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Teratoma-associated anti-N-methyl-D-aspartate receptor encephalitis

A case report and literature review

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Abstract

Rationale: Anti-N-methyl-D-aspartate receptor (anti-NMDAR) encephalitis is an autoimmune disease associated with the NMDA receptor and has a good response to treatment. However, only few cases related to teratoma have been reported. Here, we report a case of teratoma-associated anti-NMDAR encephalitis.

Patient concerns: A 25-year-old woman presenting with fever for 20 days and psychiatric symptoms for 9 days was admitted to the hospital. The patient progressed to a minimally conscious state consistent with encephalitis.

Diagnosis: Considering the possibility of autoantibody-mediated encephalitis, laboratory tests were conducted to detect anti-NMDAR antibodies in cerebrospinal fluid and serum. Results confirmed the diagnosis of anti-NMDAR encephalitis. Furthermore, gynecological ultrasound investigation detected teratoma in the left ovary.

Interventions: After resection of the teratoma with laparoscopic adnexectom, the patient was treatment with immunosuppressive therapy.

Outcomes: The patient recovered gradually and was discharged 2 months after the operation.

Lessons: Anti-NMDAR encephalitis remains difficult to diagnose because of its vague manifestations, and no clinical practice guidelines for prevention and treatment of the disease have been established yet. The clinical data of a case of teratoma-related anti-NMDAR encephalitis were analyzed, and relevant studies were reviewed.

Abbreviations: CSF = cerebrospinal fluid, GFAP = glialfibrillary acidic protein, MRI = magnetic resonance imaging, NMDAR = N-methyl-D-aspartate receptor, NR-1 = N-methyl-D-aspartate receptor 1, NR-2 = N-methyl-D-aspartate receptor 2.

Keywords: anti-N-methyl-D-aspartate receptor encephalitis, case report, comprehensive treatment, teratoma

1. Introduction

Anti-N-methyl-D-aspartate receptor (NMDAR) encephalitis is a rare form of encephalitis and is associated with presence of antibodies against the NR1 or NR2 subunits of the NMDA receptor in cerebrospinal fluid (CSF) and serum.[1] This disease occurs often in young women who manifest neuropsychiatric disturbances, including restlessness, central hypoventilation, oral facial dyskinesia, affective disturbance, psychosis, hallucination, memory loss, dyskinesia, vegetative deregulation, and autonomic dysfunction[2–5]; NMDAR encephalitis coexists with ovarian pathologies in several cases. Majority of patients with anti-NMDAR encephalitis respond to immunotherapy. For patients who also have ovarian lesions, gynecologic surgical procedures are strongly recommended.

2. Case report

A 25-year-old nulliparous Chinese female patient started to have fever (body temperature of 38.2 °C) and headache from April 1st, 2018. After 10 days, she began to develop amnesia, followed by delirium, urinate and defecate, and discontinuous confusion. On April 13th, the patient had onset of epileptic seizures, 4 or 5 times a day, each lasted for minutes, and also possessed rigid bilateral upper extremities with shouting but without frothing and twitching limbs. During this stage, the patient went to 2 different hospitals but the diagnosis remained unclear. Upon admission to the Department of Infectious Diseases of another hospital on April 16th, the results of CSF examination were as follows: 3.1 mmol/L Glu, 124 mmol/L Cl^-, 349 mg/L protein, 28×10^6/L leucocytes, 1:32 (+++) NMDA, and 1:10 (+) NMDA in serum. No abnormalities were found from the brain magnetic resonance

