

THE LANCET **Neurology**

Supplementary webappendix

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Syndromes at the frontier of autoimmune encephalitis (AE)

Morvan syndrome

Morvan syndrome is a rare CNS disorder (less than 100 patients described) affecting mostly men, and characterized by a constellation of peripheral and CNS symptoms. The clinical course of Morvan syndrome is usually chronic and the median duration of symptoms by the time of diagnosis is approximately one year. In general, the episodes of confusion, agitation, and hallucinations that may suggest a possible AE are preceded by symptoms of neuromyotonia, dysautonomia, and sleep dysfunction which should lead to the diagnosis of this disorder.¹

The full-blown syndrome includes peripheral nerve hyperexcitability with neuromyotonia and neuropathic pain, dysautonomia (mostly hyperhidrosis), encephalopathy with confusion, agitation, and hallucinations, and a characteristic sleep disorder called *agrypnia excitata*.² CSF, brain MRI, and neuropathological studies are usually normal or with nonspecific findings. Thymoma is found in approximately 20-50% of the patients and ~75% of them have CASPR2 antibodies.³ These antibodies are not specific for Morvan syndrome because they also occur in patients with isolated neuromyotonia or LE.⁴ However, in the appropriate clinical setting they are an important clue for the diagnosis.

Primary angiitis of the CNS (PACNS)

This is a rare disorder that results from inflammation of CNS vessels without evidence of involvement of systemic vessels. Obligatory diagnostic criteria include the demonstration of angiographic or histological evidence of angiitis within the CNS (Table 5S).⁵ Comprehensive reviews of the disorder in adults and children have been published.^{6,7} In adults, symptoms include headache, and diffuse or focal neurological deficits, along with CSF lymphocytic pleocytosis and MRI showing multiple bilateral ischemic foci. Stroke and transient ischemic attacks involving multiple vessels occur in 30-50% of the patients.⁶ In children the clinical picture of small vessel PACNS more frequently resembles that of AE.⁷ The differential diagnosis with AE is complicated at early stages when children present with headache, cognitive dysfunction, learning difficulties, or behavioral changes before developing seizures or stroke symptoms. The combination of headache and multifocal inflammatory lesions in the MRI, are very common in childhood PACNS (cPACNS) and less frequent in AE.⁷ For example, one the most frequent AE, anti-NMDAR encephalitis, often occurs with normal MRI or findings different from those in PACNS. Serum inflammatory markers such as C-reactive protein, C3 complement, erythrocyte sedimentation rate, and von Willebrand-factor antigen are commonly elevated in small vessel disease; this is contrast to most AE in which these serological markers are not elevated. Non-progressive cPACNS is commonly treated with a three month course of corticosteroids in addition to antithrombotic therapy, while progressive large vessel cPACNS and small vessel cPACNS mandate a combination of steroids and cyclophosphamide, followed by mycophenolate.^{8,9}

Rasmussen encephalitis and other epileptic syndromes of possible autoimmune origin

Rasmussen encephalitis (RE) is a chronic inflammatory disease characterized by intractable focal onset seizures, and deterioration of neurological functions associated with progressive atrophy of the affected hemisphere.¹⁰ Although initially reported in children, it can also affect adolescents and adults. The pathogenesis of the disease is unclear, but the current prevailing theory is a cytotoxic T-cell autoimmune mechanism.¹¹ The most effective treatment with regard to seizures is hemispherectomy. Important diagnostic clues that differentiate this disorder from most AE are the symptom chronicity, unilateral hemispheric functional and structural involvement, and refractoriness to immunotherapy.¹⁰

Another devastating epileptic syndrome often considered in the differential diagnosis of AE is febrile infection-related epilepsy syndrome (FIRES).¹² This syndrome is characterized by the onset of seizures in previously healthy children in the setting of a febrile episode. Seizures rapidly evolve to status epilepticus and pharmacoresistant epilepsy. When seizures improve, patients present an important cognitive deterioration. Paraclinical studies have failed to demonstrate a viral or autoimmune origin. CSF analysis does not show pleocytosis nor oligoclonal bands. Brain MRI is usually normal at onset of the syndrome but the subsequent studies show bilateral temporal atrophy a few months after the onset of the disease.¹²

Other epileptic syndromes include idiopathic hemiconvulsion hemiplegia and epilepsy syndrome (IHHE) and a syndrome similar to FIRES, predominantly reported in Asia: acute encephalitis with refractory, repetitive partial seizures (AERRPS).^{12,13} Several confounding factors with AE occur at initial stages of these disorders where the MRI may show FLAIR/T2 medial temporal lobe abnormalities due to seizures, and the CSF mild pleocytosis. On the other hand several antibody-associated AE can present with severe seizures and status epilepticus. To date none of the treatment-refractory epileptic syndromes mentioned above have been linked to relevant autoantibodies.

