Clinical spectrum of high-titre GAD65 antibodies


ABSTRACT

Objective To determine clinical manifestations, immunotherapy responsiveness and outcomes of glutamic acid decarboxylase-65 (GAD65) neurological autoimmunity.

Methods We identified 323 Mayo Clinic patients with high-titre (>20 nmol/L in serum) GAD65 antibodies out of 380 514 submitted anti-GAD65 samples (2003–2018). Patients classified as having GAD65 neurological autoimmunity after chart review were analysed to determine disease manifestations, immunotherapy responsiveness and predictors of poor outcome (modified Rankin score >2).

Results On review, 108 patients were classified as not having GAD65 neurological autoimmunity and 3 patients had no more likely alternative diagnoses but atypical presentations (hypermotor movement disorders). Of remaining 212 patients with GAD65 neurological autoimmunity, median age at symptom onset was 46 years (range: 5–83 years); 163/212 (77%) were female. Stiff-person spectrum disorders (SPSD) (N=71), cerebellar ataxia (N=55), epilepsy (N=35) and limbic encephalitis (N=7) could occur either in isolation or as part of an overlap syndrome (N=44), and were designated core manifestations. Cognitive impairment (N=38), myelopathy (N=23) and brainstem dysfunction (N=22) were only reported as co-occurring phenomena, and were designated secondary manifestations. Sustained response to immunotherapy ranged from 5/20 (25%) in epilepsy to 32/44 (73%) in SPSD (p=0.002). Complete immunotherapy response occurred in 2/142 (1%). Cerebellar ataxia and serum GAD65 antibody titre >500 nmol/L predicted poor outcome.

Interpretation High-titre GAD65 antibodies were suggestive of, but not pathognomonic for GAD65 neurological autoimmunity, which has discrete core and secondary manifestations. SPSD was most likely to respond to immunotherapy, while epilepsy was least immunotherapy responsive. Complete immunotherapy response was rare. Serum GAD65 antibody titre >500 nmol/L and cerebellar ataxia predicted poor outcome.

INTRODUCTION

Glutamic acid decarboxylase-65 (GAD65) is an enzyme required for synthesis of gamma-aminobutyric acid, a major central nervous system inhibitory neurotransmitter. Antibodies targeting GAD65 are a biomarker of type 1 diabetes mellitus (T1DM). Low titres in serum lack clinical specificity for autoimmune neurological disease, and may be detected in patients with alternative neurological diagnoses, isolated T1DM or even healthy controls. In contrast, high-titre GAD65 antibodies, defined in our laboratory as more than 20 nmol/L in serum (over 1000-fold higher than the upper limit of normal), reportedly confer high clinical specificity for GAD65 neurological autoimmunity. GAD65 antibodies appear unlikely to be pathogenic given the intracellular location of GAD65, and may instead be a surrogate marker of cytotoxic T-cell-mediated disease in patients with associated neurological syndromes. Stiff-person spectrum disorders (SPSD) were first characterised by Moersch and Woltman in 1956 and later determined to be a prototypical presentation of GAD65 neurological autoimmunity. Other manifestations of GAD65 neurological autoimmunity that have since been described include cerebellar ataxia, epilepsy, limbic encephalitis (LE), cognitive impairment, myelopathy and/or brainstem dysfunction. These reports, however, are limited by small sample sizes or restriction to individual phenotypes, precluding complete disease characterisation.

METHODS

Patients provided written consent to the use of their records for research.

Identification of patients with GAD65 neurological autoimmunity

We retrospectively identified 323 patients with high-titre GAD65 antibodies (defined as >20 nmol/L in serum based on previous work demonstrating high clinical specificity for GAD65 neurological autoimmunity at this cut-off) detected in the Mayo Clinic Neuroimmunology Laboratory out of 380 514 samples submitted for anti-GAD65 testing from January 2003 to May 2018, using radioimmunoassay (RIA) as previously described. Their electronic medical records (EMRs) were then reviewed by two neurologists with fellowship training in Neuroimmunology/Autoimmune Neurology (AB and NLZ). Patients with non-neurological presentations (eg, GAD65 antibody detected as part of T1DM evaluation), as well as those with neurological presentations but a more likely alternative diagnosis than GAD65 neurological autoimmunity, were classified as not having GAD65 neurological autoimmunity; these patients were excluded from study analysis and summarised separately.
Patients with no more likely alternative diagnosis but an atypical presentation for GAD65 neurological autoimmunity were also excluded from study analysis but described separately, to ensure potentially novel disease phenotypes were not overlooked. Remaining patients were classified as having GAD65 neurological autoimmunity, and data relating to their clinical presentation, neuroimaging, electrophysiological testing, laboratory findings, immunotherapy responses, and outcomes as measured by modified Rankin score (mRS) were extracted from their EMRs for analysis.

**Diagnosis of disease manifestations**

Diagnosis of disease manifestations in GAD65 neurological autoimmunity was based on clinical assessment by a Mayo Clinic physician with expertise in the disorder of interest, alongside EMR review by AB and NLZ as outlined above to ensure no more likely alternative diagnosis was present. Electrophysiological data (ie, auditory startle reflexes, exteroceptive responses and/or electromyography for SPSD as described previously, electroencephalography for epilepsy) were frequently gathered, but an abnormal electrophysiological study was not required for diagnosis given imperfect test clinical specificity. Patients with SPSD were classified as classical SPSD (trunk and limb involvement), partial SPSD (trunk or limb involvement), or SPSD with prominent exaggerated startle. LE was defined as medial temporal lobe T2-hyperintensity with subacute disease onset of less than 3 months. Cognitive impairment was diagnosed by the treating physician based on the Kokmen short test of mental status and/or formal neuropsychometric testing.

**Outcome measures**

Response to immunotherapy (corticosteroids, intravenous IG, plasma exchange (PLEX), rituximab, cyclophosphamide and/or autologous stem cell transplantation) was classified as no response, partial response, near-complete response (ie, minimal residual clinical signs/symptoms), or complete response (ie, no residual clinical signs/symptoms), as well as sustained (defined as benefit persisting for greater than 3 months) or non-sustained, based on review of the treating Mayo Clinic physician’s documentation by AB and NLZ. A poor outcome was defined as mRS >2 at last clinical follow-up.

**Statistical analyses**

Statistical analyses were performed using JMP Pro V14.1.0. Continuous and categorical variables were reported as median (range) and number (percentage), respectively. Differences across multiple groups were assessed by the Kruskal-Wallis, Pearson’s χ² or Fisher’s exact test for multiple categories, as appropriate. Associations with a poor outcome at last clinical follow-up were explored by univariate logistic regression analysis, while the simultaneous effect of multiple significant variables was assessed by multivariate logistic regression. A two-sided p<0.05 was considered statistically significant. Adjustment for multiple comparisons was not performed. The relationships among manifestations of GAD65 neurological autoimmunity were depicted using circular visualisation in R.

**RESULTS**

**One in three patients with high-titre GAD65 antibodies were classified as not having GAD65 neurological autoimmunity**

Of 323 patients with high-titre GAD65 antibodies, 37 (11%) had non-neurological presentations (eg, GAD65 antibody detected as part of T1DM evaluation) and were excluded from study analysis. Seventy-one of 323 patients (22%) were determined to have a more likely alternative diagnosis than GAD65 neurological autoimmunity during review of their EMR; these patients were excluded from study analysis but are summarised separately (online supplemental table 1). Three of 323 patients (1%) without more likely alternative diagnoses but presentations atypical for GAD65 neurological autoimmunity (hyperkinetic movement disorders) were also excluded from study analysis but are described separately (table 2). The remaining 212 of 323 patients (66%) were classified as having GAD65 neurological autoimmunity for study analysis. The median serum anti-GAD65 titre among patients classified as having a more likely alternative diagnosis was significantly lower compared with patients classified as having GAD65 neurological autoimmunity (149 nmol/L vs 334 nmol/L, p<0.0001), and was not significantly different compared with patients with non-neurological presentations (149 nmol/L vs 164 nmol/L, p=0.71). The process of classifying patients as having GAD65 neurological autoimmunity is depicted via flow diagram (figure 1).

**Defining the core and secondary manifestations of GAD65 neurological autoimmunity**

Through EMR review, we found that SPSD, cerebellar ataxia, epilepsy without LE (simply referred to hereafter as epilepsy unless otherwise specified) and LE could all occur in isolation. These were thus designated core manifestations of GAD65 neurological autoimmunity. Patients with two or more core disease manifestations were designated overlap syndromes, with the exception of LE and epilepsy (all patients with LE had seizures). No patient had cognitive impairment, myelopathy or brainstem dysfunction reported in isolation (ie, in the absence of SPSD, cerebellar ataxia, epilepsy or LE). These co-occurring phenomena were thus designated secondary manifestations of GAD65 neurological autoimmunity.

**Core manifestations of GAD65 neurological autoimmunity are SPSD, cerebellar ataxia, epilepsy and LE**

The clinical characteristics, immunological/cancer associations and laboratory results of all 212 patients with GAD65 neurological autoimmunity are presented in table 1. The median age of symptom onset was 46 years (range: 5–83 years) and 163/212 (77%) were female. Concurrent systemic autoimmunity was documented in 125/212 (59%) patients with GAD65 neurological autoimmunity and was most often thyroid disease (72/212, 34%), T1DM (63/212, 30%), and/or pernicious anaemia (40/212, 19%). A diagnosis of cancer within 5 years of symptom onset was reported in 9/212 (4%). Stratification of these findings by core manifestation is included in table 1, and discussed in relevant sections below.

**Stiff-person spectrum disorders**

SPSD was the most common core manifestation and was often classical in presentation

The most common core manifestation was SPSD, which was reported in 107/212 (50%). The majority (73/107, 68%) had classical SPSD. Partial SPSD was documented in 30/107 (28%), and a small minority were classified as SPSD with prominent exaggerated startle response (4/107, 4%). Electrophysiological findings supportive of SPSD were reported in 52/70 (74%). Common findings documented on clinical assessment included spams (93/107, 87%), gait dysfunction attributed to SPSD (85/107, 79%) and hyperlordosis (49/107, 46%).
Figure 1  Flow diagram depicting patient selection for study inclusion. GAD65, glutamic acid decarboxylase-65.
Cerebellar ataxia

Cerebellar ataxia was the second most common core manifestation and often affected gait

Cerebellar ataxia was reported in 91/212 (43%). Gait ataxia was most frequently documented (76/91, 84%), followed by limb ataxia (63/91, 69%) and ataxic dysarthria (47/91, 52%). On brain MRI, cerebellar atrophy was observed in 24/91 (26%); no evidence of chronic inflammation noted (mild leptomeningeal, focal superficial cortical and perivascular chronic inflammation, 1 patient; ‘patchy chronic inflammation’ as per Mayo Clinic). The most frequent core symptom was impaired gait (one patient had focal seizures with preserved awareness up to ten years after surgery).

Rare paraneoplastic cases associated with cerebellar ataxia

While a diagnosis of cancer within 5 years of symptom onset was reported in only 9/212 (4%), this ranged from 0/71 (0%) in SPD to 6/55 (11%) in cerebellar ataxia (p = 0.01). Cancers diagnosed included thyroid cancer, breast cancer, lung cancer, thymoma (1), lymphoma (1), and multiple myeloma (1). Seven of 9 patients had a cancer diagnosed within 2 years of symptom onset, while the remaining two patients had cancer diagnosed 2–5 years from symptom onset (one thyroid cancer not otherwise specified, 1 breast cancer not otherwise specified).

Epilepsy

Epilepsy was classically temporal lobe in origin and occasionally muscogonic

Epilepsy with or without LE was reported in 62/212 (29%). Seizures were focal-onset in 56/62 (90%) and unknown-onset in 6/62 (10%). Seizures most often localised to the medial temporal lobe (35/56, 63%). Other seizure localisations were temporal lobe not otherwise specified (11/56, 20%), temporal lobe involving Heschl’s gyrus (4/56, 7%), frontal lobe (3/35, 5%), temporoparietal region (1/56, 2%), temporal and occipital lobes (1/56, 2%), and hemispheric onset (1/56, 2%). Involvement of Heschl’s gyrus was presumed if music provoked seizures (three patients) or if the patient heard music during the seizure (one patient).

Patients evaluated for seizure management were often medically refractory

Seizures were medically refractory in the majority (42/57, 74%). However, medically refractory epilepsy was significantly more frequent among patients with epilepsy in isolation who were evaluated for seizure management (34/39, 87%), compared with patients with epilepsy as part of an overlap syndrome who may have presented for management of SPBD or cerebellar ataxia rather than epilepsy (8/18, 44%) (p = 0.0007).

Epilepsy surgery uniformly revealed gliosis and did not usually result in seizure freedom

The most common neuroimaging finding prompting consideration of epilepsy surgery was mesial temporal sclerosis, or MTS (9/62, 15%). Eight of 62 patients (13%) underwent epilepsy surgery (unilateral anterior temporal lobectomy, 7 patients; unilateral anterolateral temporal/frontal lobe resections, 1 patient). Neuropathological data was available for 5/8 patients, all of whom had gliosis reported. Two of 5 had pathological evidence of chronic inflammation noted (mild leptomeningeal, foca superficial cortical and perivascular chronic inflammation, 1 patient; ‘patchy chronic inflammation’ as per Mayo Clinic).
of follow-up). The remaining six patients continued to have disabling seizures (ie, seizures limiting daily activities, requiring acute medical evaluation and/or leading to injury) after surgery.

**Epilepsy was typically young-onset and chronic in disease duration**
On stratification by core disease manifestation (table 1), median age at symptom onset ranged from 24 years (range: 5–56 years) in epilepsy to 59 years (range: 14–83 years) in cerebellar ataxia (p<0.0001). We examined the age at symptom onset of individual core disease manifestations in patients with overlap syndromes, and similarly found that the median age ranged from 33 years (range: 11–60 years) for epilepsy onset to 53 years for both cerebellar ataxia onset (range: 26–69 years) and SPSD onset (range: 19–70 years) (p<0.0001). The median total symptom duration recorded ranged from 42 months (range: 3–171 months) in cerebellar ataxia to 137 months (range: 3–552 months) in epilepsy (p<0.0001).