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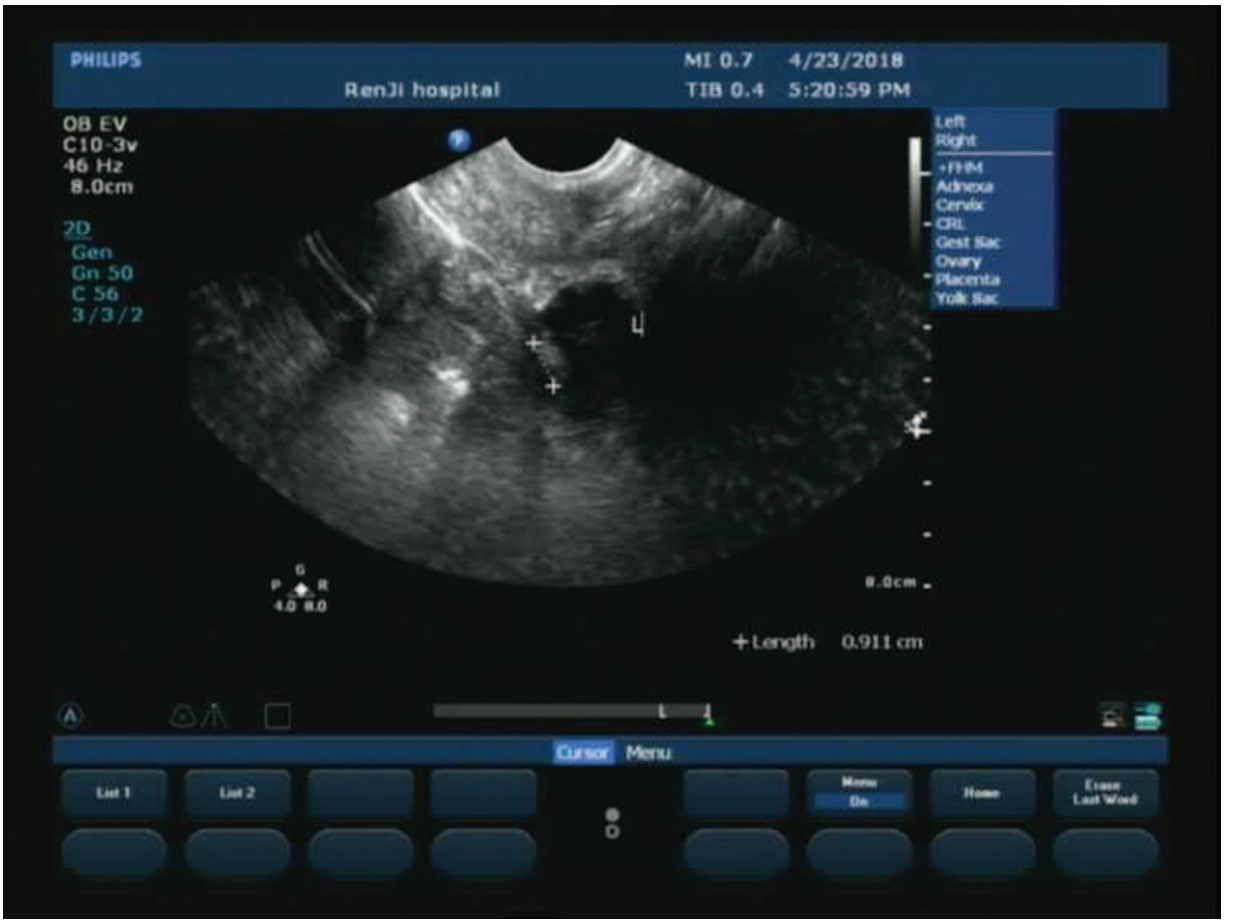

Figure 1. Gynecologic ultrasonography of the patient.

imaging (MRI) scans. Therefore, the patient was diagnosed with anti-NMDAR encephalitis and given pulse therapy of immunoglobulin (IVIG) (22.5 g/d, 0.4 g/kg) for 5 days, methylprednisolone (1 g/d) for 7 days (the dosage was decreased every 7 days), olanzapine (5 mg/d), and levetiracetan (2.0 g/d). Meanwhile, gynecological ultrasound detected a nodule (9.4 mm × 9.6 mm × 9.7 mm) in the left ovary. The nodule was considered to be teratoma (Fig. 1).

The patient was transferred to the Department of Gynecology of our hospital for further surgical treatment on April 21. Single-site laparoscopic resection of the left ovary, mesangial cystectomy of the right fallopian tube, and incision exploration of the right ovary were performed on April 24. The surgical specimen showed that the tumor was 1 cm in diameter and appeared polycystic (Fig. 2). Pathological examination confirmed the diagnosis of mature cystic teratoma in the left ovary. A small amount of mature brain tissues was also found. After the surgery, the patient was orally given with sodium valproate, levetiracetam, and olanzapine to control the epileptic and mental symptoms. On the night of May 5, the patient suddenly got delirium and hallucination. From May 6 to May 10, the patient was given 2 courses of IVIG (22.5 g/d, 0.4 g/kg). The patient's conditions gradually improved after the treatment. She started to obey commands and perform spontaneous eye opening and talking.

