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Pathological Laughter and Crying in Patients with Multiple System Atrophy-Cerebellar Type

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Abstract: In the cerebellar type of multiple system atrophy (MSA-C), the burden of pathological changes involves the cerebellum and its associated brainstem structures in the basis pontis and the inferior olivary nucleus, and as a result, the clinical phenotype is dominated early on by the cerebellar dysfunction. We report our clinical and post mortem findings in a patient with MSA-C who exhibited pathological laughter in the absence of any congruent changes of mood. A review of the clinical notes of 27 other patients with MSA-C revealed a problem with pathological laughter, or crying, or both in 9 more patients. Our finding of about 36% occurrence suggests that the problem of dysregulation of emotional expression is more prevalent in MSA-C than the paucity of reports in the literature suggests. Our findings are consistent with the view that the cerebellum and its interconnected structures may be involved in the regulation of emotional expression. © 2007 Movement Disorder Society

Key words: olivopontocerebellar atrophy; disinhibition; emotion; behavior; pseudobulbar affect

Pathological laughter and crying (PLC) is a condition in which a patient with an underlying neurological disorder exhibits episodes of laughter or crying or both, without an apparent motivating stimulus or to a stimulus that would not have elicited such emotional response prior to the onset of the disease. This problem is characterized by a deficit in the regulation and coordination of emotional *expression* unlike mood disorders that are characterized by a pervasive and sustained problem of emotional *experience*. In some patients, spells of laughter or crying are out of context and incongruent with, or even contradictory to, the valence of the triggering stimulus and the mood of the patient. In other patients, spells of laughing or crying are congruent with the valence of the triggering stimulus and the mood of the patient but pathologically exaggerated in intensity or duration.

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Numerous terms have been introduced to describe the problem of inappropriate or exaggerated laughing and crying. The most widely used are "pseudobulbar affect," "emotional lability," "emotionalism," and "emotional dysregulation." "Forced laughing and crying," "involuntary laughing and crying," "pathological emotionality," and "emotional incontinence" have also been used, although less frequently. In some instances, the same designations have been applied to clinically different conditions, whereas different descriptors have also been used to indicate the same clinical presentation.

The problem of inappropriate or exaggerated laughing and crying has been reported in patients with stroke, traumatic brain injury, multiple sclerosis, amyotrophic lateral sclerosis, Alzheimer's disease, frontotemporal dementia, brain tumor, central pontine myelinolysis, and corticobasalganglionic degeneration.[1] Here we report the occurrence of the same problem in multiple system atrophy–cerebellar type (MSA-C), a sporadic progressive synucleinopathy characterized by cerebellar dysfunction and autonomic failure with lesser degrees of parkinsonism and corticospinal findings.

CASE STUDY

Patient 1 died in 2005 at the age of 80 with the clinical diagnosis of MSA-C. He saw a neurologist in 1999 for

the evaluation of falling and was noted to have ataxic gait and intermittent tremor in the right hand. A treatment trial with carbidopa/levodopa (Sinemet CR 50/200 three times daily) and pergolide (Permax 0.25 mg three times daily) produced no detectable clinical improvement. During his first visit with us in 2000, he complained of sexual dysfunction that had been present for ~2 years, as well as worsening falls, unsteady gait, slurred speech, and intermittent tremor in the right hand for less than a year. Past medical history was otherwise unremarkable. He did not smoke or drink alcohol. He worked as a farmer most of his life and was still engaged in landscaping work. He had no history of traumatic brain injury, seizures, headaches, or stroke, and did not report any daytime sleepiness or memory problems. His family history was negative for neurological problems.