**Epilepsy showed a trend toward less cerebrospinal fluid inflammation**
On review of laboratory results (table 1), median serum and cerebrospinal fluid (CSF) anti-GAD65 titre did not differ significantly across core manifestations of GAD65 neurological autoimmunity. Patients with epilepsy had the lowest median CSF anti-GAD65 titre (2.5 nmol/L) and the lowest frequency of elevated CSF IgG index (0/22, 0%) among core disease manifestations, but these differences did not reach statistical significance (p=0.10 and p=0.17, respectively).

**Limbic encephalitis**
Patients with epilepsy uncommonly had neuroimaging evidence of LE
On MRI, medial temporal lobe T2-hyperintensity compatible with LE was seen in 10/62 (16%). These patients were classified separately as having LE and all had subacute-onset seizures/cognitive impairment. Only 1/10 (10%) were assessed at the Mayo Clinic within 3 months of disease onset, and 3/10 (30%) were assessed greater than 1 year after disease onset for management of sequelae of LE (ie, persistent seizures, cognitive difficulties).

**Secondary manifestations of GAD65 neurological autoimmunity**
Clustered with specific core manifestations
Secondary disease manifestations clustered with specific core disease manifestations: cognitive impairment with epilepsy/LE (N=30/38, 79%), myelopathy with SPSD (N=18/23, 78%), and brainstem dysfunction with cerebellar ataxia (N=20/22, 91%). The relationships among core and secondary disease manifestations are depicted via chord diagram (figure 2).

**An atypical presentation of GAD65 neurological autoimmunity: hyperkinetic movement disorders**
Three patients had high-titre GAD65 antibodies but atypical presentations for GAD65 neurological autoimmunity (table 2). All had unilateral hyperkinetic movement disorders (dystonia, 2 patients; chorea, 1 patient). In patients with dystonia the onset was insidious, while in the patient with chorea onset was subacute. One patient with right lower extremity dystonia received intravenous IG and reported 90% improvement that was confirmed by the treating physician; however, dystonia recurred seven to 8 weeks after intravenous IG was discontinued due to intolerability.

**Responses to immunotherapy and outcomes in GAD65 neurological autoimmunity**
Responses to immunotherapy were stratified by core disease manifestation and are presented in table 3. Immunotherapy usage (corticosteroids, intravenous IG, PLEX, rituximab and cyclophosphamide) was not significantly different except for...
### Table 2

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</thead>
<tbody>
<tr>
<td>1</td>
<td>3847 NA</td>
<td>NA</td>
<td>Yes, T1DM, thyroid disease</td>
<td>Yes</td>
<td>Older adult with involuntary movements of the left arm more than left leg that developed over 2 months; characterised as hemichorea on examination.</td>
<td>No trial, treated symptomatically with risperidone which reduced chorea but led to drug-induced parkinsonism.</td>
<td>Yes, reported 90% improvement of dystonia with intravenous IG intermittently over 9 months; intravenous IG discontinued due to headache with recurrence of dystonia after 7–8 weeks, but less severe than it was initially.</td>
</tr>
<tr>
<td>2</td>
<td>780 29.6</td>
<td>NA</td>
<td>Yes, thyroid disease</td>
<td>Yes</td>
<td>Child who always walked 'gingerly' on right side as per mother; difficulty walking that developed over 6 years; characterised as hemidystonia on examination.</td>
<td>No trial, intravenous IG recommended but no follow-up available.</td>
<td>No alternative aetiology identified.</td>
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<tr>
<td>3</td>
<td>296</td>
<td>780</td>
<td>Yes, thyroid disease</td>
<td>Yes</td>
<td>Young adult with clumsiness/tightness of left limbs and difficulty walking that developed over 6 years; characterised as spastic paraparesis on examination.</td>
<td>No trial, intravenous IG not recommended but no follow-up available.</td>
<td>No alternative aetiology identified.</td>
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**DISCUSSION**

This study of patients with GAD65 neurological autoimmunity provides numerous important insights into the disease. Through systematic review of all Mayo Clinic patients with high-titre GAD65 antibodies identified in our Neuroimmunology Laboratory over a 15-year period, we found that SPSD, cerebellar ataxia, epilepsy, and LE were core disease manifestations. Phenotypically, SPSD was usually classical in presentation, in keeping with previous studies. Cerebellar ataxia most often impacted gait, although limb and speech ataxia were also commonly reported. Among those with epilepsy, seizures typically originated from the temporal lobe. Interestingly, three patients had musicogenic epilepsy, suggesting patients with this rare form of reflex epilepsy should be considered for GAD65 antibody testing. With regard to immunotherapy-responsiveness, this differed significantly across core disease manifestations; SPSD was the most likely to respond to immunotherapy, while epilepsy was least immunotherapy responsive. We also determined that serum GAD65 antibody titre >500 nmol/L as well as cerebellar ataxia independently predicted poor outcome. An mRS >2 at first Mayo Clinic evaluation, cerebellar ataxia and serum GAD65 antibody titre >500 nmol/L were independent predictors of poor outcome (mRS >2) at last clinical follow-up (table 4).

** Presence of cerebellar ataxia and serum GAD65 antibody titre >500 nmol/L predicted poor outcome **

Among patients with GAD65 neurological autoimmunity the mRS at last follow-up was as follows: 0, 2/212 (1%); 1, 28/212 (13%); 2, 61/212 (29%); 3, 65/212 (31%); 4, 49/212 (23%); 5, 3/212 (1%); 6, 4/212 (2%). Logistic regression analysis revealed that mRS >2 at first Mayo Clinic evaluation, cerebellar ataxia and serum GAD65 antibody titre >500 nmol/L were independent predictors of poor outcome (mRS >2) at last clinical follow-up (table 4).

** Patients with epilepsy received immunotherapy later and were least immunotherapy responsive **

The median time from symptom onset to first immunotherapy ranged from 5 months (range: 1–22 months) in LE to 50.5 months (range: 1–324 months) in epilepsy (p<0.0001). The number of patients with sustained response to immunotherapy ranged from 5/20 (25%) in epilepsy to 32/44 (73%) in SPSD (p=0.002).

** Complete response to immunotherapy was rare **

Among all patients treated with immunotherapy, a complete response was reported in only 2/142 (1%); one patient had mild ataxic dysthria that resolved after corticosteroids, and one patient had new-onset seizures with cortical-subcortical lesions on MRI that resolved after corticosteroids, intravenous IG and PLEX. In retrospect this patient’s clinicoradiographic presentation was concerning for co-existing for gamma-aminobutyric acid type A receptor encephalitis, but confirmatory testing for this antibody was not performed.

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*Systemic autoimmunity refers to presence of T1DM, thyroid disease, pernicious anaemia, adrenal insufficiency, vitiligo or coeliac disease. GAD65, glutamic acid decarboxylase-65; NA, not available; T1DM, type 1 diabetes mellitus.*
majority but was significantly more frequent among those with epilepsy in isolation who were evaluated for seizure management, compared with those with epilepsy as part of an overlap syndrome who may have been evaluated for management of SPDS or cerebellar ataxia. This suggests that referral bias may skew toward more severe epilepsy in publications, a finding that reflects the rarity of this presentation as noted previously.30

Cognitive impairment, brainstem dysfunction and myelopathy were frequent accompaniments of GAD65 neurological autoimmunity but did not occur in isolation, hence their designation as secondary disease manifestations. This finding emphasises that patients with high-titre GAD65 antibodies who only have cognitive impairment, myelopathy or brainstem dysfunction should be thoroughly evaluated for alternative etiologies, because such presentations in isolation are not typical of GAD65 neurological autoimmunity. Secondary disease manifestations clustered intuitively with core disease manifestations: cognitive impairment,29 only occurred in 9/212 (4%). However, this differed significantly across core disease manifestations, with the highest rates of cancer in patients with cerebellar ataxia (6/55, 11%) and LE (1/7, 14%) as noted previously.30

Table 3 Responses to immunotherapy among 142 patients with GAD65 neurological autoimmunity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Median (range) or frequency (%)</th>
<th>OR (95% CI)</th>
<th>Univariate P value</th>
<th>Multivariate P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at symptom onset in years</td>
<td>46 (5–83)</td>
<td>1.04 (1.02 to 1.06)</td>
<td>&lt;0.0001</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>49/212 (23)</td>
<td>0.65 (0.34 to 1.24)</td>
<td>0.19</td>
<td>–</td>
</tr>
<tr>
<td>Acute immunotherapy*</td>
<td>151/212 (71)</td>
<td>1.72 (0.94 to 3.13)</td>
<td>0.08</td>
<td>–</td>
</tr>
<tr>
<td>Second-line acute immunotherapy†</td>
<td>23/152 (15)</td>
<td>1.6 (0.6 to 4)</td>
<td>0.3</td>
<td>–</td>
</tr>
<tr>
<td>Maintenance immunotherapy†</td>
<td>90/212 (42)</td>
<td>1.33 (0.77 to 2.32)</td>
<td>0.31</td>
<td>–</td>
</tr>
<tr>
<td>Time from symptom onset to first immunotherapy in months</td>
<td>21 (1–540)</td>
<td>0.987 (0.979 to 0.995)</td>
<td>&lt;0.0001</td>
<td>–</td>
</tr>
<tr>
<td>Epilepsy (with or without LE)</td>
<td>62/212 (29)</td>
<td>0.17 (0.09 to 0.32)</td>
<td>&lt;0.0001</td>
<td>–</td>
</tr>
<tr>
<td>Cerebellar ataxia</td>
<td>91/212 (43)</td>
<td>4.58 (2.49 to 8.39)</td>
<td>&lt;0.0001</td>
<td>0.016</td>
</tr>
<tr>
<td>Stiff-person spectrum disorder</td>
<td>101/212 (56)</td>
<td>1.35 (0.78 to 2.34)</td>
<td>0.28</td>
<td>–</td>
</tr>
<tr>
<td>Overlap syndrome</td>
<td>44/212 (21)</td>
<td>1.41 (0.71 to 2.88)</td>
<td>0.32</td>
<td>–</td>
</tr>
<tr>
<td>Serum GAD65 titre in nmol/L</td>
<td>534 (20.1–7558)</td>
<td>1.099 (0.99 to 1)</td>
<td>0.32</td>
<td>–</td>
</tr>
<tr>
<td>Serum GAD65 titre &gt;500 nmol/L</td>
<td>110/212 (52)</td>
<td>1.89 (1.09 to 3.28)</td>
<td>0.02</td>
<td>0.007</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>87/212 (41)</td>
<td>1.21 (0.69 to 2.11)</td>
<td>0.51</td>
<td>–</td>
</tr>
<tr>
<td>mRS at first Mayo Clinic evaluation (range)</td>
<td>3 (0–6)</td>
<td>5.95 (3.74 to 9.45)</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total symptom duration recorded in months</td>
<td>74 (1–636)</td>
<td>0.996 (0.993 to 0.999)</td>
<td>0.006</td>
<td>–</td>
</tr>
<tr>
<td>mRS at last follow-up</td>
<td>3 (0–6)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>mRS &gt;2 at last follow-up</td>
<td>121/212 (57)</td>
<td>–</td>
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*Acute immunotherapies used for treatment of GAD65 neurological autoimmunity included corticosteroids, intravenous immunoglobulin, plasma exchange, rituximab, cyclophosphamide and/or autologous stem cell transplantation; frequency stratified by core disease manifestation is reported in table 3.
†Second-line acute immunotherapy refers to use of rituximab and/or cyclophosphamide among patients who received acute immunotherapy.
‡Maintenance immunotherapies used for chronic immunomodulation included mycophenolate mofetil (n=27), azathioprine (n=27), intravenous IG (n=27), rituximab (n=19), corticosteroids (n=7), methotrexate (n=2), tacrolimus (n=1) and sirolimus (n=1).

GAD65, glutamic acid decarboxylase-65; LE, limbic encephalitis; mRS, modified Rankin Scale.
with epilepsy/LE, myelopathy with SPD, and brainstem dysfunction with cerebellar ataxia. Cognitive impairment was typically amnestic in keeping with medial temporal lobe dysfunction, as would be expected given the high rate of co-occurrence with temporal lobe epilepsy and LE.31,32 Myelopathic findings were most often reported in SPD and usually manifested as UMN findings (brisk reflexes, extensor plantar responses, mild UMN pattern of weakness), in keeping with previous reports.7 The frequent coexistence of brainstem dysfunction with cerebellar ataxia on the basis of oculomotor findings could reflect more diffuse posterior fossa inflammation (‘rhombencephalitis’) in some patients, as well as the difficulties parsing out whether such findings are brainstem or cerebellar in clinical practice.33,34 Three patients had hyperkinetic movement disorders, suggesting this phenotype may be part of the spectrum of GAD65 neurological autoimmunity.35 However, given the paucity of cases, thorough evaluation for other causes of a hyperkinetic movement disorder in a patient with high-titre GAD65 antibodies is recommended.

