The influencing factors and changes of cognitive function within 40 Rasmussen encephalitis patients that received a hemispherectomy

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ABSTRACT
Objective: To evaluate the influencing factors and cognitive functional changes in Rasmussen encephalitis (RE) patients who received a hemispherectomy.
Methods: Forty RE patients underwent a hemispherectomy with at least a 2 years follow-up were included in this study. Postoperative seizure outcomes were evaluated according to the Engel classification scale. Univariate analysis and a multivariate logistic regression model in a backward fashion were used to identify the potential predictors of cognitive function.
Results: All 40 patients had an Engel classification outcome at a 2 years follow-up. Univariate and multivariate analyses revealed that seizure duration (OR 10.06, 95% CI 1.54–3.85, p = 0.038), age at surgery (OR 3.06, 95% CI 1.21–3.56, p = 0.043), and MRI score (OR 0.09, 95% CI 0.01–0.67 p = 0.024) are associated with postoperative cognitive outcomes respectively. Moreover, VIQ and PIQ were negatively correlated linearly with duration of seizures and MRI score. Patients with a good VIQ and PIQ before the operation were more likely to have a better VIQ and PIQ postoperatively (p < 0.001 and p < 0.001, respectively). And, operation side is an important factor affecting cognitive function; therefore, a left hemispherectomy has a greater impact on the patient’s IQ and language. Right-side operation can achieve better postoperative cognitive outcomes especially in VIQ and language. A shorter duration of seizures, early age at surgery, and less severe brain atrophy suggest better cognitive outcomes after a hemispherectomy.

1. Introduction
Rasmussen encephalitis (RE) is a rare neurologic disorder with a prevalence of 2–3 per 10 million [1,2]. It usually occurs in children under the age of 18 years, and the mean age of onset is approximately 6 years [3]. The clinical manifestations are unilateral hemispheric atrophy, focal intractable seizures, and worsening neurological deficits [4,5]. Antiepileptic drugs cannot control the patients’ epileptic seizures, and the only effective treatment for controlling seizures and cognitive deterioration is a hemispherectomy [6]. However, considering the young age of onset and operation risk, most children suffer from this disease for an extended period of time and experience varying degrees of neurological impairment, such as dysphasia, hemiparesis, and mental decline preoperatively [7,8].
Cognitive impairment has been frequently described as a common complication of RE. Frequent seizures and longer disease duration leads to a poor clinical prognosis, especially in cognitive function. The intelligence quotient (IQ) is a common cognitive indicator. A recent study reported that RE patients have different degrees of cognitive impairment, including IQ, language, memory, judgment, and executive functions after a hemispherectomy [9]. Moreover, longitudinal investigations are crucial to evaluate the impact of repeated seizures on the unaffected, contralateral hemisphere of the brain as the disease progresses, given that this may cause additional cognitive impairments [7,10]. Likewise, the parallel decline of verbal and nonverbal abilities suggested progressive bilateral hemispheric involvement, supported by the evidence from MRI morphometry [11]. These events highlight the importance of cognitive changes in determining the optimal timing for a hemispherectomy.
Nowadays, the beneficial effects of a hemispherectomy on RE patients in terms of seizure control are evident. Some scholars have suggested that patients at a younger age who received a hemispherectomy are associated with a higher rate of seizure freedom and better cognitive function. In a previous study, we reported that patients diagnosed with RE and had an IQ greater than 70 were
more likely to suffer from IQ decline but were also more likely to have a higher IQ after surgery [12]. With respect to the time of surgery for patients with RE, the ultimate goal of a hemispherectomy is to achieve a seizure-free status and discontinuation of antiepileptic medication and more importantly, protect the brain function. The influencing factors and changes in pre-and postoperative cognitive function, especially intelligence, and language have not been systematically studied. Herein, we report a case series of 53 patients with RE with the aim to address the above issues.