On our initial neurological exam, he had a slightly reduced verbal fluency and mild dysarthria, with a moderate degree of bilateral ataxia and a wide-based gait. Blood pressure was unchanged from the recumbent to standing positions. Brain MRI at the outside facility revealed brainstem and cerebellar atrophy. Unsteady gait worsened, resulting in falls. He developed symptomatic postural hypotension, and unsteadiness and tremor continued to deteriorate to the extent that he had to use two hands to hold a glass. Later examination revealed hypermetric saccades, dysmetria of the upper extremities, and worsening of gait ataxia. When he became wheelchair bound, the patient reported mood changes and neurovegetative signs consistent with depression (i.e., anhedonia, anergia, sleep disturbance, and psychomotor slowing). At the same time his wife reported that the patient was "more giggly" than before. He had frequent outbursts of emotional expression consistent with happiness despite an emotional experience consistent with depression. His wife reported that he had a tendency to laugh inappropriately. These laughter spells were "forced," uncontrollable, and inappropriate, and "not from his heart." On our examination in spring 2002, he was surprisingly jovial despite his increasing disability. Six months later, the patient complained of worsening depression and his wife reported that he had become more irritable and occasionally "nasty." Therapy with citalopram (Table 1) did not improve the spells of inappropriate laughter that continued despite his increasing disability. His condition continued to decline, and he died in April 2005 from aspiration pneumonia.

Neuropathological Findings

On macroscopic inspection, the cerebellum was atrophic and its white matter sunken and brownish. The base of the pons was flattened and the olives severely atrophic. In contrast, the cerebral cortex showed age-appropriate atrophy without any structural lesions. The leptomeninges were clear, and the ventricles were of normal size. The basal ganglia structures and the red nuclei displayed no atrophy or discoloration. The substantia nigra was pigmented.

Selected areas of the brain were examined microscopically using conventional silver, H&E, and Bielschowsky stains. Additional sections were also processed with immunohistochemical labeling of α-synuclein for glial cytoplasmic inclusions (GCIs). In the cerebellum there was a partial loss of neuropil with preservation of radial glial fibers in the molecular layer, subtotal loss of Purkinje neurons, and an intact granular layer (Fig. 1). The neurons of the dentate nucleus were preserved. The white matter of the medullary core and the cerebellar folia was markedly gliotic and devoid of myelinated axons. Remaining cells contained numerous α-synuclein reactive GCIs. The brainstem revealed gliosis, marked loss of neurons and their myelinated axons, and a dense concentration of α-synuclein reactive GCIs in the basis pontis, the pontocerebellar fibers, the inferior olivary nuclei, and the olivocerebellar fibers (Fig. 1). The ventrolateral region of the medulla, the gigantocellular nucleus, the medial and spinal vestibular nuclei, the dorsal motor nucleus of vagus, the solitary nucleus of vagus, and the area postrema showed less prominent degeneration on conventional staining in addition to GCIs. There were no pathological findings on samples obtained from the middle frontal gyrus or hippocampus, nor was there any sign of degeneration in the red nucleus, raphe nuclei, periaqueductal gray, ventral tegmental area, locus coeruleus, nucleus ambiguous, superior cerebellar peduncles, medial lemniscus, central tegmental tracts, or the corticospinal tracts.

ADDITIONAL CASES

Alerted by the observations in patient 1, we reviewed the medical records of all patients diagnosed with MSA-C by one of us (J.D.S.) in the Ataxia Unit of the Massachusetts General Hospital (MGH). Twenty-seven patients met consensus criteria[2] for the clinical diagnosis of probable MSA-C. These patients had been referred to the Ataxia Unit because of predominant cerebellar deficits rather than neuropsychiatric problems. All patients were currently under the care of JDS and were being followed regularly.

PLC was recorded in 9 patients, bringing the total number of our MSA-C patients with this problem to 10 (Table 1). Five patients had only pathological laughing and 5 had pathological laughing and crying. Of note, similar to patient 1, all 9 patients complained of a de-