On review of immunotherapy usage across core disease manifestations, only corticosteroid usage differed significantly. This was driven by the low usage of corticosteroids in patients with SPD who instead largely received intravenous IG, which is likely due to randomised-controlled trial evidence for intravenous IG in SPD.36 When evaluating immunotherapy-responsiveness, due to the retrospective nature of this study we were not able to implement standardised measures of disease severity when monitoring responses to immunotherapy. We thus chose to classify patients as having no response, partial response, near-complete response to immunotherapy. We thus chose to classify patients as having no response, partial response, near-complete response, or complete response to immunotherapy, based on the Mayo Clinic treating physician’s documentation. There is an element of subjectivity to this approach, but it has immediate translatability to clinical practice (eg, sustained response to immunotherapy is least often seen in epilepsy, response to immunotherapy is rarely complete) and is thus of clear utility to practitioners.37 Rates of sustained response to immunotherapy ranged from 73% in SPD to only 25% in epilepsy, highlighting the recalcitrance of this disease manifestation.12 While the poor response to immunotherapy in patients with epilepsy and high-titre GAD65 antibodies may lead one to question whether or not anti-GAD65 is directly relevant to epilepsy aetiology, the high prevalence of epilepsy among these patients along with previously published series support a true disease association. Median time from symptom onset to first immunotherapy was longest for epilepsy (50.5 months), which may contribute to lack of immunotherapy-responsive. This delay to immunotherapy likely reflects epilepsy chronicity in GAD65 neurological autoimmunity, which in combination with the younger age of onset would explain the long median symptom duration recorded for epilepsy (137 months). The indolence of GAD65 epilepsy is unique compared with other autoimmune epilepsies, which usually present more rapidly.38 Inflammation was reported neuropathologically in only 2/5 patients with GAD65 epilepsy who underwent epilepsy surgery, and there was also a trend toward lower median CSF anti-GAD65 titre and less frequent elevated CSF IgG index among these patients compared with other core disease manifestations. Taken together, these findings may reflect a lack of inflammation in patients with chronic GAD65 epilepsy at the time they undergo clinical evaluation; whether a more prominent inflammatory response is present early on that may be more amenable to immunotherapy remains undetermined.

With regard to patient outcomes we found that serum GAD65 antibody titre >500 nmol/L and cerebellar ataxia were independent predictors of poor outcome (mRS >2). The mRS was chosen as a measure of disease outcome given its frequent usage in scoring neurological disability and relative ease of determination, but may skew towards poor outcomes among patients with disease manifestations that prominently affect gait (ie, cerebellar ataxia). Despite this limitation of the mRS, its broad applicability means that predictors of a poor outcome as defined by mRS >2 are helpful when discussing disease prognosis.

There are several limitations to this retrospective study. Clinical reporting of GAD65 antibodies in the Mayo Clinic Neuroimmunology Laboratory is based only on RIA, and so confirmation of high-titre GAD65 antibodies by a second assay (eg, rodent brain tissue indirect immunofluorescence, or TIIF) was not required for study inclusion. However, reporting of anti-GAD65 by TIIF is not routinely done, and so our approach is representative of clinical practice. Additionally, even serum positivity for anti-GAD65 by TIIF may occur in patients without GAD65 neurological autoimmunity,19 highlighting the challenge in determining what test methodology or cut-off best defines a clinically relevant high-titre GAD65 antibody result. Implementation of other test methodologies such as ELISA, immunoblot or cell-based assay to detect high-titre GAD65 antibodies in some laboratories has created the need for assay comparison studies, which is an area of active investigation in our laboratory. Based on our findings and that of the previous literature, high-titre GAD65 antibodies in serum are best viewed as necessary, but not sufficient for a diagnosis of GAD65 neurological autoimmunity.19

The presence of anti-GAD65 in CSF supports an autoimmune aetiology in the appropriate clinical context,19 which in keeping with our finding of anti-GAD65 CSF positivity in all patients who were classified as having GAD65 neurological autoimmunity. Calculation of intrathecal anti-GAD65 synthesis has recently been suggested as the most definitive laboratory evidence of GAD65 neurological autoimmunity.19 This calculation (which requires paired serum and CSF as well as albumin measurement to determine synthesis rate) is not performed in our testing laboratory, and was not required for study inclusion. While its calculation may aid in the determination of GAD65 neurological autoimmunity, it is not yet in widespread use and so systematic evaluation of its diagnostic utility in clinical practice is required. Given the lack of a diagnostic gold standard for GAD65 neurological autoimmunity that is independent of GAD65 antibody testing,19 rigorous clinical evaluation to rule out alternative diagnoses in patients with atypical features remains prudent.

Prior to study analysis, we excluded one-third of patients with high-titre GAD65 antibodies who were classified as not having GAD65 neurological autoimmunity due to non-neurological presentations (eg, isolated T1DM) or more likely alternative neurological diagnoses. This seemingly high number of excluded patients could in part reflect referral bias at our specialised tertiary care centre, which may be enriched with patients who have atypical presentations for GAD65 neurological autoimmunity and are ultimately determined to have more likely alternative diagnoses. Additionally, it is possible that some patients who were considered to have a more likely alternative diagnosis for their neurological presentation may have had contributory GAD65 neurological autoimmunity (eg, SPD potentially contributing to stiffness/spasms in a patient with myotonia congenita, GAD65 cerebellar dysfunction potentially contributing to episodic vestibular symptoms in patients diagnosed as having more common vestibular disorders such as vestibular neuritis or migraine, or GAD65 epilepsy potentially contributing to seizure aetiology in a patient with febrile seizures who...
developed MTS). However, rigorous efforts to only include patients with the disease of interest in studies such as this is critical to prevent ‘phenotype creep’, whereby neurological features of alternative diagnoses are mistakenly assumed to broaden the clinical spectrum of a neural antibody based solely on seropositivity by an imperfectly specific assay. Our finding that high-titre GAD65 antibodies in serum are suggestive of, but not pathognomonic for GAD65 neurological autoimmunity emphasises the importance of clinical-serological correlation when enrolling patients in future studies of this disease.

Contributors AB designed/conceptualised the study, acquired/analysed the data, drafted the manuscript and composed the tables/figures. ES, EPD, DD, AZ, SSS, AG, EN and AM acquired/analysed the data, and revised the manuscript for intellectual content. SJP and NLZ designed/conceptualised the study, acquired/analysed the data, revised the manuscript for intellectual content and supervised the study.

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Competing interests AB has no disclosures to report. EPF is a site principal investigator in a randomised placebo-controlled clinical trial of Inebilizumab (A CD19 inhibitor) in neuromyelitis optica spectrum disorders funded by MedImmune/Velvia Bio. He receives no personal compensation and just receives reimbursement for the research activities related to the trial. DD has a patent pending for Kelch-like protein 11 as a marker of neurological autoimmunity and has received research support from Grifols, Translational Research Innovation and Test Development Office and, Center for Clinical and Translational Science. DD has consulted for UCB and Astellas. All compensation for consultancy activities is paid directly to Mayo Clinic. AZ has a patent pending for PDE10A-IgG as a biomarker of neurological autoimmunity. SS has no disclosures to report. AG has a patent pending for MAP1B IgG as a biomarker of neurological autoimmunity and small-cell lung cancer. EN has no disclosures to report. AM reports grants from Alexion, grants from Grifols, grants from Euroimmun, outside the submitted work; in addition, AM has a patent for Septin-5-IgG pending, a patent for PDE10A-IgG pending, a patent for MAP1B-IgG pending, and a patent for GFAP-IgG pending. SJP reports grants, personal fees and non-financial support from Alexion Pharmaceuticals, grants from Grifols, Autoimmune Encephalitis Alliance, grants, personal fees, non-financial support and other from MedImmune; SJP has a patent (application#12-678350) on neuremyelitis optica autoantibodies as a marker for neoplasia, and also a patent (patent# 898121982) (application#12-573942) on methods for treating neuremyelitis optica (NMOSD) by administration of eciluzumab to an individual that is aquaporin-4 (AQP4)-IgG antibody positive; SJP also has patents pending for the following IgGs as biomarkers of autoimmune neurological disorders (Septin-5, Kelch-like protein 11, GFAP PDE10A and MAP1B). NLZ has no disclosures to report.

Patient consent for publication Not required.

Ethics approval This study was approved by the institutional review board of the Mayo Clinic, Rochester, Minnesota.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Deidentified participant data will be made available to any qualified investigator on reasonable request directed to the corresponding author (NLZ).

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ORCID iDs
Adrian Budhram http://orcid.org/0000-0003-4860-0470
Elia Sechi http://orcid.org/0000-0003-4698-662X
Eoin P Flanagan http://orcid.org/0000-0002-6661-2910
Elie Naddaf http://orcid.org/0000-0001-6212-1236
Andrew McKeon http://orcid.org/0000-0001-6856-8143
Sean J Pittcock http://orcid.org/0000-0002-6140-5584

REFERENCES
Neuro-inflammation

### Supplementary Table. Patients with high-titer GAD65 antibodies but a more likely diagnosis for their neurological presentation