One month later, the patient mobilized independently with no further involuntary movements or seizures. No abnormalities were found in her routine CSF test, CSF bacteriology, and brain MRI. After 3 months, she remained well and was fully independent in all acts of daily living.

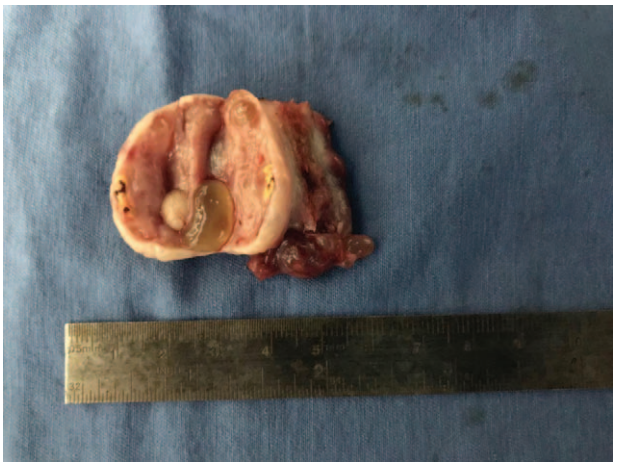

Figure 2. Left ovary tissue after incision reveals a mature cystic teratoma.

The ethical approval was not necessary for this case report. Informed written consent was obtained from the patient for publication of this case report and accompanying images.

3. Discussion

3.1. Method of obtaining information and data

Here, we reviewed studies on teratoma-associated anti-NMDAR encephalitis published up to January 2018 and stored in various databases sources, including PubMed, Web of Science, and the California encephalitis project.[6] The following key words were used for literature retrieval: ("case report") and ("teratoma") and ("anti-NMDAR encephalitis" or "anti-N-methyl D-aspartate receptors encephalitis"). We also manually identified the references of the selected articles for supplement studies. Overall, 11 cases published from 2010 to 2017 were obtained after strict selection (Table 1).

3.2. Epidemiology

Anti-NMDAR encephalitis was first described in 2007.[20] The disease mostly occurs in women and rarely in men and adolescents. The association of psychiatric and neurological symptoms with ovarian teratoma was previously reported in Hong Kong.[21] The overall incidence of the condition remains unknown, but it is high among individuals of Asian or African origin.[21]

3.3. Clinical presentation

Patients with anti-NMDAR encephalitis manifest psychiatric symptoms, usually preceded by fever and headache. Most patients also develop seizures followed by dyskinesia, autonomic symptoms, decreased level of consciousness, and central hypoventilation that requires frequent mechanical ventilation.[22,23] The development of anti-NMDAR encephalitis can be divided into 5 stages that have distinctive clinical manifestations but their boundaries are not strict[4,24–28]: prodromal stage, psychiatric symptom stage, no reaction stage, excessive movement stage, and recovery stage.

3.4. Diagnostic testing

The ectopic expression of the teratoma is speculated to have an anti-NMDAR antibody, which leads to the disease.[7] The possibility of anti-NMDAR encephalitis should be considered for women who present signs of acute abnormal mental behavior, posture and movement disorders (mainly abnormal movements of the mouth, face, and limbs), epilepsy, autonomic dysfunction, and ventilatory disorders. NMDAR-Ab may be found in serum and/or CSF. In several cases, electroencephalogram reveals diffuse delta slowing waves. MRI examination may produce normal results or abnormally high signals, which briefly appear in the cerebral cortex, cerebellum, or medial temporal lobe. Meanwhile, ultrasound, a simple and feasible test, often reveals ovarian occupying that exhibits high echoes, contributing to the diagnosis in time.