2. Patients and methods

2.1. Patients

We retrospectively reviewed the records of 53 RE patients with pre-and postoperative cognitive assessment results at our hospital between January 2008 and December 2016. The study was approved by the ethical committee of our hospital. The clinical evaluation of the patients with RE included a medical history and a neurological examination such as video electroencephalogram (EEG), brain magnetic resonance imaging (MRI), and a neuropsychological test. All the examination results must be consistent with the clinical diagnosis of RE according to the 2005 European diagnostic criteria [1].

2.2. Neuroimaging examination

As for MRI examination, T1, T2, and fluid-attenuated inversion recovery (FLAIR) sequences were performed in all patients using a 1.5-T MRI. Furthermore, the brain atrophy score was measured by the MRI image workstation (PACS, Neusoft Corporation, China).

2.3. Neuropsychological testing

For the evaluation of the intelligence profile, the following tests were used: Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R) (4–5y), Wechsler Intelligence Scale for Children-Revised (WISC-R) (6–16y), and Wechsler Adult Intelligence Scale-Revised (WAIS-R) (17 + y). Language measurements including expressive grammar, receptive vocabulary, receptive grammar, semantic association, and instruction comprehension were evaluated via Formulated Sentences (FS) from the Clinical Evaluation of Language Fundamentals (CELF), British Picture Vocabulary Scale (BPVS), Test for Reception of Grammar (TROG), Word Classes (WC) from CELF, and Concepts and Directions (CD) from CELF. Language measurement was analyzed using CD, TROG, WC, FS, and BPVS five measures. Language composite measure (LANG) reflected a composite of CD, TROG, WC, and FS. BPVS reflected the receptive vocabulary component (VOCAB). Preoperative and postoperative (3 months, 6 months, 1 year, and 2 years) neuropsychological test results were collected from patients and assessed by an experienced psychologist. Favorable outcomes were defined as total IQ scores equal or greater than 70, and unfavorable outcomes were defined as those lower than 70.

2.4. Seizure outcomes

Patients were evaluated from 3 months to 2 years postoperatively. Neurosurgeons assessed patients’ clinical outcomes in either the outpatient setting or via a telephone interview according to the Engle classification [13].

2.5. Statistical analysis

All analyses were performed using SPSS Software version 18.0, and p < 0.05 was considered statistically significant. Pearson’s correlation analysis was used to determine the correlation between the duration of seizures, brain atrophy, and changes in pre-and postoperative IQ, VIQ, and PIQ. In the univariate analysis, Chi-square or a Fisher’s exact test was used to explore the association between the clinical characteristics and their relationship with postoperative cognitive outcomes. Variables with a p value < 0.05 within the univariate analysis were entered into a binary logistic regression model in a backward manner. The Mann-Whitney tests were used to analyze and compare the pre-and postoperative cognition of patients that were operated on different sides of the brain.

3. Results

3.1. General characteristics

Due to the loss of follow-up information in 13 patients, 40 patients, including 22 males and 18 females, were evaluated in this study finally. All patients were drug-refractory epilepsy patients. The mean ± standard deviation (SD) age at surgery was 8.73 ± 3.16 years (range = 4 - 16 years), and the course of the disease was 2.18 ± 1.48 years (range = 0.50 - 4.92 years). No significant family histories of febrile seizures or epilepsy were noted. Left-side involvement was noted in 18 patients (45.00%). Apparent preoperative speech disorders such as difficulty in speaking or aphasia were noted in 9 patients (22.50%), and 18 patients (45.00%) had varying degrees of hemiplegia. After diagnosis, all patients received a hemispherectomy.

3.2. Neuroimaging results

MRI results were obtained in all patients. All 40 patients had varying degrees of brain atrophy, primarily located in the frontal lobe, temporal lobe, insula,
and frontotemporal junction. The swollen sulcus and caudate nucleus, particularly the right cerebral hemisphere’s grey and white matter, showed hyperintensity on FLAIR (Figure 1). We used a brain atrophy score (the ratio of the widest anterior horn length of the affected lateral ventricle to that of the healthy side) to evaluate brain atrophy. The MRI score was 1.08 ± 0.32 (range = 0.5 – 2.2). In this series, the MRI results were stratified across MRI scores represented by brain atrophy and brain atrophy was positive linearly related to the duration of seizures (r = 0.679, p < 0.001) (Figure 2(a)).