<table>
<thead>
<tr>
<th>Patient</th>
<th>Brief clinical description of neurological presentation</th>
<th>Concern raised for core or secondary manifestation of GAD65 neurological autoimmunity?</th>
<th>More likely alternative diagnosis</th>
<th>Sustained response to immunotherapy reported?</th>
<th>Systemic autoimmunity reported?</th>
<th>Serum anti-GAD65 titer (nmol/L)</th>
<th>CSF anti-GAD65 titer (nmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Child with epilepsy and febrile seizures dating back to infancy; left mesial temporal sclerosis on MRI</td>
<td>Yes (Epilepsy)</td>
<td>Febrile seizures resulting in mesial temporal sclerosis</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease, adrenal insufficiency</td>
<td>2245</td>
<td>8.34</td>
</tr>
<tr>
<td>2</td>
<td>Middle-aged adult with chronic pain and fatigue; normal tone and paraspinal tenderness on examination</td>
<td>Yes (SPSD)</td>
<td>Fibromyalgia</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td>111</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>Middle-aged adult with bilateral hand tingling and gait difficulties; gait ataxia on examination</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Subacute combined degeneration due to B12 deficiency</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>57.8</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Middle-aged adult with acute-onset vertigo and imbalance, followed by vague sense of dizziness without objective neurological findings; peripheral vestibular dysfunction on initial vestibular testing</td>
<td>Yes (Cerebellar Ataxia/Brainstem Dysfunction)</td>
<td>Vestibular neuritis followed by PPPD</td>
<td>No trial</td>
<td>No</td>
<td>2136</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Middle-aged adult with rapidly progressive behavioral change/cognitive decline and motor neuron disease; father had amyotrophic lateral sclerosis</td>
<td>Yes (Cognitive Impairment)</td>
<td>Frontotemporal dementia with amyotrophic lateral sclerosis</td>
<td>No trial</td>
<td>No</td>
<td>3077</td>
<td>20.9</td>
</tr>
<tr>
<td>6</td>
<td>Older adult with insidious short-term memory loss and temporal lobe-onset seizures; equivocal right hippocampal T2-hyperintensity/atrophy on MRI; decreased uptake in posterior cingulate on PET scan</td>
<td>Yes (LE/Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
<td>33.1</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Older adult with more rapidly progressive ataxia after milder gait difficulties for several years and dysautonomia; cruciform</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple system atrophy-cerebellar type</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease</td>
<td>614</td>
<td>0.75</td>
</tr>
<tr>
<td>No.</td>
<td>Case Description</td>
<td>Diagnosis</td>
<td>Trial</td>
<td>Other Diagnoses</td>
<td>Notes</td>
<td></td>
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<tr>
<td>8</td>
<td>Middle-aged adult with abnormal movements of face/shoulders elicited by swallowing; reported abdominal stiffness and pain in lower extremities</td>
<td>Yes (SPSD)</td>
<td>Functional neurological disorder, diabetic peripheral neuropathy</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Young adult with headache, neck and back pain dating back to childhood/adolescence; some reported low back stiffness/spasms; multiple tender points on examination</td>
<td>Yes (SPSD)</td>
<td>Fibromyalgia</td>
<td>No, trialed IVIG and PLEX</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Middle-aged adult with low back pain/tightness, calf fasciculations and eyelid twitching; clinical diagnosis of anxiety</td>
<td>Yes (SPSD)</td>
<td>Myofascial low back pain, Anxiety</td>
<td>No trial</td>
<td>No</td>
<td></td>
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</tr>
<tr>
<td>11</td>
<td>Middle-aged adult with insidious executive dysfunction; epileptiform discharges on EEG, frontoparietal hypometabolism on PET scan; CSF biomarker profile consistent with Alzheimer’s disease</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
<td></td>
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<tr>
<td>12</td>
<td>Middle-aged adult with insidious spastic paraparesis without sensory or bowel/bladder involvement; reported low back pain/spasms and left leg stiffness</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Primary lateral sclerosis</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Adolescent with rapidly progressive spastic dysarthria/dysphagia after respiratory infection; pathogenic mutation in ATP1A3 gene</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>ATP1A3 gene-related neurological disease</td>
<td>No, improved with rituximab after failing corticosteroids, IVIG and PLEX</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Young adult with orthostatic lightheadedness, fatigue, abdominal bloating</td>
<td>No</td>
<td>Postural orthostatic tachycardia syndrome</td>
<td>No trial</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Young adult with insidious limb weakness, ptosis and dysphagia; muscle biopsy found evidence of a chronic and severe myopathy</td>
<td>No</td>
<td>Inherited myopathy</td>
<td>No, trialed IVIG, steroids and abatacept</td>
<td>Yes, T1DM, pernicious anemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Number</td>
<td>Description</td>
<td>Diagnosis/Condition</td>
<td>Type of Treatment</td>
<td>Trial History</td>
<td>BMI</td>
<td>Comments</td>
<td></td>
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<tr>
<td>16</td>
<td>Young adult with two generalized tonic-clonic seizures in the setting of hyperglycemia</td>
<td>Yes (Epilepsy)</td>
<td>Provoked seizures due to hyperglycemia</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Older adult with dysphagia, dysarthria, and hand weakness; upper and lower motor neuron signs on examination; evidence of lower motor neuron involvement on EMG</td>
<td></td>
<td>Amyotrophic lateral sclerosis</td>
<td>No trial</td>
<td>No</td>
<td>68.3</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Older adult with insidious amnestic syndrome; hippocampal atrophy on MRI</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>192</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Middle-aged adult with insidious sensory symptoms in legs; length-dependent, axonal, predominantly sensory neuropathy on NCS/EMG; mother has idiopathic peripheral neuropathy</td>
<td></td>
<td>Inherited neuropathy</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Child with five generalized tonic-clonic seizures in the setting of hypocalcemia</td>
<td>Yes (Epilepsy)</td>
<td>Provoked seizures due to hypocalcemia</td>
<td>No trial</td>
<td>Yes, autoimmune polyglandular syndrome type 1 (hypothyroidism, hypoparathyroidism, adrenal insufficiency)</td>
<td>28.2</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Middle-aged adult with insidious amnestic syndrome; parietal lobe hypometabolism on PET scan</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed corticosteroids</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>168</td>
<td>0.37</td>
</tr>
<tr>
<td>22</td>
<td>Middle-aged adult with insidious sensory loss with insensitivity to pain, length-dependent sensorimotor peripheral neuropathy with mixed axonal and demyelinating features on NCS/EMG</td>
<td></td>
<td>Inherited neuropathy</td>
<td>No trial</td>
<td>No</td>
<td>388</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Middle-aged adult with gait difficulty followed by urinary urgency, dysarthria, antecollis and myoclonus; parkinsonism on examination; T2-hyperintensity of posterolateral putamen on MRI</td>
<td></td>
<td>Multiple system atrophy-parkinsonian type</td>
<td>No trial</td>
<td>No</td>
<td>43.2</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Older adult with insidious amnestic syndrome;</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed IVIG</td>
<td>Yes, T1DM</td>
<td>95.5</td>
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<tr>
<td>#</td>
<td>Case Description</td>
<td>Diagnosis</td>
<td>Treatment Plan</td>
<td>Lab Results</td>
<td></td>
<td></td>
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<tr>
<td>25</td>
<td>Middle-aged adult with insidiously progressive gait difficulties; findings of length-dependent peripheral neuropathy without cerebellar signs on examination; outside NCS/EMG documenting peripheral neuropathy</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Diabetic peripheral neuropathy</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease</td>
<td>24.1</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Middle-aged adult with episodic gait unsteadiness correlating to timing of carbamazepine dose; negative genetic testing for episodic ataxia; history of epilepsy secondary to traumatic brain injury</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Side effect of carbamazepine; recommended switching to levetiracetam but no follow-up available</td>
<td>No, trialed corticosteroids</td>
<td>No</td>
<td>198</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Older adult with insidious mild amnestic syndrome and subjective feeling of weakness; partial improvement after treatment of B12 deficiency</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer's disease, B12 deficiency</td>
<td>No trial</td>
<td>Pernicious anemia, vitiligo</td>
<td>51.7</td>
<td>0.19</td>
</tr>
<tr>
<td>28</td>
<td>Older adult with insidious leg weakness/spasms; upper motor neuron signs in legs on examination; electrophysiologic evidence of motor neuron disease in cervical, thoracic and lumbar segments on NCS/EMG</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>38.7</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Young adult with insidious difficulty walking and low back/leg stiffness/spasms; evidence of myotonia on EMG; pathogenic mutation in CLCN1 gene</td>
<td>Yes (SPSD)</td>
<td>Becker’s myotonia</td>
<td>Yes, improved with corticosteroids³</td>
<td>Yes, thyroid disease</td>
<td>33</td>
<td>1.1</td>
</tr>
<tr>
<td>30</td>
<td>Middle-aged adult with ataxic dysarthria, left-sided ataxia/dystonia and stiffness of left leg; ATP1A3 mutation of uncertain clinical significance; brother with atypical parkinsonism</td>
<td>Yes (Cerebellar Ataxia/SPSD)</td>
<td>ATP1A3-associated neurological disease</td>
<td>No, trialed IVIG and corticosteroids</td>
<td>Yes, T1DM</td>
<td>889</td>
<td>3.72</td>
</tr>
<tr>
<td>31</td>
<td>Older adult with insidious cognitive decline with rapid worsening after heart surgery;</td>
<td>Yes (Cognitive Impairment)</td>
<td>Dementia with Lewy bodies</td>
<td>No, trialed corticosteroids</td>
<td>No</td>
<td>123</td>
<td>0.82</td>
</tr>
<tr>
<td>32</td>
<td>Young adult with limping related to leg pain; equivocally increased tone in legs but overall “quite normal” neurological examination</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Myofascial pain syndrome</td>
<td>No trial</td>
<td>Yes, T1DM, pernicious anemia</td>
<td>23.6</td>
<td>-</td>
</tr>
<tr>
<td>33</td>
<td>Adolescent with new-onset psychosis, delusions, disorganized thoughts, and insomnia with impaired memory/concentration, followed by catatonia; mild dysmorphism; chromosome 22q11.1 microdeletion identified</td>
<td>Yes (Cognitive Impairment)</td>
<td>Primary psychotic disorder (reported higher risk with chromosome 22q11.1 microdeletion)</td>
<td>No, trialed steroids and IVIG</td>
<td>No</td>
<td>28.1</td>
<td>-</td>
</tr>
<tr>
<td>34</td>
<td>Adolescent with episodic vertigo and gait unsteadiness with headache 50% of the time; triggers reported include certain foods, bright lights, loud sounds, and foul odors</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Vestibular migraine</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>53.4</td>
<td>-</td>
</tr>
<tr>
<td>35</td>
<td>Child with episodes of mouth-opening, head tilt and breath-holding with preserved awareness in patient with developmental delay and hand-wringing; no abnormality on EEG during episodes</td>
<td>Yes (Epilepsy)</td>
<td>Primary complex motor stereotypy</td>
<td>No trial</td>
<td>No</td>
<td>1514</td>
<td>-</td>
</tr>
<tr>
<td>36</td>
<td>Older adult with insidious difficulty walking long distances; mild parkinsonism on examination; decreased striatal dopamine transporter density on DaTscan</td>
<td>No</td>
<td>Idiopathic Parkinson’s disease</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td>33.1</td>
<td>-</td>
</tr>
<tr>
<td>37</td>
<td>Young adult with Trisomy 21, visual and auditory hallucinations</td>
<td>No</td>
<td>Primary psychotic disorder</td>
<td>No, trialed corticosteroids, IVIG and rituximab</td>
<td>Yes, thyroid disease, celiac disease</td>
<td>35.4</td>
<td>-</td>
</tr>
<tr>
<td>38</td>
<td>Middle-aged adult with mild cognitive complaints (less efficient at work, some forgetfulness); essentially normal neuropsychometric</td>
<td>Yes (Cognitive Impairment)</td>
<td>Depression/Anxiety</td>
<td>No, only non-sustained subjective benefit with corticosteroids and IVIG</td>
<td>Yes, thyroid disease</td>
<td>364</td>
<td>-</td>
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<tr>
<td>Case</td>
<td>Presentation</td>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Trial</td>
<td>Comment</td>
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<tr>
<td>39</td>
<td>Older adult with chronic right-sided facial pain, exacerbated by changes in barometric pressure and radiating right occipital pain; right occipital notch tenderness on examination</td>
<td>No</td>
<td>Chronic migraine, occipital neuralgia</td>
<td>No trial</td>
<td>No</td>
<td>459</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Older adult with insidious sensory loss in feet and imbalance; mild findings of sensory neuropathy in feet on examination stable over years; length-dependent small-fiber neuropathy on TST</td>
<td>No</td>
<td>Idiopathic length-dependent small fiber neuropathy</td>
<td>No trial</td>
<td>No</td>
<td>258</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Older adult with insidious cognitive decline, bilateral posterior temporal and parietal hypometabolism on PET scan</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>No</td>
<td>161</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Middle-aged adult with insidious leg weakness and gait difficulties; spastic quadriplegia with impaired vibration/proprioception in legs on examination</td>
<td>Yes (Cerebellar Ataxia/Myelopathy)</td>
<td>Subacute combined degeneration due to B12 deficiency</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
<td>470</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Middle-aged adult with chronic hypersensitivity to touch in feet and intermittent painful color change in toes and fingers; high arches, hammertoes and allodynia in feet on examination</td>
<td>No</td>
<td>Inherited neuropathy, Raynaud’s phenomenon</td>
<td>No trial</td>
<td>No</td>
<td>237</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Middle-aged adult with episodic paralysis lasting hours but preserved consciousness and ability to swallow; episodes provoked by anxious situations; normal ictal serum potassium; no findings of periodic paralysis on NCS/EMG</td>
<td>No</td>
<td>Functional neurological disorder</td>
<td>No trial</td>
<td>No</td>
<td>461</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Middle-aged adult with longstanding depression with psychotic features; presented to hospital with impaired attention/concentration/anxiety in context of multiple psychosocial stressors; resolved</td>
<td>Yes (Cognitive Impairment)</td>
<td>Exacerbation of known psychiatric disease</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>45.3</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Diagnosis</td>
<td>Symptom Description</td>
<td>Treatment</td>
<td>Response</td>
<td>Follow-up</td>
<td>Score</td>
<td></td>
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<td>-----</td>
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<td></td>
</tr>
<tr>
<td>46</td>
<td>Middle-aged adult with chronic leg muscle cramps</td>
<td>Normal neurological examination aside from witnessed cramp in foot; cramps resolved with gabapentin</td>
<td>Muscle cramps</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
<td>219</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Young adult with chronic fatigue, poor sleep and orthostatic lightheadedness</td>
<td>Numerous stressful life events; clinical concern for depression; normal neurological examination</td>
<td>Orthostatic intolerance, Somatic symptoms of depression</td>
<td>No trial</td>
<td>No</td>
<td>29.2</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Young adult with chronic sensory symptoms in feet and hands</td>
<td>Evidence of chronic length-dependent large fiber neuropathy on EMG</td>
<td>Idiopathic length-dependent large fiber neuropathy</td>
<td>No trial</td>
<td>No</td>
<td>30.7</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Young adult with chronic diffuse upper body pain and reported stiffness</td>
<td>Varying stiffness, spasms or paraspinal hypertrophy on examination; diffuse tenderness</td>
<td>Fibromyalgia</td>
<td>No, trialed IVIG with only non-sustained response</td>
<td>Yes, T1DM</td>
<td>39.6</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Middle-aged adult with headache, poor concentration, dizziness and difficulty sleeping after head injury</td>
<td></td>
<td>Post-concussive syndrome</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>434</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Older adult with memory complaints and feeling of exhaustion in context of B12 deficiency, anemia, hypothyroidism and worsening depression; partial improvement with B12 supplementation</td>
<td></td>
<td>B12 Deficiency, Depression</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>348</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Middle-aged adult with chronic intermittent paresthesias of the hands and feet that improve with movement, feeling of hand “swelling”, sense of imbalance, and heat intolerance; only equivocal sensory loss in hands</td>
<td></td>
<td>Chronic idiopathic anhidrosis</td>
<td>No trial</td>
<td>No</td>
<td>1377</td>
<td></td>
</tr>
<tr>
<td>Case Number</td>
<td>Description</td>
<td>Diagnosis/Condition</td>
<td>Treatment</td>
<td>Notes</td>
<td></td>
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<tr>
<td>53</td>
<td>Young adult with tremulousness, spasms and internal feeling of vibration after starting ziprasidone for bipolar disorder; normal neurological examination</td>
<td>Yes (SPSD)</td>
<td>Side effect of ziprasidone, recommended discontinuation</td>
<td>No trial</td>
<td>Yes, T1DM 149 0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Young adult with intermittent stuttering of speech, feeling of head heaviness and cognitive difficulties; variable stuttering but otherwise normal neurological examination</td>
<td>Yes (Cognitive Impairment)</td>
<td>Functional neurological disorder</td>
<td>No trial</td>
<td>Yes, thyroid disease 31.5 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Middle-aged adult with insidious numbness and tingling in hands and feet, stable for last year; findings of both mild length-dependent sensory loss and right-sided spasticity/hyperreflexia on examination; mild axonal sensorimotor peripheral neuropathy and C5/C6 radiculopathies on NCS/EMG; severe cervical spinal and foraminal stenosis due to degenerative spondylosis on MRI</td>
<td>Yes (Myelopathy)</td>
<td>Compressive myelopathy/ radiculopathy, Diabetic peripheral neuropathy</td>
<td>No trial</td>
<td>No (has type 2 diabetes mellitus) 69.3 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Middle-aged adult with chronic feeling of low energy, body aches, stiffness, “brain fog”, and postural lightheadedness/ dizziness dating back to childhood; episodic kicking/flailing of legs elicited by medication injection</td>
<td>Yes (SPSD)</td>
<td>Postural orthostatic tachycardia syndrome, Functional neurological disorder</td>
<td>No, trialed IVIG and then SCIG with only non-sustained response</td>
<td>No</td>
<td>216 -</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Middle-aged adult with remote upper extremity paresthesias and more recently weakness; mild neck flexor and proximal upper extremity weakness/ hyporeflexia and lower extremity hyperreflexia on examination; motor neuron</td>
<td>Yes (Myelopathy)</td>
<td>Subacute combined degeneration, followed by bibrachial amyotrophic diplegia (limited follow-up)</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia, vitiligo 322 1.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient ID</td>
<td>Age Group</td>
<td>Symptoms</td>
<td>Neuroinflammatory Diagnoses</td>
<td>Clinical Course</td>
<td>Treatment</td>
<td>Age at Diagnosis</td>
<td>Cause</td>
</tr>
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<tr>
<td>58</td>
<td>Young adult</td>
<td>Dysarthria, dysphagia, hand weakness and right-sided stiffness developing over one year; flaccid dysarthria, right arm weakness and spasticity in all limbs on examination; evidence of diffuse motor neuron process on NCS/EMG</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No, trialed IVIG</td>
<td>No</td>
<td>45.8</td>
<td>-</td>
</tr>
<tr>
<td>59</td>
<td>Middle-aged adult</td>
<td>Limb weakness, slurred speech, dysphagia and involuntary laughing/crying developed over ten years (more rapidly over three years); spastic dysarthria, mild proximal right arm and lower extremity weakness with brisk reflexes and scattered fasciculations on examination; evidence of diffuse motor neuron process on NCS/EMG</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No, trialed steroids and IVIG</td>
<td>Yes, thyroid disease</td>
<td>284</td>
<td>0.49</td>
</tr>
<tr>
<td>60</td>
<td>Middle-aged adult</td>
<td>Insidious gait difficulties, leg weakness and numbness, right arm tremor; previous episodes of double vision and history of right eye blurring; distractible tremor, “astasia abasia” and give-way weakness on examination; lesions typical of demyelination on MRI</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple sclerosis with functional overlay</td>
<td>No trial</td>
<td>No</td>
<td>82.8</td>
</tr>
<tr>
<td>61</td>
<td>Young adult</td>
<td>Progressive gait imbalance, blurred vision, intermittent diplopia; optic disc pallor, cerebellar signs and left leg weakness on examination;</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple sclerosis</td>
<td>Yes, stabilized/mildly improved with rituximab</td>
<td>No</td>
<td>72.5</td>
</tr>
<tr>
<td>ID</td>
<td>Case Description</td>
<td>Diagnosis</td>
<td>Response</td>
<td>Comorbidities</td>
<td></td>
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<tr>
<td>62</td>
<td>Middle-aged adult with episode of limb dysesthesias and abdominal tightness, and right followed by left eye vision loss; right optic nerve swelling and left optic nerve pallor on examination; several lesions concerning for demyelination on MRI</td>
<td>Multiple sclerosis</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease</td>
<td>23.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Older adult with persistent mild bilateral leg numbness/heaviness for two years; previous episodes of vision loss, numbness and facial weakness; lesions in cervical cord concerning for demyelination on MRI</td>
<td>Multiple sclerosis</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>25.1</td>
<td></td>
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</tr>
<tr>
<td>64</td>
<td>Middle-aged adult with fluctuating ptosis and diplopia, followed by jaw weakness with chewing; left ptosis, ophthalmoparesis, facial weakness, subtle flaccid dysarthria and mild deltoid weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Myasthenia gravis</td>
<td>No, trialed IVIG with only non-sustained response and limited follow-up thereafter</td>
<td>No</td>
<td>419</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>Older adult with neck weakness, followed by dysarthria and dysphagia; bilateral ptosis with sustained upgaze, bilateral weakness and neck extensor weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Myasthenia gravis</td>
<td>Yes, improved with IVIG and mycophenolate</td>
<td>Yes, thyroid disease</td>
<td>434</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Middle-aged adult with new-onset difficulty chewing and dysphagia, followed by fluctuating ptosis and transient diplopia; positive acetylcholine</td>
<td>Myasthenia gravis</td>
<td>Yes, improved with IVIG</td>
<td>Yes, thyroid disease</td>
<td>251</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Age</td>
<td>Case Description</td>
<td>Paraneoplastic Syndrome</td>
<td>Other</td>
<td>Treatment</td>
<td>Improvement</td>
<td>Other Conditions</td>
<td></td>
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<tr>
<td>67</td>
<td>Older adult with subacute proximal muscle weakness and slurred speech; evidence of myopathy on NCS/EMG; inflammatory myopathy on muscle biopsy; thymoma diagnosed</td>
<td>No</td>
<td>Paraneoplastic myositis</td>
<td>Yes, improved with corticosteroids</td>
<td>No</td>
<td>42.7</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Middle-aged adult with difficulty walking; lower extremity weakness, upper motor neuron signs, gait and limb ataxia on examination; clinical history of relapses; lesions typical of demyelination on MRI</td>
<td>Yes (Cerebellar Ataxia/Myelopathy)</td>
<td>Multiple sclerosis</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Older adult with new-onset dysphagia followed by respiratory failure; evidence of neuromuscular junction defect on outside NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>Myasthenia gravis</td>
<td>Yes, improved with IVIG and PLEX</td>
<td>No</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Young adult with transverse myelitis and recurrent optic neuritis; MOG-IgG positive by live cell-based assay</td>
<td>Yes (Myelopathy)</td>
<td>MOG-IgG-associated disease</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>2068</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Middle-aged adult with cognitive impairment and seizures following allogenic stem cell transplant, nodular dural enhancement with multifocal lesions on MRI</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Central nervous system graft-versus-host disease with documented ocular and gastrointestinal involvement</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
<td>3108</td>
<td></td>
</tr>
</tbody>
</table>