In the course of diagnostics, viral and autoimmune diseases and metabolic, toxic, and other types of paraneoplastic limbic encephalitis (such as anti-AMPA receptor encephalitis[29] and anti-GABA receptor encephalitis[30]) should be excluded. The presence of anti-NMDAR antibodies should be confirmed in serum or CSF. All patients should be examined for the presence of tumors, especially ovarian teratoma or testicular germ cell cancer. In a recent case of incidental finding of ovarian teratoma, anti-NMDA-R and glial fibrillary acidic protein (GFAP) antibodies were detected in CSF; as such, GFAP could be a novel biomarker of autoimmune meningoencephalitis.[4,31–33]

3.5. Treatment

An increasing number of studies have reported on anti-NMDAR encephalitis in recent years.[4,31–33] This disease is closely associated with the development of a tumor, particularly teratoma. Identifying the causative factor at the early stage often results in good prognosis.[34] Basic therapeutic management for anti-NMDA encephalitis mainly includes tumor resection and immune therapy[35]; of which, tumor resection is important to the treatment. Furthermore, for most young women, avoiding residual disease is vital to the surgery considering the fertility requirements and protection of the ovary. Therefore, the laparoscopic operation technique of the operator is highly demanded. In the present case, the tumor is only 1 cm in diameter and can be easily neglected. For example, the nerve tissue containing the NMDAR subunit in residual lesions is used as an antigen-inducing antibody, and the patient cannot recover after the operation. For teratoma, laparoscopic surgery should be conducted to prevent leakage of cyst fluid, avoid residual lesions, and protect ovarian function. The use of anesthetics that could target at NMDARs remains controversial because it may alter the activation of the central nervous system by excitatory or inhibitory neurons.[25]

3.6. Prognosis

The prognosis of anti-NMDAR encephalitis is usually better than other types of paraneoplastic encephalitis.[36] Dalmau et al[2] reported that approximately 75% of patients recovered completely or only suffered minor disabilities. Compared with other types of paraneoplastic encephalitis, anti-NMDAR encephalitis differs because it results in a highly specific syndrome, is associated with benign tumors, usually affects young women, and has good prognosis with early treatment. Despite the presence of a tumor, the immune response is not maintained. As such, the contributory role of the prodromal "viral-like" disorder, which by itself or in combination with teratoma set off or enhances the autoimmune response, should be considered. Further investigations must be conducted to understand this disorder. Meanwhile, awareness and diagnosis of anti-NMDAR encephalitis are of extreme importance to pediatricians, gynecologists, general practitioners, and psychiatrists. Complete recovery of patients with anti-NMDAR encephalitis can only be achieved after surgical resection despite the severity of symptoms. Young patients presenting with neuropsychiatric symptoms are occasionally misdiagnosed with psychiatric illness or viral encephalitis.

Given the small number of cases of anti-NMDAR encephalitis reported, comparative results should be interpreted with caution and the disorder must be further investigated.

Table 1

Literature review of cases of ovarian teratoma-associated anti-N-methyl-D-aspartate receptor encephalitis.

