syndrome and to characterize its natural history and prevalence.

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