1. Systemic autoimmunity refers to presence of T1DM, thyroid disease, pernicious anemia, adrenal insufficiency, vitiligo or celiac disease.
2. Improvement in temporal relationship to rituximab administration may have been natural history of disease, as ATP1A3-associated neurological disease may present with subacute episodes of neurological decline following infection with spontaneous recovery.
3. Improvement in temporal relationship to steroids may have been related to baclofen and carbamazepine, which were started at the same time.

Age stratification is as follows: child, less than 12 years of age; adolescent, 13-18 years of age; young adult, 19-45 years of age; middle-aged adult, 46-65 years of age; older adult, greater than 65 years of age.

ATP1A3 = ATPase Na+/K+ transporting subunit alpha 3; CLCN1 = chloride voltage-gated channel; CSF = cerebrospinal fluid; DaTscan = dopamine transporter (DAT) single photon emission computerized tomography; EEG = electroencephalography; NCS/EMG = nerve conduction studies/electromyography; GAD65 = glutamic acid decarboxylase-65.
IVIG = intravenous immunoglobulin; LE = limbic encephalitis; MOG = myelin oligodendrocyte glycoprotein; MRI = magnetic resonance imaging; PET = positron emission tomography; PLEX = plasma exchange; PPPD = persistent postural-perceptual dizziness; SCIG = subcutaneous immunoglobulin; SPSD = stiff-person spectrum disorders; T1DM = type 1 diabetes mellitus; TST = thermoregulatory sweat test
## Supplementary Table. Patients with high-titer GAD65 antibodies but a more likely diagnosis for their neurological presentation