TABLE 1. *MSA-C patients with pathological laughter and crying (PLC)*

Patients	Sex	Age	Medications	Brain MRI	Neurological exam	PL/PLC
1	M	80	Citalopram	Atrophy of the cerebellum, the pons and the medulla.	Orthostatic hypotension; reduced verbal fluency; hypermetric saccades; absence of masked face; dysarthria; intermittent tremor on right hand; normal tone; full strength; no rigidity or bradykinesia; normal foot tapping; normal reflexes; mute toes; dysmetria of the upper and lower extremities; dysdiadocokinesia; overshoots on mirror movements; gait ataxia.	Laughter
2	M	58	Omeprazole, Serteraline	Mildly prominent fourth ventricle, atrophy of the cerebellum, the pons and the medulla. T2-signal abnormality in the middle cerebellar peduncles bilaterally.	Orthostatic hypotension; saccadic intrusions; dysarthria; dysphagia; normal tone; full strength; dysmetric finger to nose & heel to shin tests; normal reflexes; flexor plantar responses; negative jaw jerk, cross adductor, pectoral or supraclavicular reflexes; absent snout, root or grasp reflexes; gait ataxia.	Laughter
3	M	68	Gemfibrozil, Macrodantin, Serteraline	Atrophy of the cerebellum, the pons and the medulla.	Orthostatic hypotension; saccadic intrusions; vertical diplopia with lateral gaze; normal facial movement; hypoactive gag; dysarthria; excess salivation; mildly increased tone throughout with some cogwheeling in the upper extremities; full strength; dysmetric finger-to-nose test; impaired rapid alternating movements; hyperreflexia in legs; bilateral extensor plantar responses; negative jaw jerk; absent snout, root or grasp reflexes; gait ataxia.	Laughter
4	F	59	Methylphenidate, Venlafaxine, Levothyroxine	Prominent fourth ventricle. Atrophy of the cerebellum, the pons and the medulla.	Orthostatic hypotension; saccadic intrusions; dysarthria; hoarse voice; stridor; relatively preserved strength; decreased tone throughout; dysmetric finger-to-nose test; slow tapping of the legs; hyperreflexia; bilateral extensor plantar reflexes; gait ataxia.	Laughter
5	F	46	Nefazodone, Tolterodine	Atrophy of the cerebellum, the pons and the medulla.	Orthostatic hypotension; saccadic intrusions; mild nystagmus with lateral gaze; dysarthria; mildly reduced strength throughout; dysmetric finger-to-nose test and heel-to-shin tests; hyperreflexia with bilateral crossed adductor reflexes; bilateral extensor plantar responses; positive Hoffmann reflex, jaw jerk, and crossed supraclavicular and pectoral reflexes; gait ataxia.	Laughter
6	F	57	Gabapentin, Fluoxetine	Atrophy of the cerebellum, the pons and the medulla	Orthostatic hypotension; saccadic intrusions; dysarthria; full strength; bradykinesia; mildly dysmetric finger to nose test; hyporeflexia; bilateral flexor plantar responses; positive Romberg; gait ataxia.	Laughter and crying
7	M	77	HCTZ, Tamsulosin, Serteraline	Atrophy of cerebellum, pons, and medulla	Orthostatic hypotension; saccadic intrusions; hypermetric saccades; nystagmus with lateral gaze; poor convergence; decreased spontaneous facial expressions; stuttering; hypophonia; dysarthria; increased tone throughout; cogwheeling; bradykinesia; full strength; dysmetric finger-to-nose test; extensor plantar responses; hyperreflexia; positive jaw jerk; no palmar grasp; abnormal glabellar test; ataxic gait.	Laughter and crying
8	F	69	Atorvastatin, Aspirin, Baclofen, Lorazepam, Bupropion	Prominent fourth ventricle. Atrophy of the cerebellum, the pons and the medulla.	Orthostatic hypotension; saccadic intrusions; dysphagia; dysarthria; facial bradykinesia with decreased blinking; increased tone throughout; cogwheeling; full strength; dysmetria; slow alternating movements; hyperreflexia; Hoffman reflexes bilaterally; extensor plantar responses; gait ataxia.	Laughter and crying