No	Study	Age	Prodromal fever or headache	Nervous and mental symptoms	Dyskinesia	Autonomic instability	Central hypoventilation	Memory loss	Seizure	Electroencephalogram	CSF	NMDAR Ab	Ovarian teratoma	Resection surgery	Immunotherapy	Others	Outcome
1	Dalmau et al[7]	22	Fever	Delirious, uncooperative, agitated, demanding, and impulsive and displayed aggressive behavior	None	Tachycardia	Unknown	Unknown	None	Normal	Lymphocytic pleocytosis	Serum (+) and CSF (+)	Mature cystic teratoma (right ovary)	Yes	Intravenous (IV) steroids, IV immunoglobulin (IVIG) and plasma exchange	Olanzapine clonazepam sodium valproate	Completely recovered
2	Lee et al[8]	7	Unknown	Cognitive disturbances	Unknown	Unknown	Unknown	Unknown	Unknown	Diffuse background slowing	Normal	Serum (+) and CSF (+)	Mature cystic teratoma with neural tissue (right ovary)	Yes	Unknown	Unknown	Completely recovered
3	Consoli et al[9]	13	Fever and headache	Agitation	Leg weakness and difficulty walking	Photophobia, phonophobia, nausea and vomitting	Unknown	Unknown	None	Diffuse background slowing	Lymphocytic pleocytosis	CSF (+)	Mature cystic teratoma with neural tissue (right ovary)	Yes	Methylprednis-olone, intravenous immunoglobuli-n and plasma exchanges	Ceftriaxone, vancomycin, and acyclovir	Completely recovered
4	Armangue et al[10]	17	Fever, pharyngeal pain	Speech confusion, and unresponsiveness	None	None	Unknown	Unknown	Unknown	Slow wave	Normal	Serum (-) and CSF (+)	Mature cystic teratoma (left ovary)	Yes	Methylprednisolone and gamma globulin	Chemotherapy	Completely recovered
		16	Low fever	Psychotic disorder and paroxysmal convulsion	Unknown	Unable to urinate or defecate	Unknown	Unknown	Limb twitching and slow reaction	High-amplitude θ waves in the slow waves	Normal	CSF (+), 1:100	High-grade immature teratoma (right ovary)	Yes	Methylprednisolone and gamma globulin	PEB (platinum, etoposide, bleomycin) chemotherapy	Completely recovered
5	Hughes et al[11]	25	Prodromal flu-like symptoms and non-specific headache	Agitation	Orofacial dyskinesia	None	Hypoventilation	Memory impairment	Tonic-clonic seizures	Slow wave	Lymphocytic pleocytosis	Serum (+) and CSF (+)	Mature cystic teratoma/dermoid cyst with mature neuroglial elements resembling a cerebral ventricle	Yes	Intravenous (IV) steroids, IV immunoglobulin (IVIG) and plasma exchange	Rituximab cyclophosphamide	Completely recovered
6	Weiner et al[12]	23	Sudden headache	Personality changes	Unknown	Unknown	Hypoventilation	Unknown	Seizure	Unknown	Normal	Serum (+) and CSF (+)	Bilateral small ovarian teratomas	Yes	Intravenous immunoglobulin and steroids	Acyclovir	Completely recovered
7	Stone et al[13]	30	High fever with headaches	Unknown	Nuchal rigidity	Unknown	Hypoventilation	Unknown	Unknown	Unknown	Unknown	CSF (+)	Mature cystic teratoma of the right ovary	Yes	Intravenous (IV) steroids, IV immunoglobulin (IVIG) and plasma exchange	Unknown	Completely recovered
8	Iizuka et al[14]	33	Unknown	Musical hallucinations	None	Unknown	Unknown	Unknown	Seizure	Normal	Normal	Positive	Immature teratoma	Yes	Intravenous (IV) steroids, IV immunoglobulin (IVIG) and plasma exchange	Bleomycin-etoposide-platinum chemotherapy	Completely recovered
9	Li and Zhao[15]	18	Unknown	Personality changes, involuntary movements, disturbance of consciousness	Unknown	Unknown	Central hypoventilation	Unknown	None	Unknown	Lymphocytic pleocytosis	Serum (+) and CSF (+)	Mature cystic teratoma with components of brain tissue	Yes	Unknown	Cyclophosphamide	Completely recovered
10	Mitra and Afify[16]	33	Prodromal illness	States of terror, insomnia, delirium, self-harm and suicidal ideation	Facial dyskinesias	Verbigeration	Unknown	Memory impairment	None	Slow wave	Normal	Positive	Dermoid cyst	Yes	Unknown	Unknown	Completely recovered
11	Lai et al[17]	21	Headache, fever, mild cough, and vomiting	Agitated	Myoclonic and dystonic movements of all four limbs and trunk	Unknown	Hypoventilation	Unknown	Generalized tonic-clonic seizures	Slow wave	Lymphocytic pleocytosis	Positive	Teratoma	Yes	Unknown	Trihexphenidyl, tetrabenazine, haloperidol, piracetam and bromocriptine	Residual orofacial dyskinesia, dysarthria, a severe cognitive impairment
12	Lancaster et al[18]	19	Unknown	Amnesia and personality changes	Dystonic movements	Unknown	Decreased respiratory drive	Unknown	Resistant seizures	Unknown	Unknown	CSF (+)	Teratoma	Yes	High-dose steroids and plasma exchange	Cyclophosphamide	Near-complete recovery
13	Baltagi et al[19]	20	Unknown	Musical hallucinations	Unknown	Unknown	Hypoventilation	Memory impairment	Seizures	Slow wave	Lymphocytic pleocytosis	CSF (+)	Necrotic mature ovarian teratoma	Yes	Intravenous immunoglobulin and steroids	Unknown	Completely recovered

CSF = cerebrospinal fluid, NMDAR = N-methyl-D-aspartate receptor.