<table>
<thead>
<tr>
<th>Patient</th>
<th>Brief clinical description of neurological presentation</th>
<th>Concern raised for core or secondary manifestation of GAD65 neurological autoimmunity?</th>
<th>More likely alternative diagnosis</th>
<th>Sustained response to immunotherapy reported?</th>
<th>Systemic autoimmunity reported?</th>
<th>Serum anti-GAD65 titer (nmol/L)</th>
<th>CSF anti-GAD65 titer (nmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Child with epilepsy and febrile seizures dating back to infancy; left mesial temporal sclerosis on MRI</td>
<td>Yes (Epilepsy)</td>
<td>Febrile seizures resulting in mesial temporal sclerosis</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease, adrenal insufficiency</td>
<td>2245</td>
<td>8.34</td>
</tr>
<tr>
<td>2</td>
<td>Middle-aged adult with chronic pain and fatigue; normal tone and paraspinal tenderness on examination</td>
<td>Yes (SPSD)</td>
<td>Fibromyalgia</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td>111</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>Middle-aged adult with bilateral hand tingling and gait difficulties; gait ataxia on examination</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Subacute combined degeneration due to B12 deficiency</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>57.8</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Middle-aged adult with acute-onset vertigo and imbalance, followed by vague sense of dizziness without objective neurological findings; peripheral vestibular dysfunction on initial vestibular testing</td>
<td>Yes (Cerebellar Ataxia/Brainstem Dysfunction)</td>
<td>Vestibular neuritis followed by PPPD</td>
<td>No trial</td>
<td>No</td>
<td>2136</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Middle-aged adult with rapidly progressive behavioral change/cognitive decline and motor neuron disease; father had amyotrophic lateral sclerosis</td>
<td>Yes (Cognitive Impairment)</td>
<td>Frontotemporal dementia with amyotrophic lateral sclerosis</td>
<td>No trial</td>
<td>No</td>
<td>3077</td>
<td>20.9</td>
</tr>
<tr>
<td>6</td>
<td>Older adult with insidious short-term memory loss and temporal lobe-onset seizures; equivocal right hippocampal T2-hyperintensity/atrophy on MRI; decreased uptake in posterior cingulate on PET scan</td>
<td>Yes (LE/Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
<td>33.1</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Older adult with more rapidly progressive ataxia after milder gait difficulties for several years and dysautonomia; cruciform</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple system atrophy-cerebellar type</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease</td>
<td>614</td>
<td>0.75</td>
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<tr>
<td>Case</td>
<td>Description</td>
<td>SPSD</td>
<td>Diagnosis</td>
<td>Trial</td>
<td>Notes</td>
<td></td>
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<tr>
<td>8</td>
<td>Middle-aged adult with abnormal movements of face/shoulders elicited by swallowing; reported abdominal stiffness and pain in lower extremities</td>
<td>Yes</td>
<td>Functional neurological disorder, diabetic peripheral neuropathy</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Young adult with headache, neck and back pain dating back to childhood/adolescence; some reported low back stiffness/spasms; multiple tender points on examination</td>
<td>Yes</td>
<td>Fibromyalgia</td>
<td>No</td>
<td>No, trialed IVIG and PLEX</td>
<td></td>
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<tr>
<td>10</td>
<td>Middle-aged adult with low back pain/tightness, calf fasciculations and eyelid twitching; clinical diagnosis of anxiety</td>
<td>Yes</td>
<td>Myofascial low back pain, Anxiety</td>
<td>No trial</td>
<td>No</td>
<td></td>
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</tr>
<tr>
<td>11</td>
<td>Middle-aged adult with insidious executive dysfunction; epileptiform discharges on EEG, frontoparietal hypometabolism on PET scan; CSF biomarker profile consistent with Alzheimer’s disease</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Middle-aged adult with insidious spastic paraparesis without sensory or bowel/bladder involvement; reported low back pain/spasms and left leg stiffness</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Primary lateral sclerosis</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Adolescent with rapidly progressive spastic dysarthria/dysphagia after respiratory infection; pathogenic mutation in ATP1A3 gene</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>ATP1A3 gene-related neurological disease</td>
<td>No</td>
<td>Yes, improved with rituximab after failing corticosteroids, IVIG and PLEX²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Young adult with orthostatic lightheadedness, fatigue, abdominal bloating</td>
<td>No</td>
<td>Postural orthostatic tachycardia syndrome</td>
<td>No trial</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Young adult with insidious limb weakness, ptosis and dysphagia; muscle biopsy found evidence of a chronic and severe myopathy</td>
<td>No</td>
<td>Inherited myopathy</td>
<td>No, trialed IVIG, steroids and abatacept</td>
<td>Yes, T1DM, pernicious anemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>Description</td>
<td>Diagnosis</td>
<td>Seizures</td>
<td>Treatment</td>
<td>Comments</td>
<td></td>
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<tr>
<td>16</td>
<td>Young adult with two generalized tonic-clonic seizures in the setting of hyperglycemia</td>
<td>Yes (Epilepsy)</td>
<td>Provoked seizures due to hyperglycemia</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Older adult with dysphagia, dysarthria, and hand weakness; upper and lower motor neuron signs on examination; evidence of lower motor neuron involvement on EMG</td>
<td>No</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No trial</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Older adult with insidious amnestic syndrome; hippocampal atrophy on MRI</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Middle-aged adult with insidious sensory symptoms in legs; length-dependent, axonal, predominantly sensory neuropathy on NCS/EMG; mother has idiopathic peripheral neuropathy</td>
<td>No</td>
<td>Inherited neuropathy</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Child with five generalized tonic-clonic seizures in the setting of hypocalcemia</td>
<td>Yes (Epilepsy)</td>
<td>Provoked seizures due to hypocalcemia</td>
<td>No trial</td>
<td>Yes, autoimmune polyglandular syndrome type 1 (hypothyroidism, hypoparathyroidism, adrenal insufficiency)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Middle-aged adult with insidious amnestic syndrome; parietal lobe hypometabolism on PET scan</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed corticosteroids</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Middle-aged adult with insidious sensory loss with insensitivity to pain, length-dependent sensorimotor peripheral neuropathy with mixed axonal and demyelinating features on NCS/EMG</td>
<td>No</td>
<td>Inherited neuropathy</td>
<td>No trial</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Middle-aged adult with gait difficulty followed by urinary urgency, dysarthria, antecollis and myoclonus; parkinsonism on examination; T2-hyperintensity of posterolateral putamen on MRI</td>
<td>No</td>
<td>Multiple system atrophy-parkinsonian type</td>
<td>No trial</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Older adult with insidious amnestic syndrome;</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed IVIG</td>
<td>Yes, T1DM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Case</th>
<th>Presentation</th>
<th>Diagnosis</th>
<th>Treatments</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Middle-aged adult with insidiously progressive gait difficulties; findings of length-dependent peripheral neuropathy without cerebellar signs on examination; outside NCS/EMG documenting peripheral neuropathy</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Diabetic peripheral neuropathy</td>
<td>No trial</td>
</tr>
<tr>
<td>26</td>
<td>Middle-aged adult with episodic gait unsteadiness correlating to timing of carbamazepine dose; negative genetic testing for episodic ataxia; history of epilepsy secondary to traumatic brain injury</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Side effect of carbamazepine; recommended switching to levetiracetam but no follow-up available</td>
<td>No, trialed corticosteroids</td>
</tr>
<tr>
<td>27</td>
<td>Older adult with insidious mild amnestic syndrome and subjective feeling of weakness; partial improvement after treatment of B12 deficiency</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease, B12 deficiency</td>
<td>No trial</td>
</tr>
<tr>
<td>28</td>
<td>Older adult with insidious leg weakness/spasms; upper motor neuron signs in legs on examination; electrophysiologic evidence of motor neuron disease in cervical, thoracic and lumbar segments on NCS/EMG</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No trial</td>
</tr>
<tr>
<td>29</td>
<td>Young adult with insidious difficulty walking and low back/leg stiffness/spasms; evidence of myotonia on EMG; pathogenic mutation in CLCN1 gene</td>
<td>Yes (SPSDD)</td>
<td>Becker’s myotonia</td>
<td>Yes, improved with corticosteroids³</td>
</tr>
<tr>
<td>30</td>
<td>Middle-aged adult with ataxic dysarthria, left-sided ataxia/dystonia and stiffness of left leg; ATP1A3 mutation of uncertain clinical significance; brother with atypical parkinsonism</td>
<td>Yes (Cerebellar Ataxia/SPSDD)</td>
<td>ATP1A3-associated neurological disease</td>
<td>No, trialed IVIG and corticosteroids</td>
</tr>
<tr>
<td>31</td>
<td>Older adult with insidious cognitive decline with rapid worsening after heart surgery;</td>
<td>Yes (Cognitive Impairment)</td>
<td>Dementia with Lewy bodies</td>
<td>No, trialed corticosteroids</td>
</tr>
<tr>
<td>Case</td>
<td>History/Examination</td>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Referrer</td>
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<tr>
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</tr>
<tr>
<td>32</td>
<td>Young adult with limping related to leg pain; equivocally increased tone in legs but overall “quite normal” neurological examination</td>
<td>Yes (SPSD/Myelopathy) Myofascial pain syndrome No trial</td>
<td>Yes, T1DM, pernicious anemia</td>
<td>23.6</td>
</tr>
<tr>
<td>33</td>
<td>Adolescent with new-onset psychosis, delusions, disorganized thoughts, and insomnia with impaired memory/concentration, followed by catatonia; mild dysmorphism; chromosome 22q11.1 microdeletion identified</td>
<td>Yes (Cognitive Impairment) Primary psychotic disorder (reported higher risk with chromosome 22q11.1 microdeletion) No trialed steroids and IVIG</td>
<td>No</td>
<td>28.1</td>
</tr>
<tr>
<td>34</td>
<td>Adolescent with episodic vertigo and gait unsteadiness with headache 50% of the time; triggers reported include certain foods, bright lights, loud sounds, and foul odors</td>
<td>Yes (Cerebellar Ataxia) Vestibular migraine</td>
<td>No trial</td>
<td>Yes, T1DM</td>
</tr>
<tr>
<td>35</td>
<td>Child with episodes of mouth-opening, head tilt and breath-holding with preserved awareness in patient with developmental delay and hand-wringing; no abnormality on EEG during episodes</td>
<td>Yes (Epilepsy) Primary complex motor stereotypy No trial</td>
<td>No</td>
<td>1514</td>
</tr>
<tr>
<td>36</td>
<td>Older adult with insidious difficulty walking long distances; mild parkinsonism on examination; decreased striatal dopamine transporter density on DaTscan</td>
<td>No</td>
<td>Idiopathic Parkinson’s disease No trial</td>
<td>Yes, thyroid disease</td>
</tr>
<tr>
<td>37</td>
<td>Young adult with Trisomy 21, visual and auditory hallucinations</td>
<td>No</td>
<td>Primary psychotic disorder No, trialed corticosteroids, IVIG and rituximab</td>
<td>Yes, thyroid disease, celiac disease</td>
</tr>
<tr>
<td>38</td>
<td>Middle-aged adult with mild cognitive complaints (less efficient at work, some forgetfulness); essentially normal neuropsychometric</td>
<td>Yes (Cognitive Impairment) Depression/Anxiety No, only non-sustained subjective benefit with corticosteroids and IVIG</td>
<td>Yes, thyroid disease</td>
<td>364</td>
</tr>
<tr>
<td>Case</td>
<td>Description</td>
<td>Diagnoses</td>
<td>Trial</td>
<td>Treatment</td>
</tr>
<tr>
<td>------</td>
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</tr>
<tr>
<td>39</td>
<td>Older adult with chronic right-sided facial pain, exacerbated by changes in barometric pressure and radiating right occipital pain; right occipital notch tenderness on examination</td>
<td>Chronic migraine, occipital neuralgia</td>
<td>No trial</td>
<td>No</td>
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<tr>
<td>40</td>
<td>Older adult with insidious sensory loss in feet and imbalance; mild findings of sensory neuropathy in feet on examination stable over years; length-dependent small-fiber neuropathy on TST</td>
<td>Idiopathic length-dependent small fiber neuropathy</td>
<td>No trial</td>
<td>No</td>
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<tr>
<td>41</td>
<td>Older adult with insidious cognitive decline, bilateral posterior temporal and parietal hypometabolism on PET scan</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>42</td>
<td>Middle-aged adult with insidious leg weakness and gait difficulties; spastic quadripareisis with impaired vibration/proprioception in legs on examination</td>
<td>Subacute combined degeneration due to B12 deficiency</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
</tr>
<tr>
<td>43</td>
<td>Middle-aged adult with chronic hypersensitivity to touch in feet and intermittent painful color change in toes and fingers; high arches, hammertoes and allodynia in feet on examination</td>
<td>Inherited neuropathy, Raynaud’s phenomenon</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>44</td>
<td>Middle-aged adult with episodic paralysis lasting hours but preserved consciousness and ability to swallow; episodes provoked by anxious situations; normal ictal serum potassium; no findings of periodic paralysis on NCS/EMG</td>
<td>Functional neurological disorder</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>45</td>
<td>Middle-aged adult with longstanding depression with psychotic features; presented to hospital with impaired attention/concentration/anxiety in context of multiple psychosocial stressors; resolved</td>
<td>Exacerbation of known psychiatric disease</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Test</td>
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<tr>
<td>46</td>
<td>Middle-aged adult with chronic leg muscle cramps; normal neurological examination aside from witnessed cramp in foot; cramps resolved with gabapentin</td>
<td>Muscle cramps</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
</tr>
<tr>
<td>47</td>
<td>Young adult with chronic fatigue, poor sleep and orthostatic lightheadedness after numerous stressful life events; clinical concern for depression; normal neurological examination</td>
<td>Orthostatic intolerance, Somatic symptoms of depression</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>48</td>
<td>Young adult with chronic sensory symptoms in feet and hands; glove-and-stocking distribution sensory loss on examination; evidence of chronic length-dependent axonal peripheral neuropathy on EMG</td>
<td>Idiopathic length-dependent large fiber neuropathy</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>49</td>
<td>Young adult with chronic diffuse upper body pain and reported stiffness; variably stiff posturing but no objective stiffness, spasms or paraspinal hypertrophy on examination; diffuse tenderness</td>
<td>Fibromyalgia</td>
<td>No, trialed IVIG with only non-sustained response</td>
<td>Yes, T1DM</td>
</tr>
<tr>
<td>50</td>
<td>Middle-aged adult with headache, poor concentration, dizziness and difficulty sleeping after head injury</td>
<td>Post-concussive syndrome</td>
<td>No trial</td>
<td>Yes, T1DM</td>
</tr>
<tr>
<td>51</td>
<td>Older adult with memory complaints and feeling of exhaustion in context of B12 deficiency, anemia, hypothyroidism and worsening depression; partial improvement with B12 supplementation</td>
<td>B12 Deficiency, Depression</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
</tr>
<tr>
<td>52</td>
<td>Middle-aged adult with chronic intermittent paresthesias of the hands and feet that improve with movement, feeling of hand “swelling”, sense of imbalance, and heat intolerance; only equivocal sensory loss in hands</td>
<td>Chronic idiopathic anhidrosis</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>Case</td>
<td>Description</td>
<td>Diagnosis</td>
<td>Side Effect</td>
<td>Trial</td>
</tr>
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<td>------</td>
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<tr>
<td>53</td>
<td>Young adult with tremulousness, spasms and internal feeling of vibration after starting ziprasidone for bipolar disorder; normal neurological examination</td>
<td>Yes (SPSD)</td>
<td>Side effect of ziprasidone, recommended discontinuation</td>
<td>No trial</td>
</tr>
<tr>
<td>54</td>
<td>Young adult with intermittent stuttering of speech, feeling of head heaviness and cognitive difficulties; variable stuttering but otherwise normal neurological examination</td>
<td>Yes (Cognitive Impairment)</td>
<td>Functional neurological disorder</td>
<td>No trial</td>
</tr>
<tr>
<td>55</td>
<td>Middle-aged adult with insidious numbness and tingling in hands and feet, stable for last year; findings of both mild length-dependent sensory loss and right-sided spasticity/hyperreflexia on examination; mild axonal sensorimotor peripheral neuropathy and C5/C6 radiculopathies on NCS/EMG; severe cervical spinal and foraminal stenosis due to degenerative spondylosis on MRI</td>
<td>Yes (Myelopathy)</td>
<td>Compressive myelopathy/radiculopathy, Diabetic peripheral neuropathy</td>
<td>No trial</td>
</tr>
<tr>
<td>56</td>
<td>Middle-aged adult with chronic feeling of low energy, body aches, stiffness, “brain fog”, and postural lightheadedness/dizziness dating back to childhood; episodic kicking/flailing of legs elicited by medication injection</td>
<td>Yes (SPSD)</td>
<td>Postural orthostatic tachycardia syndrome, Functional neurological disorder</td>
<td>No, trialed IVIG and then SCIG with only non-sustained response</td>
</tr>
<tr>
<td>57</td>
<td>Middle-aged adult with remote upper extremity paresthesias and more recently weakness; mild neck flexor and proximal upper extremity weakness/hyporeflexia and lower extremity hyperreflexia on examination; motor neuron</td>
<td>Yes (Myelopathy)</td>
<td>Subacute combined degeneration, followed by bibrachial amyotrophic diplegia (limited follow-up)</td>
<td>No trial</td>
</tr>
<tr>
<td>Patient ID</td>
<td>Description</td>
<td>Diagnoses</td>
<td>Treatment</td>
<td>Follow-up</td>
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<tr>
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<tr>
<td>58</td>
<td>Young adult with dysarthria, dysphagia, hand weakness and right-sided stiffness developing over one year; flaccid dysarthria, right arm weakness and spasticity in all limbs on examination; evidence of diffuse motor neuron process on NCS/EMG</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No, trialed IVIG</td>
<td>45.8</td>
</tr>
<tr>
<td>59</td>
<td>Middle-aged adult with limb weakness, slurred speech, dysphagia and involuntary laughing/crying developed over ten years (more rapidly over three years); spastic dysarthria, mild proximal right arm and lower extremity weakness with brisk reflexes and scattered fasciculations on examination; evidence of diffuse motor neuron process on NCS/EMG</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No, trialed steroids and IVIG</td>
<td>284</td>
</tr>
<tr>
<td>60</td>
<td>Middle-aged adult with insidious gait difficulties, leg weakness and numbness, right arm tremor; previous episodes of double vision and history of right eye blurring; distractible tremor, “astasia abasia” and give-way weakness on examination; lesions typical of demyelination on MRI</td>
<td>Multiple sclerosis with functional overlay</td>
<td>No trial</td>
<td>82.8</td>
</tr>
<tr>
<td>61</td>
<td>Young adult with progressive gait imbalance, blurred vision, intermittent diplopia; optic disc pallor, cerebellar signs and left leg weakness on examination;</td>
<td>Multiple sclerosis</td>
<td>Yes, stabilized/mildly improved with rituximab</td>
<td>72.5</td>
</tr>
<tr>
<td>Case</td>
<td>Presentation</td>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Disease Status</td>
</tr>
<tr>
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<tr>
<td>62</td>
<td>Extensive lesions typical of demyelination on MRI</td>
<td>Middle-aged adult with episode of limb dysesthesias and abdominal tightness, and right followed by left eye vision loss; right optic nerve swelling and left optic nerve pallor on examination; several lesions concerning for demyelination on MRI</td>
<td>Yes (Myelopathy)</td>
<td>Multiple sclerosis</td>
</tr>
<tr>
<td>63</td>
<td>Older adult with persistent mild bilateral leg numbness/heaviness for two years; previous episodes of vision loss, numbness and facial weakness; lesions in cervical cord concerning for demyelination on MRI</td>
<td>Older adult with persistent mild bilateral leg numbness/heaviness for two years; previous episodes of vision loss, numbness and facial weakness; lesions in cervical cord concerning for demyelination on MRI</td>
<td>Yes (Myelopathy)</td>
<td>Multiple sclerosis</td>
</tr>
<tr>
<td>64</td>
<td>Middle-aged adult with fluctuating ptosis and diplopia, followed by jaw weakness with chewing; left ptosis, ophthalmoplegia, facial weakness, subtle flaccid dysarthria and mild deltoid weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Middle-aged adult with fluctuating ptosis and diplopia, followed by jaw weakness with chewing; left ptosis, ophthalmoplegia, facial weakness, subtle flaccid dysarthria and mild deltoid weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>Myasthenia gravis</td>
</tr>
<tr>
<td>65</td>
<td>Older adult with neck weakness, followed by dysarthria and dysphagia; bilateral ptosis with sustained upgaze, bifacial weakness and neck extensor weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Older adult with neck weakness, followed by dysarthria and dysphagia; bilateral ptosis with sustained upgaze, bifacial weakness and neck extensor weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>Myasthenia gravis</td>
</tr>
<tr>
<td>66</td>
<td>Middle-aged adult with new-onset difficulty chewing and dysphagia, followed by fluctuating ptosis and transient diplopia; positive acetylcholine</td>
<td>Middle-aged adult with new-onset difficulty chewing and dysphagia, followed by fluctuating ptosis and transient diplopia; positive acetylcholine</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>Myasthenia gravis</td>
</tr>
<tr>
<td>Age Strata</td>
<td>Symptoms and History</td>
<td>Neurological Disorders</td>
<td>Treatment</td>
<td>Improvement</td>
</tr>
<tr>
<td>------------</td>
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</tr>
<tr>
<td>Child</td>
<td>Systemic autoimmunity; thymoma diagnosed</td>
<td>Yes (Cerebellar Ataxia/Myelopathy)</td>
<td>Yes, improved with corticosteroids</td>
<td>No</td>
</tr>
<tr>
<td>Middle-aged</td>
<td>Difficulty walking; lower extremity weakness, upper motor neuron signs, gait and limb ataxia on examination; clinical history of relapses; lesions typical of demyelination on MRI</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>Yes, improved with IVIG and PLEX</td>
<td>No</td>
</tr>
<tr>
<td>Older adult</td>
<td>New-onset dysphagia followed by respiratory failure; evidence of neuromuscular junction defect on outside NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Yes (Myelopathy)</td>
<td>Yes, improved with corticosteroids</td>
<td>No</td>
</tr>
<tr>
<td>Young adult</td>
<td>Transverse myelitis and recurrent optic neuritis; MOG-IgG positive by live cell-based assay</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, pernicious anemia</td>
</tr>
<tr>
<td>Middle-aged</td>
<td>Cognitive impairment and seizures following allogeneic stem cell transplant, nodular dural enhancement with multifocal lesions on MRI</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
</tr>
</tbody>
</table>

1 Systemic autoimmunity refers to presence of T1DM, thyroid disease, pernicious anemia, adrenal insufficiency, vitiligo or celiac disease.