TABLE 1. *(Continued)*

9	F	61	Oxybutynin10 mg, Sertraline 100 mg	Atrophy of the cerebellum, and brain stem with a hot cross bun sign	Orthostatic hypotensions; saccadic intrusions; dysphagia; dysphonia; dysarthria; full strength; increased tone with cogwheeling in upper extremities; overshoot in both upper extremities; bradykinesia; hyperreflexia; extensor plantar responses bilaterally; occasional tremor; gait ataxia.	Laughter and crying
10	F	45	Detrol 2 mg, Fluoxetine 40 mg	Enlargement of the 4th ventricle, prominent atrophy of the cerebellum and brain stem	Orthostatic hypotension; saccadic intrusions; nystagmus with lateral gaze; dysarthria; overshoot and mild rebound with the upper extremities bilaterally; side-to-side dysmetria with the heel-to-shin test; spastic catch in the left arm; full strength; hyperreflexia in the legs; extensor plantar responses bilaterally; gait ataxia.	Laughter and crying

pressed mood. The problem of PLC was witnessed in all these patients during the clinical exam and was verified by the patients themselves and their caretakers. In follow-up appointments, all 10 reported some, but incomplete improvement of their condition upon treatment with the currently suggested doses of selective serotonergic reuptake inhibitors[3] (Table 1). Seven patients continued on these medication despite incomplete resolution