4. Conclusion

Teratoma-related anti-NMDAR encephalitis is a rare disease that has uncertain etiology and pathogenesis. Emphasis is placed on detecting ovarian teratomas and anti-NMDAR antibodies in young women presenting symptoms such as sudden onset of psychiatric symptoms, seizures, decreased level of consciousness, and movement disorders after common cold. Confirming the diagnosis with serological and imaging methods as early as possible and timely laparoscopic surgery may lead to good prognosis.

Author contributions

Conceptualization: Weihua Lou.
Investigation: Bin Yan.
Methodology: Bin Yan.
Resources: Ying Zhang.
Supervision: Weihua Lou.
Writing – original draft: You Wang.
Writing – review & editing: You Wang, Wen Di.

References

[1] Graus F, Titulaer MJ, Balu R, et al. A clinical approach to diagnosis of autoimmune encephalitis. Lancet Neurol 2016;15:391–404.
[2] Dalmau J, Lancaster E, Martinez-Hernandez E, et al. Clinical experience and laboratory investigations in patients with anti-NMDAR encephalitis. Lancet Neurol 2011;10:63–74.
[3] Suhs KW, Wegner F, Skripuletz T, et al. Heterogeneity of clinical features and corresponding antibodies in seven patients with anti-NMDA receptor encephalitis. Exp Ther Med 2015;10:1283–92.
[4] Dalmau J, Gleichman AJ, Hughes EG, et al. Anti-NMDA-receptor encephalitis: case series and analysis of the effects of antibodies. Lancet Neurol 2008;7:1091–8.
[5] Barry H, Byrne S, Barrett E, et al. Anti-N-methyl-d-aspartate receptor encephalitis: review of clinical presentation, diagnosis and treatment. BJPsych Bull 2015;39:19–23.
[6] Fowlkes AL, Honarmand S, Glaser C, et al. Enterovirus-associated encephalitis in the California encephalitis project, 1998-2005. J Infect Dis 2008;198:1685–91.
[7] Mitra AD, Afify A. Ovarian teratoma associated Anti-N-methyl-D-aspartate receptor encephalitis: a difficult diagnosis with a favorable prognosis. Autops Case Rep 2018;8:e2018019.
[8] Leel N, Thakkar HS, Drake D, et al. Ovarian teratoma associated with anti-NMDA (N-methyl D-aspartate) receptor encephalitis. BMJ Case Rep 2018;2018:pii: bcr-2017-220333.
[9] Martin AL, Jolliffe E, Hertweck SP. Ovarian teratoma associated with coexisting anti-N-Methyl-D-aspartate receptor and glial fibrillary acidic protein autoimmune meningoencephalitis in an adolescent girl: a case report. J Pediatr Adolesc Gynecol 2018;31:321–4.
[10] Liang Z, Yang S, Sun X, et al. Teratoma-associated anti-NMDAR encephalitis: two cases report and literature review. Medicine (Baltimore) 2017;96:e9177.
[11] Abdul-Rahman ZM, Panegyres PK, Roeck M, et al. Anti-N-methyl-D-aspartate receptor encephalitis with an imaging-invisible ovarian teratoma: a case report. J Med Case Rep 2016;10:296.
[12] Tantipalakorn C, Soontornpun A, Pongsuvareeyakul T, et al. Rapid recovery from catastrophic paraneoplastic anti-NMDAR encephalitis secondary to an ovarian teratoma following ovarian cystectomy. BMJ Case Rep 2016;2016:pii: bcr2016216484.
[13] Mizutamari E, Matsuo Y, Namimoto T, et al. Successful outcome following detection and removal of a very small ovarian teratoma associated with anti-NMDA receptor encephalitis during pregnancy. Clin Case Rep 2016;4:223–5.
[14] Malayev Y, Alberts J, Verardi MA, et al. Immature teratoma associated with anti-N-Methyl-D-aspartate receptor encephalitis. J Am Osteopath Assoc 2015;115:573–7.
[15] Hayashi M, Motegi E, Honma K, et al. Successful laparoscopic resection of 7 mm ovarian mature cystic teratoma associated with anti-NMDAR encephalitis. Case Rep Obstet Gynecol 2014;2014:618742.
