INTRODUCTION
Multiple systems atrophy (MSA) is a rare neurodegenerative disorder combining varying presentations of cerebellar impairment, parkinsonism and autonomic dysfunction that relies on pathological examination for a definitive diagnosis. The second consensus diagnostic criteria (SCDC) subdivide patients into two groups based on a predominance of either parkinsonism (MSA-P) or cerebellar impairment (MSA-C). MSA is frequently misdiagnosed, especially early in the disease course, with only 60% of possible and probable MSA meeting the pathological criteria.

A recessive intronic expansion in replication factor C subunit 1 (RFC1) has been found to be a cause of late-onset ataxia and cerebellar ataxia, neuropathy and vestibular areflexia syndrome (CANVAS). Due to the overlapping clinical features of MSA and CANVAS, we hypothesised that the recessive RFC1 expansion may be implicated in patients that atypically fit the diagnostic criteria for MSA. Here, we present three cases with biallelic RFC1 expansions: two clinically diagnosed with ‘probable’ MSA and one with ‘probable’ based on the SCDC for MSA.

METHODS
Samples
We enrolled 207 patients with ‘possible’ and ‘probable’ MSA, from the National Hospital for Neurology and Neurosurgery (NHHN), MSA diagnosis based on the SCDC for MSA.

Genetic testing
Genomic DNA was extracted from blood and investigated under approval of the joint ethics committee of the UCL Institute of Neurology and The NHNN, London, UK (UCLH: 04/N034). Flanking PCR, repeat-primed PCR and Southern blot were performed on all samples as previously described (figure 1A).

RESULTS
Three patients had biallelic RFC1 expansions, as defined by no amplifiable product on PCR, and a positive repeat primed PCR for AAGGG(n) (figure 1A,B). The allelic frequencies in clinical MSA cases were 1.7% (n=7) for pathogenic AAGGG(n) 2.4% (n=10) for AAGGG(n) and 11.4% (n=47) for AAAAG(n) and 82.8% (n=343) for AAAAG(n) (figure 1D). Southern blotting revealed two large expansions, sized at 9434 kb (887 repeat units) and 12477 kb (1495 repeat units) in patient 1 (figure 1C) and 11244 kb (1249 repeat units) in patient 2, corresponding to the two expanded alleles; both patients were initially diagnosed...
with 'possible' MSA. There was insufficient DNA to perform a Southern blot for patient 3, initially diagnosed with 'probable' MSA.

Case studies

Patient 1 has possible MSA: symptom onset at 62 years old, autonomic tests within 3 years of disease onset showed mild cardiovascular autonomic dysfunction, levodopa non-responsive parkinsonism and a cerebellar syndrome (online supplemental video 1). He progressed to wheelchair use at 67 years, complicated by neurogenic bladder and presyncope. He had no preceding chronic cough or pins and needles. His brother also had ataxia, attributed to alcohol abuse and died at 62 years old. Examination at 69 years old revealed a combination of parkinsonism and cerebellar ataxia with orthostatic blood pressure drop >30/15 mm Hg. His strength was retained but reflexes were brisk with absent ankle jerks and absent plantar response. Pinprick was absent throughout with asymmetrical impairment of vibration to trunk and reduced proprioception distally in the lower limbs. Neuro-otological review showed no vestibular areflexia. Routine investigations for ataxia and genetic tests (SCA 1, 2, 3, 6, 7, 12, 17, FRDA and whole exome sequencing) were negative.

Figure 1E and H show his MRI head, DaTscan and nerve conduction study (NCS). Patient 2 has possible MSA: symptom onset at 62 years old, orthostatic decrease of blood pressures was <30 mm/15 mm Hg with symptoms of unexplained bladder urgency, levodopa non-responsive parkinsonism and a cerebellar syndrome (online supplemental video 2). Her initial symptoms were postural dizziness, gait imbalance and reduced tempo in her right hand but no increased tone in her lower limbs, with a slight reduction in her left. She also had finger dysmetria bilaterally with impaired tandem gait. Her reflexes were reduced in the lower limbs with upgoing plantar responses bilaterally. Autonomic testing showed parasympathetic impairment, with postural blood pressure drop, unexplained urinary incontinence and incomplete bladder emptying. NCS results were normal (figure 1H). MRI head showed extensive atrophy of the superior and middle cerebellar peduncles, cerebellum and pons (figure 1G). Genetic tests were negative.

Discussion

We have identified three patients that have biallelic RFC1 repeat expansions, presenting with a combination of cerebellar ataxia and parkinsonism: two initially diagnosed with possible MSA and one with probable MSA. This expands the spectrum of RFC1 related disease that can range from idiopathic late onset ataxia through to CANVAS, but is absent in neuropathologically confirmed MSA cases.5 We suggest that the phenotype includes mimics of MSA-C and likely other atypical parkinsonian phenotypes. If these cases come to autopsy, we would not expect to see MSA pathology. These patients present with an MSA mimic in the early stage, but slower clinical and radiological progression suggest that they are not phenotypically representative of MSA. Sensory neuropathy is always difficult to assess in MSA, given the frequent cold and swollen feet with dependent oedema. Given the difficulty in diagnosing MSA in the early stages, we recommend testing for the RFC1 expansion in atypical MSA and parkinsonian patients, particularly in those with atypical features such as peripheral neuropathy, slow disease progression, impaired vestibulo-ocular reflex and clinically mild autonomic dysfunction.
RS and WYY contributed equally.


Received 10 September 2020

Revised 10 December 2020

Accepted 13 December 2020

Published Online First 9 February 2021

REFERENCES