Table 1S: Differential diagnosis in patients with possible autoimmune encephalitis

Disorder
CNS infections ¹⁴
Septic encephalopathy ¹⁵
Metabolic encephalopathy ¹⁶
Drug toxicity*
Cerebrovascular disease ¹⁷
Neoplastic disorders ¹⁸
Creutzfeldt-Jakob disease ¹⁹
Epileptic disorders ¹²
Rheumatologic disorders (e.g., lupus, sarcoidosis, other) ²⁰
Kleine-Levin ²¹
Reye syndrome (children) ²²
Mitochondrial diseases ²³
Inborn errors of metabolism (children) ²⁴

*Including use of illicit drugs, direct neurotoxic effect of prescribed drugs or through induction of seizures, posterior reversible encephalopathy, idiosyncratic reaction (e.g. neuroleptic malignant syndrome), drug interaction (e.g. serotonergic syndrome) or drug withdrawal.

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Table 2S: Limbic encephalitis and systemic disorders of presumably autoimmune pathophysiology*

	Bilateral involvement of medial temporal lobes in MRI FLAIR sequences	CSF pleocytosis	Distinctive features	Diagnostic tests
Systemic lupus erythematosus ²⁵	Yes	Yes	Systemic and serological abnormalities	Lupus criteria
Sjögren's syndrome ²⁶	Unilateral	Unknown	Systemic symptoms (sicca syndrome)	SS-A, SS-B antibodies; salivary gland biopsy
Kikuchi-Fujimoto disease ²⁷	Yes	Yes	Cervical lymphadenopathy; MRI abnormalities beyond the temporal lobes	Lymph node biopsy showing histiocytic necrotizing lymphadenitis
Behçet' disease ²⁸	Yes	Yes	Systemic symptoms (recurrent attacks of oral, genital ulcers, uveitis, polychondritis)	Behçet criteria
X-linked lymphoproliferative disease ²⁹	Yes	Yes	MRI abnormalities beyond the temporal lobes	Genetic confirmation

* These diagnoses are associated rarely with LE, we acknowledge that causation is unclear and the underlying diagnosis may just be a comorbidity or epidemiological risk factor

Table 3S: Differential diagnosis of autoimmune limbic encephalitis

Disorder	Bilateral involvement of medial temporal lobes in MRI FLAIR sequences	CSF pleocytosis	Distinctive features	Diagnostic tests
Herpes simplex virus encephalitis (HSE) ³⁰	Yes	Yes	Fever (>38°C). MRI hemorrhagic lesions, beyond medial temporal lobes	HSV DNA in CSF. This test can be negative if done too early (≤24 hours) or too late (after 10-14 days). Consider determination of intrathecal HSV antibody synthesis for atypical or protracted cases.
HHV-6 encephalitis ³¹	Yes	Occasional	Most common in immunosuppressed patients	HHV-6 DNA in CSF
Glioma ³²	Almost always unilateral	No	Contrast enhancement common	Biopsy
Status epilepticus ³³	Bilateral	Unknown	More common in children and young adults. MRI abnormalities beyond temporal lobes	None. Reversible evolution of MRI findings sometimes leading to atrophy
Neurosyphilis ³⁴	Variable	Yes	Symptoms and MRI findings beyond medial temporal lobe involvement	CSF treponemal antibody tests
Whipple ³⁵	Yes	Yes	Systemic symptoms (polyarthralgia and intermittent diarrhea), oculomasticatory myorhythmia. Symptoms and MRI findings beyond medial temporal lobe involvement.	<i>T whipplei</i> DNA in CSF
HIV ³⁶	Yes	Yes	Low CD4 cell count	Positive HIV serology

Table 4S: Clinical clues and comorbidities that associate with antibodies related to subtypes of limbic encephalitis³⁷