[16] Roberts R, MacDougall NJ, O'Brien P, et al. Not hysteria: ovarian teratoma-associated anti-N-methyl-D-aspartate receptor encephalitis. Scott Med J 2012;57:182.
[17] Lo JW, Leung EY, Ng BL, et al. Anti-N-methyl-D-aspartate receptor encephalitis in a young woman with an ovarian tumour. Hong Kong Med J 2010;16:313–6.
[18] Stover DG, Eisenberg R, Johnson DH. Anti-N-methyl-D-aspartate receptor encephalitis in a young woman with a mature mediastinal teratoma. J Thorac Oncol 2010;5:1872–3.
[19] Dulcey I, Cespedes MU, Ballesteros JL, et al. Necrotic mature ovarian teratoma associated with anti-N-methyl-D-aspartate receptor encephalitis. Pathol Res Pract 2012;208:497–500.
[20] Dalmau J, Tuzun E, Wu HY, et al. Paraneoplastic anti-N-methyl-D-aspartate receptor encephalitis associated with ovarian teratoma. Ann Neurol 2007;61:25–36.
[21] Lee AC, Ou Y, Lee WK, et al. Paraneoplastic limbic encephalitis masquerading as chronic behavioural disturbance in an adolescent girl. Acta Paediatr 2003;92:506–9.
[22] Consoli A, Ronen K, An-Gourfinkel I, et al. Malignant catatonia due to anti-NMDA-receptor encephalitis in a 17-year-old girl: case report. Child Adolesc Psychiatry Ment Health 2011;5:15.
[23] Armangue T, Titulaer MJ, Malaga I, et al. Pediatric anti-N-methyl-D-aspartate receptor encephalitis-clinical analysis and novel findings in a series of 20 patients. J Pediatr 2013;162:850.e2–6.e2.
[24] Hughes EG, Peng X, Gleichman AJ, et al. Cellular and synaptic mechanisms of anti-NMDA receptor encephalitis. J Neurosci 2010; 30:5866–75.
[25] Weiner AL, Vieira L, McKay CA, et al. Ketamine abusers presenting to the emergency department: a case series. J Emerg Med 2000;18:447–51.
[26] Stone JM, Morrison PD, Pilowsky LS. Glutamate and dopamine dysregulation in schizophrenia–a synthesis and selective review. J Psychopharmacol 2007;21:440–52.
[27] Iizuka T, Sakai F, Ide T, et al. Anti-NMDA receptor encephalitis in Japan: long-term outcome without tumor removal. Neurology 2008;70:504–11.
[28] Li S, Zhao A. A case of anti-NMDAR encephalitis induced by ovarian teratoma. Cell Biochem Biophys 2015;71:1011–4.
[29] Lai M, Hughes EG, Peng X, et al. AMPA receptor antibodies in limbic encephalitis alter synaptic receptor location. Ann Neurol 2009;65: 424–34.
[30] Lancaster E, Lai M, Peng X, et al. Antibodies to the GABA(B) receptor in limbic encephalitis with seizures: case series and characterisation of the antigen. Lancet Neurol 2010;9:67–76.
[31] Baltagi SA, Shoykhet M, Felmet K, et al. Neurological sequelae of 2009 influenza A (H1N1) in children: a case series observed during a pandemic. Pediatr Crit Care Med 2010;11:179–84.
[32] Florance NR, Davis RL, Lam C, et al. Anti-N-methyl-D-aspartate receptor (NMDAR) encephalitis in children and adolescents. Ann Neurol 2009;66:11–8.
[33] Verhelst H, Verloo P, Dhondt K, et al. Anti-NMDA-receptor encephalitis in a 3 year old patient with chromosome 6p21.32 microdeletion including the HLA cluster. Eur J Paediatr Neurol 2011;15:163–6.
[34] Miya K, Takahashi Y, Mori H. Anti-NMDAR autoimmune encephalitis. Brain Dev 2014;36:645–52.
[35] Iizuka T, Sakai F. [Anti-nMDA receptor encephalitis–clinical manifestations and pathophysiology]. Brain Nerve 2008;60:1047–60.
[36] Ishiura H, Matsuda S, Higashihara M, et al. Response of anti-NMDA receptor encephalitis without tumor to immunotherapy including rituximab. Neurology 2008;71:1921–3.