3.3. Neuropsychological outcomes

In this series, 40 patients underwent pre-and postoperative intellectual assessments from 3 months to 2 years. As shown in Table 1, duration of seizures, age at surgery, MRI score, and concordance of interictal and ictal EEG were associated with postoperative cognitive outcomes (p = 0.008, p = 0.023, p = 0.008, and p = 0.012, respectively). Multivariate analysis revealed that duration of seizures (OR 10.06, 95% CI 1.54–3.85, p = 0.038), age at surgery (OR 3.06, 95% CI 1.21–3.56, p = 0.043), and MRI score (OR 0.09, 95% CI 0.01–0.67 p = 0.024) were associated with postoperative cognitive outcomes respectively (Table 2).

Regarding cognitive function, we focused on the changes in total IQ, PIQ, and VIQ before and after surgery. To determine the optimal timing of surgery, we examined the association between age at hemispherectomy and changes in IQ before and 2 years after the operation. The results showed that the greatest IQ improvement was seen in patients under 6 years of age; however, little improvement or a worse IQ was observed among patients older than 10 (Figure 2(b)).

![Figure 1](image1.png)

Figure 1. MRI characteristics and pathological changes in the brain of RE patients. Unilateral cerebral hemisphere atrophy is a typical MRI feature of RE. Atrophy of the right hemisphere cortex (rough arrows) and widening of the sulcus and caudate nucleus (thin arrows) were determined based on T1 (a), T2 (b), and FLAIR with hyperintense signal (c). MRI score: 16.5/8.8 = 1.9.

![Figure 2](image2.png)

Figure 2. The influencing factors of total IQ (Tot IQ), verbal IQ (Ver IQ) and performance IQ (Per IQ) changes in 40 RE patients. (a) Relationship between MRI score and duration of seizures prior to operation in 40 patients; (b) Relationship between IQ and age in 40 patients before operation; (c) Relationship between Tot IQ, Ver IQ, Per IQ and duration of seizures prior to surgery in 40 patients; (d) Relationship between Tot IQ, Ver IQ, Per IQ and MRI score in 40 patients; (e and f) Relationship between post-and preoperative Ver IQ and Per IQ in 40 patients.
**Table 1.** Clinical characteristics and their relationship with 2 years postoperative cognitive outcomes (n = 40)

| Variable                        | Favorable outcomes | Unfavorable outcomes | P    |
|---------------------------------|--------------------|----------------------|------|
| Sex                             |                    |                      |      |
| Male (n=24)                     | 18                 | 6                    | 0.717|
| Female (n=16)                   | 13                 | 3                    |      |
| Age of onset (year)             |                    |                      |      |
| <3 (n=24)                       | 20                 | 4                    | 0.441|
| 3-11 (n=16)                     | 11                 | 5                    |      |
| Duration of seizures (year)     |                    |                      |      |
| <3 (n=25)                       | 23                 | 2                    | 0.008*|
| 3-11 (n=15)                     | 8                  | 7                    |      |
| Age at surgery (year)           |                    |                      |      |
| 0-10 (n=26)                     | 22                 | 4                    | 0.023*|
| 11-18 (n=14)                    | 9                  | 5                    |      |
| Daily seizure frequency         |                    |                      |      |
| <12 (n=18)                      | 15                 | 3                    | 0.476|
| 12+ (n=22)                      | 16                 | 6                    |      |
| Seizure types                   |                    |                      |      |
| With EPC (n=18)                 | 15                 | 3                    | 0.476|
| Without EPC (n=22)              | 16                 | 6                    |      |
| MRI score                       |                    |                      |      |
| 0-1.0 (n=15)                    | 8                  | 7                    | 0.008*|
| 1.1-2.0 (n=25)                  | 23                 | 2                    |      |
| IEDs                            |                    |                      |      |
| Regional (n=12)                 | 9                  | 3                    | 0.318|
| Multilobe (n=17)                | 15                 | 2                    |      |
| Diffuse (n=11)                  | 7                  | 4                    |      |
| Ictal onset rhythms             |                    |                      |      |
| Regional (n=5)                  | 3                  | 2                    | 0.285|
| Multilobe (n=18)                | 13                 | 5                    |      |
| Hemispheric (n=17)              | 15                 | 2                    |      |
| Concordance of IEDs and ictal onset rhythms | 25 | 3 | 0.012* |
| Discordance (n=12)              | 6                  | 6                    |      |
| Concordance of EEG and MRI      |                    |                      |      |
| Cordance (n=29)                 | 24                 | 5                    | 0.227|
| Cordance (n=29)                 | 7                  | 4                    |      |