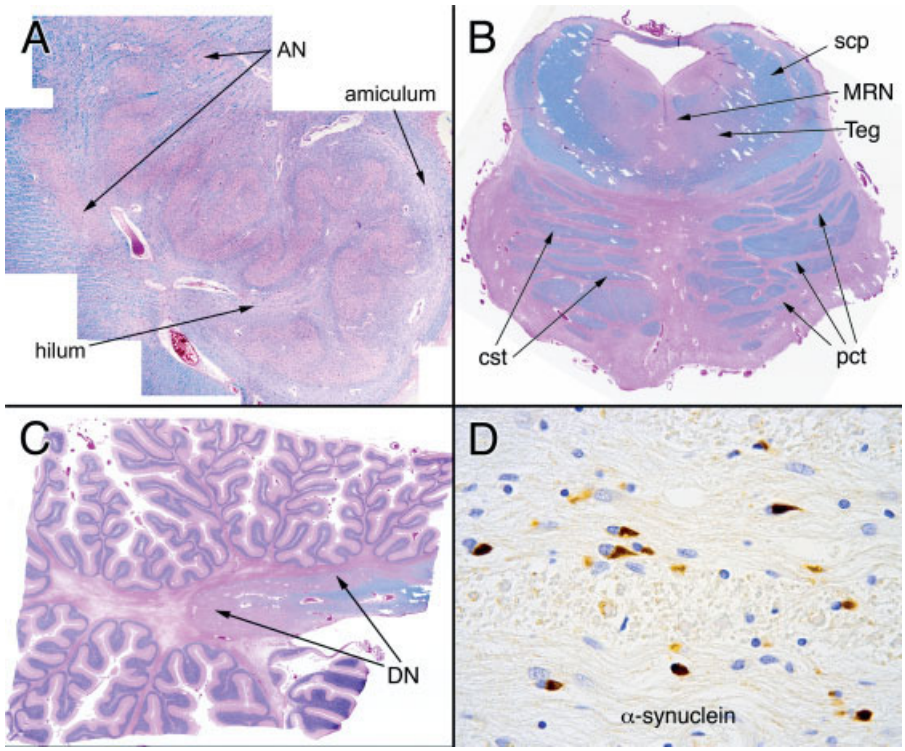

FIG. 1. Postmortem findings of pathological changes in patient 1. **A:** This photomicrograph is a montage of images obtained from a transverse section of the inferior olivary nucleus stained with the H&E/Luxol fast blue stain. The pink appearance of the inferior olivary nucleus, including the accessory nuclei (AN), olivary amiculum, and the olivary hilum are suggestive of neurodegenerative changes in the nucleus and its projections to the cerebellum. Note that the inferior olivary nucleus is almost devoid of neurons. **B:** This photomicrograph is from a horizontal section of the pons stained with the H&E/Luxol fast blue stain showing severe atrophy of the basis pontis. Projections from these neurons target the cerebellum in the pontocerebellar tracts (pct) which also are severely degenerated. Note that myelinated fibers in the corticospinal tract (cst) stand in contrast to severely atrophic and gliotic fibers of the pontocerebellar tract. The pontine tegmentum (teg), the superior cerebellar peduncle (scp), and the serotonergic median raphe nucleus (MRN) show no pathological changes. **C:** This photomicrograph is from a parasagittal section of the cerebellum stained with the H&E/Luxol fast blue stain showing severe atrophy of the white matter whereas the dentate nucleus (DN) remains unaffected. **D:** Darkly labeled α-synuclein reactive glial cytoplasmic inclusions are seen in pontocerebellar fibers in the white matter of the basis pontis in an immunohistochemically labeled section of the pons. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

of their symptoms. Eight patients reported that they were bothered by their PLC. One patient (#5, Table 1) was not bothered by her pathological laughter and thought that it actually helped her and her family with the overall sense of hopelessness.

DISCUSSION

In our sample of patients with MSA-C, 10 (35.7%) of 28 patients had problems with pathological laughter or pathological laughter and crying. Neuropathological findings in patient 1 revealed that the burden of the disease was centered in the cerebellum and its associated brainstem structures rather than in brain regions such as the middle frontal gyrus, the hippocampus, the basal ganglia, the brainstem serotonergic raphe, the periaqueductal gray, the facial nuclei, or the upper brainstem reticular formation, i.e., the brain foci often discussed in the context of the pathophysiology of PLC.

Diagnosis of MSA-C

Our post mortem findings in patient 1 are consistent with the neuropathological signature of MSA-C reported in the literature.[4–10] The other 9 patients are still alive and the definitive diagnosis of MSA-C, which requires neuropathological confirmation, remains to be determined. This notwithstanding, the clinical presentation in each of these patients is consistent with the diagnosis of MSA-C, and thus it appears likely that the distribution of the pathological changes in these 9 patients may resemble the pattern observed in this disorder, i.e., the cerebellum and its associated brainstem structures bear the brunt of the disease. In keeping with this assumption, all 9 patients were referred to the Ataxia Unit because of predominantly cerebellar deficits.

Previous Reports

The problem of PLC in MSA-C has received only limited attention in the current literature. One exception is the mention of the problem in a review of clinical manifestations of MSA by Quinn[6] who states that "the new development of emotional incontinence with weeping or, less commonly, laughing, when moved by an event, music, or something on the television is very common in progressive supranuclear palsy, common in MSA, and less common in idiopathic Parkinson's disease." Another exception is the study of 754 patients with various movement disorders by Siddiqui and colleagues[11] who reported that exaggerated and inappropriate laughter or crying, which they referred to as pseudobulbar affect, was present in 2 of 33 patients with MSA (cerebellar and other types of MSA). Of the 33 patients, 2 were diagnosed with MSA-C and 1 of them had pseudobulbar affect. They also reported that pseudobulbar affect was present at a rate of 5% in their sample of patients with either Parkinson's disease or the Parkinsonian type of MSA.

Scope of the Problem

Our sample included only a small number of patients, and the true community prevalence of the problem may be different than that reported here. However, our patients were referred to our clinic because of predominantly cerebellar deficits, rather than mood lability. It seems unlikely that the prevalence of PLC in our patients is overestimated due to a sampling bias, and indeed this may be an underestimate because some of the 18 patients who do not have PLC may yet develop the problem later in the course of their disease.