2 Improvement in temporal relationship to rituximab administration may have been natural history of disease, as ATP1A3-associated neurological disease may present with subacute episodes of neurological decline following infection with spontaneous recovery.

3 Improvement in temporal relationship to steroids may have been related to baclofen and carbamazepine, which were started at the same time.

Age stratification is as follows: child, less than 12 years of age; adolescent, 13-18 years of age; young adult, 19-45 years of age; middle-aged adult, 46-65 years of age; older adult, greater than 65 years of age.

ATP1A3 = ATPase Na+/K+ transporting subunit alpha 3; CLCN1 = chloride voltage-gated channel; CSF = cerebrospinal fluid; DaTscan = dopamine transporter (DAT) single photon emission computerized tomography; EEG = electroencephalography; NCS/EMG = nerve conduction studies/electromyography; GAD65 = glutamic acid decarboxylase-65;
IVIG = intravenous immunoglobulin; LE = limbic encephalitis; MOG = myelin oligodendrocyte glycoprotein; MRI = magnetic resonance imaging; PET = positron emission tomography; PLEX = plasma exchange; PPPD = persistent postural-perceptual dizziness; SCIG = subcutaneous immunoglobulin; SPSD = stiff-person spectrum disorders; T1DM = type 1 diabetes mellitus; TST = thermoregulatory sweat test
Supplementary Table. Patients with high-titer GAD65 antibodies but a more likely diagnosis for their neurological presentation

<table>
<thead>
<tr>
<th>Patient</th>
<th>Brief clinical description of neurological presentation</th>
<th>Concern raised for core or secondary manifestation of GAD65 neurological autoimmunity?</th>
<th>More likely alternative diagnosis</th>
<th>Sustained response to immunotherapy reported?</th>
<th>Systemic autoimmunity reported?</th>
<th>Serum anti-GAD65 titer (nmol/L)</th>
<th>CSF anti-GAD65 titer (nmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-neuroinflammatory diagnoses</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Child with epilepsy and febrile seizures dating back to infancy; left mesial temporal sclerosis on MRI</td>
<td>Yes (Epilepsy)</td>
<td>Febrile seizures resulting in mesial temporal sclerosis</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease, adrenal insufficiency</td>
<td>2245</td>
<td>8.34</td>
</tr>
<tr>
<td>2</td>
<td>Middle-aged adult with chronic pain and fatigue; normal tone and paraspinal tenderness on examination</td>
<td>Yes (SPSD)</td>
<td>Fibromyalgia</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td>111</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>Middle-aged adult with bilateral hand tingling and gait difficulties; gait ataxia on examination</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Subacute combined degeneration due to B12 deficiency</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>57.8</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Middle-aged adult with acute-onset vertigo and imbalance, followed by vague sense of dizziness without objective neurological findings; peripheral vestibular dysfunction on initial vestibular testing</td>
<td>Yes (Cerebellar Ataxia/Brainstem Dysfunction)</td>
<td>Vestibular neuritis followed by PPPD</td>
<td>No trial</td>
<td>No</td>
<td>2136</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Middle-aged adult with rapidly progressive behavioral change/cognitive decline and motor neuron disease; father had amyotrophic lateral sclerosis</td>
<td>Yes (Cognitive Impairment)</td>
<td>Frontotemporal dementia with amyotrophic lateral sclerosis</td>
<td>No trial</td>
<td>No</td>
<td>3077</td>
<td>20.9</td>
</tr>
<tr>
<td>6</td>
<td>Older adult with insidious short-term memory loss and temporal lobe-onset seizures; equivocal right hippocampal T2-hyperintensity/atrophy on MRI; decreased uptake in posterior cingulate on PET scan</td>
<td>Yes (LE/Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No, trialed corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
<td>33.1</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Older adult with more rapidly progressive ataxia after milder gait difficulties for several years and dysautonomia; cruciform</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple system atrophy-cerebellar type</td>
<td>No trial</td>
<td>Yes, T1DM, thyroid disease</td>
<td>614</td>
<td>0.75</td>
</tr>
<tr>
<td>Case</td>
<td>Clinical Presentation</td>
<td>Diagnosis/Syndrome</td>
<td>Clinical Finding</td>
<td>Treatment</td>
<td>Trial</td>
<td>Other Relevant Conditions</td>
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<tr>
<td>8</td>
<td>Middle-aged adult with abnormal movements of face/shoulders elicited by swallowing; reported abdominal stiffness and pain in lower extremities</td>
<td>Yes (SPSD)</td>
<td>Functional neurological disorder, diabetic peripheral neuropathy</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Young adult with headache, neck and back pain dating back to childhood/adolescence; some reported low back stiffness/spasms; multiple tender points on examination</td>
<td>Yes (SPSD)</td>
<td>Fibromyalgia</td>
<td>No, trialed IVIG and PLEX</td>
<td>No</td>
<td>36.8</td>
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</tr>
<tr>
<td>10</td>
<td>Middle-aged adult with low back pain/tightness, calf fasciculations and eyelid twitching; clinical diagnosis of anxiety</td>
<td>Yes (SPSD)</td>
<td>Myofascial low back pain, Anxiety</td>
<td>No trial</td>
<td>No</td>
<td>869</td>
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</tr>
<tr>
<td>11</td>
<td>Middle-aged adult with insidious executive dysfunction; epileptiform discharges on EEG, frontoparietal hypometabolism on PET scan; CSF biomarker profile consistent with Alzheimer’s disease</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial</td>
<td>Yes, pernicious anemia</td>
<td>334</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Middle-aged adult with insidious spastic paraparesis without sensory or bowel/bladder involvement; reported low back pain/spasms and left leg stiffness</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Primary lateral sclerosis</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
<td>248</td>
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<tr>
<td>13</td>
<td>Adolescent with rapidly progressive spastic dysarthria/dysphagia after respiratory infection; pathogenic mutation in ATP1A3 gene</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>ATP1A3 gene-related neurological disease</td>
<td>Yes, improved with rituximab after failing corticosteroids, IVIG and PLEX</td>
<td>No</td>
<td>2680</td>
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</tr>
<tr>
<td>14</td>
<td>Young adult with orthostatic lightheadedness, fatigue, abdominal bloating</td>
<td>No</td>
<td>Postural orthostatic tachycardia syndrome</td>
<td>No trial</td>
<td>No</td>
<td>214</td>
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<tr>
<td>15</td>
<td>Young adult with insidious limb weakness, ptosis and dysphagia; muscle biopsy found evidence of a chronic and severe myopathy</td>
<td>No</td>
<td>Inherited myopathy</td>
<td>No, trialed IVIG, steroids and abatacept</td>
<td>Yes, T1DM, pernicious anemia</td>
<td>61.4</td>
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<tr>
<td></td>
<td>Description</td>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Details</td>
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<tr>
<td>16</td>
<td>Young adult with two generalized tonic-clonic seizures in the setting of hyperglycemia</td>
<td>Yes (Epilepsy)</td>
<td>Provoked seizures due to hyperglycemia</td>
<td>Yes, T1DM</td>
<td></td>
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<tr>
<td>17</td>
<td>Older adult with dysphagia, dysarthria, and hand weakness; upper and lower motor neuron signs on examination; evidence of lower motor neuron involvement on EMG</td>
<td>No</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No</td>
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<tr>
<td>18</td>
<td>Older adult with insidious amnestic syndrome; hippocampal atrophy on MRI</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>Yes, T1DM</td>
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</tr>
<tr>
<td>19</td>
<td>Middle-aged adult with insidious sensory symptoms in legs; length-dependent, axonal, predominantly sensory neuropathy on NCS/EMG; mother has idiopathic peripheral neuropathy</td>
<td>No</td>
<td>Inherited neuropathy</td>
<td>Yes, thyroid disease</td>
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<td></td>
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</tr>
<tr>
<td>20</td>
<td>Child with five generalized tonic-clonic seizures in the setting of hypocalcemia</td>
<td>Yes (Epilepsy)</td>
<td>Provoked seizures due to hypocalcemia</td>
<td>Yes, autoimmune polyglandular syndrome type 1 (hypothyroidism, hypoparathyroidism, adrenal insufficiency)</td>
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<tr>
<td>21</td>
<td>Middle-aged adult with insidious amnestic syndrome; parietal lobe hypometabolism on PET scan</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>Yes, thyroid disease, pernicious anemia</td>
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<tr>
<td>22</td>
<td>Middle-aged adult with insidious sensory loss with insensitivity to pain, length-dependent sensorimotor peripheral neuropathy with mixed axonal and demyelinating features on NCS/EMG</td>
<td>No</td>
<td>Inherited neuropathy</td>
<td>No</td>
<td></td>
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<tr>
<td>23</td>
<td>Middle-aged adult with gait difficulty followed by urinary urgency, dysarthria, antecollis and myoclonus; parkinsonism on examination; T2-hyperintensity of posterolateral putamen on MRI</td>
<td>No</td>
<td>Multiple system atrophy-parkinsonian type</td>
<td>No</td>
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</tr>
<tr>
<td>24</td>
<td>Older adult with insidious amnestic syndrome;</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>Yes, T1DM</td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
<th>Diagnosis</th>
<th>Treatment</th>
<th>Other Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Middle-aged adult with insidiously progressive gait difficulties; findings of length-dependent peripheral neuropathy without cerebellar signs on examination; outside NCS/EMG documenting peripheral neuropathy</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Diabetic peripheral neuropathy</td>
<td>No trial</td>
</tr>
<tr>
<td>26</td>
<td>Middle-aged adult with episodic gait unsteadiness correlating to timing of carbamazepine dose; negative genetic testing for episodic ataxia; history of epilepsy secondary to traumatic brain injury</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Side effect of carbamazepine; recommended switching to levetiracetam but no follow-up available</td>
<td>No, trialed corticosteroids</td>
</tr>
<tr>
<td>27</td>
<td>Older adult with insidious mild amnestic syndrome and subjective feeling of weakness; partial improvement after treatment of B12 deficiency</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease, B12 deficiency</td>
<td>No trial</td>
</tr>
<tr>
<td>28</td>
<td>Older adult with insidious leg weakness/spasms; upper motor neuron signs in legs on examination; electrophysiologic evidence of motor neuron disease in cervical, thoracic and lumbar segments on NCS/EMG</td>
<td>Yes (SPSD/Myelopathy)</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No trial</td>
</tr>
<tr>
<td>29</td>
<td>Young adult with insidious difficulty walking and low back/leg stiffness/spasms; evidence of myotonia on EMG; pathogenic mutation in CLCN1 gene</td>
<td>Yes (SPD)</td>
<td>Becker’s myotonia</td>
<td>Yes, improved with corticosteroids</td>
</tr>
<tr>
<td>30</td>
<td>Middle-aged adult with ataxic dysarthria, left-sided ataxia/dystonia and stiffness of left leg; ATP1A3 mutation of uncertain clinical significance; brother with atypical parkinsonism</td>
<td>Yes (Cerebellar Ataxia/SPSD)</td>
<td>ATP1A3-associated neurological disease</td>
<td>No, trialed IVIG and corticosteroids</td>
</tr>
<tr>
<td>31</td>
<td>Older adult with insidious cognitive decline with rapid worsening after heart surgery;</td>
<td>Yes (Cognitive Impairment)</td>
<td>Dementia with Lewy bodies</td>
<td>No, trialed corticosteroids</td>
</tr>
<tr>
<td>Row</td>
<td>Description</td>
<td>Diagnosis</td>
<td>Treatment</td>
<td>Additional Information</td>
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<tr>
<td>32</td>
<td>Young adult with limping related to leg pain; equivocally increased tone in legs but overall “quite normal” neurological examination</td>
<td>Myofascial pain syndrome</td>
<td>No trial</td>
<td>Yes, T1DM, pernicious anemia</td>
</tr>
<tr>
<td>33</td>
<td>Adolescent with new-onset psychosis, delusions, disorganized thoughts, and insomnia with impaired memory/concentration, followed by catatonia; mild dysmorphism; chromosome 22q11.1 microdeletion identified</td>
<td>Primary psychotic disorder (reported higher risk with chromosome 22q11.1 microdeletion)</td>
<td>No, trialed steroids and IVIG</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Adolescent with episodic vertigo and gait unsteadiness with headache 50% of the time; triggers reported include certain foods, bright lights, loud sounds, and foul odors</td>
<td>Vestibular migraine</td>
<td>No trial</td>
<td>Yes, T1DM</td>
</tr>
<tr>
<td>35</td>
<td>Child with episodes of mouth-opening, head tilt and breath-holding with preserved awareness in patient with developmental delay and hand-wringing; no abnormality on EEG during episodes</td>
<td>Primary complex motor stereotypy</td>
<td>No trial</td>
<td>No</td>
</tr>
<tr>
<td>36</td>
<td>Older adult with insidious difficulty walking long distances; mild parkinsonism on examination; decreased striatal dopamine transporter density on DaTscan</td>
<td>Idiopathic Parkinson’s disease</td>
<td>No trial</td>
<td>Yes, thyroid disease</td>
</tr>
<tr>
<td>37</td>
<td>Young adult with Trisomy 21, visual and auditory hallucinations</td>
<td>Primary psychotic disorder</td>
<td>No, trialed corticosteroids, IVIG and rituximab</td>
<td>Yes, thyroid disease, celiac disease</td>
</tr>
<tr>
<td>38</td>
<td>Middle-aged adult with mild cognitive complaints (less efficient at work, some forgetfulness); essentially normal neuropsychometric</td>
<td>Depression/Anxiety</td>
<td>No, only non-sustained subjective benefit with corticosteroids and IVIG</td>
<td>Yes, thyroid disease</td>
</tr>
<tr>
<td>Case</td>
<td>Description</td>
<td>Diagnosis</td>
<td>Treatment Administered</td>
<td>Additional Information</td>
</tr>
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<tr>
<td>39</td>
<td>Older adult with chronic right-sided facial pain, exacerbated by changes in barometric pressure and radiating right occipital pain; right occipital notch tenderness on examination</td>
<td>No</td>
<td>Chronic migraine, occipital neuralgia</td>
<td>No trial No 459 -</td>
</tr>
<tr>
<td>40</td>
<td>Older adult with insidious sensory loss in feet and imbalance; mild findings of sensory neuropathy in feet on examination stable over years; length-dependent small-fiber neuropathy on TST</td>
<td>No</td>
<td>Idiopathic length-dependent small fiber neuropathy</td>
<td>No trial No 258 -</td>
</tr>
<tr>
<td>41</td>
<td>Older adult with insidious cognitive decline, bilateral posterior temporal and parietal hypometabolism on PET scan</td>
<td>Yes (Cognitive Impairment)</td>
<td>Alzheimer’s disease</td>
<td>No trial No 161 -</td>
</tr>
<tr>
<td>42</td>
<td>Middle-aged adult with insidious leg weakness and gait difficulties; spastic quadriparesis with impaired vibration/proprioception in legs on examination</td>
<td>Yes (Cerebellar Ataxia/Myelopathy)</td>
<td>Subacute combined degeneration due to B12 deficiency</td>
<td>No trial Yes, pernicious anemia 470 -</td>
</tr>
<tr>
<td>43</td>
<td>Middle-aged adult with chronic hypersensitivity to touch in feet and intermittent painful color change in toes and fingers; high arches, hammertoes and allodynia in feet on examination</td>
<td>No</td>
<td>Inherited neuropathy, Raynaud’s phenomenon</td>
<td>No trial No 237 -</td>
</tr>
<tr>
<td>44</td>
<td>Middle-aged adult with episodic paralysis lasting hours but preserved consciousness and ability to swallow; episodes provoked by anxious situations; normal ictal serum potassium; no findings of periodic paralysis on NCS/EMG</td>
<td>No</td>
<td>Functional neurological disorder</td>
<td>No trial No 461 -</td>
</tr>
<tr>
<td>45</td>
<td>Middle-aged adult with longstanding depression with psychotic features; presented to hospital with impaired attention/concentration/anxiety in context of multiple psychosocial stressors; resolved</td>
<td>Yes (Cognitive Impairment)</td>
<td>Exacerbation of known psychiatric disease</td>
<td>No trial Yes, thyroid disease, pernicious anemia 45.3 -</td>
</tr>
<tr>
<td>No.</td>
<td>Case Description</td>
<td>Treatment</td>
<td>Response</td>
<td>Disorder</td>
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</tr>
<tr>
<td>46</td>
<td>Middle-aged adult with chronic leg muscle cramps; normal neurological examination aside from witnessed cramp in foot; cramps resolved with gabapentin</td>
<td>No</td>
<td>Muscle cramps</td>
<td>No trial, Yes, pernicious anemia</td>
</tr>
<tr>
<td>47</td>
<td>Young adult with chronic fatigue, poor sleep and orthostatic lightheadedness after numerous stressful life events; clinical concern for depression; normal neurological examination</td>
<td>No</td>
<td>Orthostatic intolerance, Somatic symptoms of depression</td>
<td>No trial, No</td>
</tr>
<tr>
<td>48</td>
<td>Young adult with chronic sensory symptoms in feet and hands; glove-and-stocking distribution sensory loss on examination; evidence of chronic length-dependent axonal peripheral neuropathy on EMG</td>
<td>No</td>
<td>Idiopathic length-dependent large fiber neuropathy</td>
<td>No trial, No</td>
</tr>
<tr>
<td>49</td>
<td>Young adult with chronic diffuse upper body pain and reported stiffness; variably stiff posturing but no objective stiffness, spasms or paraspinal hypertrophy on examination; diffuse tenderness</td>
<td>Yes (SPSD)</td>
<td>Fibromyalgia</td>
<td>No, trialed IVIG with only non-sustained response, Yes, T1DM</td>
</tr>
<tr>
<td>50</td>
<td>Middle-aged adult with headache, poor concentration, dizziness and difficulty sleeping after head injury</td>
<td>Yes (Cognitive Impairment)</td>
<td>Post-concussive syndrome</td>
<td>No trial, Yes, T1DM</td>
</tr>
<tr>
<td>51</td>
<td>Older adult with memory complaints and feeling of exhaustion in context of B12 deficiency, anemia, hypothyroidism and worsening depression; partial improvement with B12 supplementation</td>
<td>Yes (Cognitive Impairment)</td>
<td>B12 Deficiency, Depression</td>
<td>No trial, Yes, thyroid disease, pernicious anemia</td>
</tr>
<tr>
<td>52</td>
<td>Middle-aged adult with chronic intermittent paresthesias of the hands and feet that improve with movement, feeling of hand “swelling”, sense of imbalance, and heat intolerance; only equivocal sensory loss in hands</td>
<td>No</td>
<td>Chronic idiopathic anhidrosis</td>
<td>No trial, No</td>
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<tr>
<td>Case</td>
<td>Complaints</td>
<td>Diagnostic Findings</td>
<td>Side Effect</td>
<td>Recommendation</td>
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<tr>
<td>53</td>
<td>Young adult with tremulousness, spasms and internal feeling of vibration after starting ziprasidone for bipolar disorder; normal neurological examination</td>
<td>Yes (SPSD)</td>
<td>Side effect of ziprasidone, recommended discontinuation</td>
<td>No trial</td>
</tr>
<tr>
<td>54</td>
<td>Young adult with intermittent stuttering of speech, feeling of head heaviness and cognitive difficulties; variable stuttering but otherwise normal neurological examination</td>
<td>Yes (Cognitive Impairment)</td>
<td>Functional neurological disorder</td>
<td>No trial</td>
</tr>
<tr>
<td>55</td>
<td>Middle-aged adult with insidious numbness and tingling in hands and feet, stable for last year; findings of both mild length-dependent sensory loss and right-sided spasticity/hyperreflexia on examination; mild axonal sensorimotor peripheral neuropathy and C5/C6 radiculopathies on NCS/EMG; severe cervical spinal and foraminal stenosis due to degenerative spondylosis on MRI</td>
<td>Yes (Myelopathy)</td>
<td>Compressive myelopathy/ radiculopathy, Diabetic peripheral neuropathy</td>
<td>No trial</td>
</tr>
<tr>
<td>56</td>
<td>Middle-aged adult with chronic feeling of low energy, body aches, stiffness, “brain fog”, and postural lightheadedness/ dizziness dating back to childhood; episodic kicking/flailing of legs elicited by medication injection</td>
<td>Yes (SPSD)</td>
<td>Postural orthostatic tachycardia syndrome, Functional neurological disorder</td>
<td>No, trialed IVIG and then SCIG with only non-sustained response</td>
</tr>
<tr>
<td>57</td>
<td>Middle-aged adult with remote upper extremity paresthesias and more recently weakness; mild neck flexor and proximal upper extremity weakness/ hyporeflexia and lower extremity hyperreflexia on examination; motor neuron</td>
<td>Yes (Myelopathy)</td>
<td>Subacute combined degeneration, followed by bibrachial amyotrophic diplegia (limited follow-up)</td>
<td>No trial</td>
</tr>
<tr>
<td>No.</td>
<td>Age</td>
<td>Presentation</td>
<td>Diagnosis</td>
<td>Treatments</td>
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<tr>
<td>58</td>
<td>Young adult</td>
<td>Dysarthria, dysphagia, hand weakness and right-sided stiffness developing over one year; flaccid dysarthria, right arm weakness and spasticity in all limbs on examination; evidence of diffuse motor neuron process on NCS/EMG</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No, trialed IVIG</td>
</tr>
<tr>
<td>59</td>
<td>Middle-aged</td>
<td>Limb weakness, slurred speech, dysphagia and involuntary laughing/crying developed over ten years (more rapidly over three years); spastic dysarthria, mild proximal right arm and lower extremity weakness with brisk reflexes and scattered fasciculations on examination; evidence of diffuse motor neuron process on NCS/EMG</td>
<td>Amyotrophic lateral sclerosis</td>
<td>No, trialed steroids and IVIG</td>
</tr>
</tbody>
</table>