ANTIBODIES THAT OFTEN OR PREDOMINANTLY ASSOCIATE WITH LIMBIC ENCEPHALITIS	
Hu (ANNA1)	Usually affect older subjects with history of smoking or SCLC; rarely associated with pure LE; frequently accompanied by encephalomyelitis or sensory neuronopathy
Ma2	Usually affect men younger than 45 years, with germ-cell tumor of the testis. The tumor is frequently microscopic. In older men and women a variety of other tumors have been reported. The syndrome develops as LE, upper brainstem or diencephalic encephalitis. Symptoms may include failure of the hypothalamic-pituitary axis, narcolepsy-cataplexy, or severe rigidity with hypokinesia.
LGII	Frequently occurs in patients older than 50 years, with mild male predominance. In most cases the clinical picture is a typical LE; 60% of the patients develop hyponatremia. Symptoms of LE may be preceded or associated with bradycardia sometimes leading to pacemaker placement or short-lasting myoclonic-like movements described as facio-brachial dystonic seizures. In some patients the presentation mimics a rapidly progressive dementia (e.g., Creutzfeldt-Jakob)
GABA _B R	Usually affect adults; 50% have an underlying SCLC or neuroendocrine tumor. The syndrome presents as typical LE with early and prominent seizures. Some patients develop cerebellar ataxia. As with AMPAR antibodies (see below), the GABA _B R antibodies may occur with co-existing tumor-related antibodies.
AMPA _R	Mildly predominates in women. About 50% of the patients present with LE; the rest develop LE combined with other symptoms. Some cases present with pure psychosis or RPD. About 65% of the patients have an underlying tumor (mainly SCLC, thymoma). These antibodies may co-exist with onconeural antibodies, other neuronal cell surface, thyroid, or tumor-related antibodies (SOX1, VGCC) reflecting a propensity to autoimmunity.
GAD	May occur as pure or predominant LE. In these cases the syndrome is often paraneoplastic and screening for an underlying tumor is recommended. However, regardless of the neurological syndrome, the co-existence of GAD antibodies and cell surface neuronal antibodies (e.g., AMPA or GABA _B R) frequently associate with an underlying cancer, and tumor screening is also recommended. Many patients with anti-GAD associated neurological symptoms have type I diabetes mellitus or other endocrinopathies.
ANTIBODIES THAT RARELY ASSOCIATE WITH LIMBIC ENCEPHALITIS	
CV2 (CRMP5)	Similar demographics and tumor association as for Hu antibodies, but some patients may have thymoma or other tumors. Rarely associated with pure LE. Accompanying features may include uveitis, retinopathy, optic neuropathy, chorea, and peripheral neuropathy.
Caspr2	Rarely present as classical LE. Associate more frequently with Morvan syndrome; in these cases the presence of an underlying thymoma should be investigated. The occurrence of history of neuropathic pain or neuromyotonia suggest Morvan syndrome.
DPPX	Patients often have gastrointestinal dysfunction, diarrhea, and loss of weight preceding the neurological syndrome (psychiatric manifestations, confusion, seizures, tremor, myoclonus, nystagmus). Hyperekplexia is frequent, and patients may develop a syndrome resembling progressive encephalomyelitis with rigidity and myoclonus. Most patients do not have a tumor. Presentation as classical LE is unusual.
GABA _A R	Patients present with multifocal (cortical-subcortical FLAIR MRI changes) or diffuse encephalitis, with prominent seizures and status epilepticus, often requiring induced coma. If antibodies are only detected in serum the syndrome association is broad. Presentation as classical LE is unusual. Most patients do not have a tumor; some have thymoma.
mGluR5	Patients present with non-focal encephalitis, and a clinical picture suggesting involvement beyond the limbic system. Most patients have Hodgkin's lymphoma.
Adenylate-kinase 5	Patients present with isolated severe short-term memory loss. No seizures. No association with cancer. Poor response to immunotherapy.

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Table 5S: Diagnostic criteria of primary vasculitis of the CNS³⁸

1. A newly acquired focal or diffuse neurological deficit and/or psychiatric symptoms
 2. Demonstration of classic angiographic or histopathological features of vasculitis in the CNS.
 3. No evidence of systemic vasculitis or any disorder that could cause or mimic the angiographic or pathological features of the disorder.
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