The occurrence of PLC in about 36% of our patients with MSA-C suggests that pathological regulation of emotional expression in this group of patients is more pervasive than previously recognized. This prevalence ranks quite high compared to the numbers reported in other neurological disorders. For instance, PLC occurs in about 11% of patients with traumatic brain injury,[12,13] 10% of patients with multiple sclerosis,[14–16] and depending on the location of vascular lesions, in 11% to 34% of patients with stroke.[17–19] The problem seems to be more prevalent (49%) only in amyotrophic lateral sclerosis.[20]

Pathophysiology

The pathological mechanisms of exaggerated or inappropriate emotional behavior in patients with PLC are still a matter of debate. The traditional explanation holds that bilateral lesions in corticobulbar tracts lead to disinhibition of a presumed brainstem center for laughing and crying and releases the center's activity from voluntary control and thus the emotional behavior becomes uncontrollable.[21,22] As described elsewhere, there are problems with this traditional view.[23–26] For instance, PLC can occur without the associated neurological features of pseudobulbar palsy or signs of long tract compromise.[23,24,27,28] As noted in patient 1's postmortem brain examination (Fig. 1), the descending long tract fibers were unaffected in contrast to the severely atrophic and gliotic basis pontis and the pontocerebellar fibers.

Another possibility is that patients with MSA-C have molecular changes in the form of α-synuclein labeled glial and neuronal cytoplasmic inclusions[2] in the basal ganglia that could potentially contribute to the pathophysiology of emotional dysregulation in our patients. However, at least three lines of evidence suggest that this is less likely to be the cause of PLC in our patients. First, 30% of our patients had no extrapyramidal signs at the

onset of PLC (Table 1). Second, according to the literature[9,10] and our own observations of the brain of patient 1, the molecular changes in the basal ganglia or other brain regions (including the prefrontal cortices) are less prominent than the same changes in the olivopontocerebellar system in patients with MSA-C; and third, more severe forms of these molecular changes occur in the basal ganglia in patients with idiopathic Parkinson's disease or the parkinsonian type of MSA, but PLC is observed only rarely in those patients.[11]

Inspired by the notion of the cerebellar cognitive affective syndrome,[29] and the dysmelyia of thought theory,[30] an alternative hypothesis was recently offered, which suggests that the cerebellum may be involved in modulating the profile of an emotional response unconsciously and automatically according to the information it receives from the cerebral cortex regarding the cognitive and social context of the triggering stimulus.[25] In keeping with this hypothesis, selective lesions along the corticopontocerebellar fibers (which travel in the vicinity of the classical corticobulbar tracts), or in the basis pontis and the cerebellum, could cause a selective and partial dysfunction of the cerebellum, leading to impairment in the cerebellar modulation of emotional behavior. The high prevalence of disturbed regulation of emotional expression in our patients with severe structural abnormalities of the cerebellum and basis pontis appears to provide indirect evidence for the involvement of the cerebellar system in the regulation of emotional expression.

Although a definitive account of the pathophysiology of PLC is not yet available, the present report serves as a useful reminder that the problem of pathological regulation of emotional expression in patients with MSA occurs more frequently than has been appreciated. We hope that greater awareness of the problem of PLC in MSA-C will facilitate its diagnosis and treatment and help patients and their caretakers enhance their quality of life and relationships.[1]