### Neuroinflammatory diagnoses

<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Presentation</th>
<th>Diagnosis</th>
<th>Treatments</th>
<th>Secondary Diagnosis</th>
<th>No. of Follow-Up Observation</th>
<th>Baseline EDSS</th>
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<tbody>
<tr>
<td>60</td>
<td>Middle-aged</td>
<td>Insidious gait difficulties, leg weakness and numbness, right arm tremor; previous episodes of double vision and history of right eye blurring; distractible tremor, “astasia abasia” and give-way weakness on examination; lesions typical of demyelination on MRI</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple sclerosis with functional overlay</td>
<td>No trial</td>
<td>No</td>
<td>82.8</td>
</tr>
<tr>
<td>61</td>
<td>Young adult</td>
<td>Progressive gait imbalance, blurred vision, intermittent diplopia; optic disc pallor, cerebellar signs and left leg weakness on examination;</td>
<td>Yes (Cerebellar Ataxia)</td>
<td>Multiple sclerosis</td>
<td>Yes, stabilized/mildly improved with rituximab</td>
<td>No</td>
<td>72.5</td>
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<td>Case</td>
<td>Clinical Presentation</td>
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<td>Outcome</td>
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<tr>
<td>62</td>
<td>Middle-aged adult with episode of limb dysesthesias and abdominal tightness, and right followed by left eye vision loss; right optic nerve swelling and left optic nerve pallor on examination; several lesions concerning for demyelination on MRI</td>
<td>Multiple sclerosis</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease</td>
<td></td>
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<tr>
<td>63</td>
<td>Older adult with persistent mild bilateral leg numbness/heaviness for two years; previous episodes of vision loss, numbness and facial weakness; lesions in cervical cord concerning for demyelination on MRI</td>
<td>Multiple sclerosis</td>
<td>No trial</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td></td>
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</tr>
<tr>
<td>64</td>
<td>Middle-aged adult with fluctuating ptosis and diplopia, followed by jaw weakness with chewing; left ptosis, ophthalmoparesis, facial weakness, subtle flaccid dysartria and mild deltoid weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Myasthenia gravis</td>
<td>No, trialed IVIG with only non-sustained response and limited follow-up thereafter</td>
<td>No</td>
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</tr>
<tr>
<td>65</td>
<td>Older adult with neck weakness, followed by dysarthria and dysphagia; bilateral ptosis with sustained upgaze, bilafacial weakness and neck extensor weakness on examination; abnormal jitter on NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Myasthenia gravis</td>
<td>Yes, improved with IVIG and mycophenolate</td>
<td>Yes, thyroid disease</td>
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<tr>
<td>66</td>
<td>Middle-aged adult with new-onset difficulty chewing and dysphagia, followed by fluctuating ptosis and transient diplopia; positive acetylcholine</td>
<td>Myasthenia gravis</td>
<td>Yes, improved with IVIG</td>
<td>Yes, thyroid disease</td>
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<tr>
<td>#</td>
<td>Case Description</td>
<td>Paraneoplastic Myositis</td>
<td>Improvement</td>
<td>Trial</td>
<td>Patient Age</td>
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<tr>
<td>67</td>
<td>Older adult with subacute proximal muscle weakness and slurred speech; evidence of myopathy on NCS/EMG; inflammatory myopathy on muscle biopsy; thymoma diagnosed</td>
<td>Yes (Cerebellar Ataxia/Myelopathy)</td>
<td>No trial</td>
<td>Yes, T1DM</td>
<td>136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Middle-aged adult with difficulty walking; lower extremity weakness, upper motor neuron signs, gait and limb ataxia on examination; clinical history of relapses; lesions typical of demyelination on MRI</td>
<td>Yes (Brainstem Dysfunction)</td>
<td>Yes, improved with IVIG and PLEX</td>
<td>No</td>
<td>260</td>
<td></td>
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</tr>
<tr>
<td>69</td>
<td>Older adult with new-onset dysphagia followed by respiratory failure; evidence of neuromuscular junction defect on outside NCS/EMG; positive acetylcholine receptor antibodies; no thymoma diagnosed</td>
<td>Yes (Myelopathy)</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, pernicious anemia</td>
<td>2068</td>
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</tr>
<tr>
<td>70</td>
<td>Young adult with transverse myelitis and recurrent optic neuritis; MOG-IgG positive by live cell-based assay</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
<td>3108</td>
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</tr>
<tr>
<td>71</td>
<td>Middle-aged adult with cognitive impairment and seizures following allogenic stem cell transplant, nodular dural enhancement with multifocal lesions on MRI</td>
<td>Yes (Epilepsy/Cognitive Impairment)</td>
<td>Yes, improved with corticosteroids</td>
<td>Yes, thyroid disease, adrenal insufficiency</td>
<td>154</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Systemic autoimmunity refers to presence of T1DM, thyroid disease, pernicious anemia, adrenal insufficiency, vitiligo or celiac disease.

2Improvement in temporal relationship to rituximab administration may have been natural history of disease, as ATP1A3-associated neurological disease may present with subacute episodes of neurological decline following infection with spontaneous recovery.

3Improvement in temporal relationship to steroids may have been related to baclofen and carbamazepine, which were started at the same time.

Age stratification is as follows: child, less than 12 years of age; adolescent, 13-18 years of age; young adult, 19-45 years of age; middle-aged adult, 46-65 years of age; older adult, greater than 65 years of age.

ATP1A3 = ATPase Na+/K+ transporting subunit alpha 3; CLCN1 = chloride voltage-gated channel; CSF = cerebrospinal fluid; DaTscan = dopamine transporter (DAT) single photon emission computerized tomography; EEG = electroencephalography; NCS/EMG = nerve conduction studies/electromyography; GAD65 = glutamic acid decarboxylase-65;
IVIG = intravenous immunoglobulin; LE = limbic encephalitis; MOG = myelin oligodendrocyte glycoprotein; MRI = magnetic resonance imaging; PET = positron emission tomography; PLEX = plasma exchange; PPPD = persistent postural-perceptual dizziness; SCIG = subcutaneous immunoglobulin; SPSD = stiff-person spectrum disorders; T1DM = type 1 diabetes mellitus; TST = thermoregulatory sweat test