REFERENCES

1. Parvizi J, Arciniegas DB, Bernardini GL, et al. Diagnosis and management of pathological laughing and crying: a concise review. Mayo Clin Proc 2006;81:1482–1486.
2. Gilman S, Low PA, Quinn N, et al. Consensus statement on the diagnosis of multiple system atrophy. J Neurol Sci 1999;163:94–98.
3. Schiffer R, Pope LE. Review of pseudobulbar affect including a novel and potential therapy. J Neuropsychiatry Clin Neurosci 2005;17:447–454.
4. Gilman S, Quinn NP. The relationship of multiple system atrophy to sporadic olivopontocerebellar atrophy and other forms of idiopathic late-onset cerebellar atrophy. Neurology 1996;46:1197–1199.
5. Gilman S, Little R, Johanns J, et al. Evolution of sporadic olivopontocerebellar atrophy into multiple system atrophy. Neurology 2000;55:527–532.
6. Quinn NP. How to diagnose multiple system atrophy? Mov Disord 2005;20(Suppl. 12):S5–S10.
7. Ozawa T, Paviour D, Quinn NP, et al. The spectrum of pathological involvement of the striatonigral and olivopontocerebellar systems in multiple system atrophy: clinicopathological correlations. Brain 2004;127:2657–2671.
8. Geser F, Wenning GK, Seppi K, et al. Progression of multiple system atrophy (MSA): a prospective natural history study by the European MSA Study Group (EMSA SG). Mov Disord 2006;21:179–186.
9. Wenning GK, Colosimo C, Geser F, Poewe W. Multiple system atrophy. Lancet Neurol 2004;3:93–103.
10. Jellinger KA, Seppi K, Wenning GK. Grading of neuropathology in multiple system atrophy: proposal for a novel scale. Mov Disord 2005;20(Suppl. 12):S29–S36.
11. Siddiqui MS, Kirsch-Darrow L, Fernandez HH, Jacobsen CE, Okun MS. Prevalence of pseudobulbar affect in movement disorders and its mood correlates. Neurology 2006;66 (Suppl 2):A369.
12. Zeilig G, Drubach DA, Katz-Zeilig M, Karatinos J. Pathological laughter and crying in patients with closed traumatic brain injury. Brain Inj 1996;10:591–597.
13. Tateno A, Jorge RE, Robinson RG. Pathological laughing and crying following traumatic brain injury. J Neuropschiatry Clin Neurosci 2004;16:426–434.
14. Minden SL, Schiffer RB. Affective disorders in multiple sclerosis. Review and recommendations for clinical research. Arch Neurol 1990;47:98–104.
15. Feinstein A, Feinstein K, Gray T, O'Connor P. Prevalence and neurobehavioral correlates of pathological laughing and crying in multiple sclerosis. Arch Neurol 1997;54:1116–1121.
16. Feinstein A, O'Connor P, Gray T, Feinstein K. Pathological laughing and crying in multiple sclerosis: a preliminary report suggesting a role for the prefrontal cortex. Mult Scler 1999;5:69–73.
17. House A, Dennis M, Molyneux A, Warlow C, Howton K. Emotionalism after stroke. Br Med J 1989;298:991–994.
18. Morris PL, Robinson RG, Raphael B. Emotional lability after stroke. Aust N Z J Psychiatry 1993;27:601–605.
19. Kim JS, Choi-Kwon S. Poststroke depression and emotional incontinence: correlation with lesion location. Neurology 2000;54:1805–1810.
20. Gallagher JP. Pathologic laughter and crying in ALS: a search for their origin. Acta Neurol Scand 1989;80:114–117.
21. Oppenheim H, Siemerling E. Mitteilungen uber pseudobulbarparalyse und akute bulbarparalyse. Berl kli Woch 1886; 46.
22. Wilson SAK. Some problems in neurology. II. Pathological laughing and crying. J Neurol Psychopathol 1924;IV:299–333.
23. Black DW. Pathological laughter. A review of the literature. J Nerv Ment Dis 1982;170:67–71.
24. Poeck K. Pathophysiology of emotional disorders associated with brain damage. In: Vinken PJ, Bruyn GW, editors. Disorders of higher nervous activity. Amsterdam: Elsevier; 1985. p 343–367.
25. Parvizi J, Anderson SW, Martin C, Damasio AR, Damasio H. Pathological laughter and crying: a link to the cerebellum. Brain 2001;124:1708–1719.
26. Wild B, Rodden FA, Grodd W, Ruch W. Neural correlates of laughter and humour. Brain 2003;126:2121–2138.
27. Poeck K. Pathological laughter and crying. In: Frederiks JAM, editor. Clinical Neuropsychology. Elsevier; 1985. p 219–225.
28. Asfora WT, DeSalles AA, Abe M, Kjellberg RN. Is the syndrome of pathological laughing and crying a manifestation of pseudobulbar palsy? J Neurol Neurosurg Psyshiatry 1989;52:523–525.
29. Schmahmann JD, Sherman JC. The cerebellar cognitive affective syndrome. Brain 1998;121:561–579.
30. Schmahmann JD. An emerging concept: the cerebellar contribution to higher function. Arch Neurol 1991;48:1178–1187.