Abbreviations: EEG, electroencephalogram; IEDs, interictal epileptic discharges; MRI, magnetic resonance imaging; RE, Rasmussen’s encephalitis

*p < 0.05

**Table 2.** The multivariate logistic regression analyses for predictors of favorable 2 years postoperative cognitive outcomes for RE patients.

| Variable                                                | OR    | 95% CI          | p Value |
|---------------------------------------------------------|-------|-----------------|---------|
| Duration of seizures (<3 year)                          | 10.06 | 1.54–3.85       | 0.038*  |
| Age at surgery (0–10 year)                              | 3.06  | 1.21–3.56       | 0.043*  |
| MRI score (0–1.0)                                       | 0.09  | 0.01–0.67       | 0.024*  |
| Concordance of IEDs and ictal onset rhythms (Cordance)  | 8.33  | 1.95–33.25      | 0.037   |

*p < 0.05

Apart from the age at surgery, the association between duration of seizures, brain atrophy, and PIQ and VIQ were also analyzed. With the extension of duration of seizures, there was a downward trend in preoperative VIQ and PIQ. VIQ was significantly negatively correlated linearly with disease duration (p < 0.05) (Figure 2 (c)). Furthermore, MRI score is linearly related to VIQ and PIQ (p = 0.001 and p = 0.002, respectively). The more severe the brain atrophy, the lower the preoperative VIQ and PIQ (Figure 2(d)). Patients with a good VIQ and PIQ before the operation were more likely to have a better VIQ and PIQ postoperatively (p < 0.001 and p < 0.001, respectively) (Figure 2(e,f)). Although the postoperative total IQ, VIQ, PIQ of some patients decreased at a short time, the overall trend was good after operation (Supplementary Fig. 1A, 1B and 1C). Due to the functional differences between the cerebral hemispheres, the operation side is an important factor affecting cognitive function. To explore the relationship between the side of surgery and pre-and postoperative cognitive function (2 years follow-up), we divided the patients into two groups according to the side of the brain the hemispherectomy was performed. A Man-Whitney test revealed no significant differences between the left-side and right-side groups based on the descriptive variables listed in Table 3 (p > 0.53 in all cases). Furthermore, significant differences were found regarding the side of the brain the hemispherectomy was performed. As for postoperative VIQ and PIQ, right-hemispherectomy RE patients scored higher than left-hemispherectomy patients. Furthermore, the hemispherectomy groups were
further divided into subgroups before and 2 years after the operation. Concerning VIQ, patients in the right-side group performed best with a mean score within the low average range postoperatively, while the other groups’ scores were within the extremely low range (70 or below, Table 4). Statistical analyses showed a significant effect on the side and changes before and after operation (F = 9.06, p = 0.012); Moreover, their interactions were significant (F = 8.74, p = 0.012). A Mann-Whitney with a Bonferroni correction-familywise (p = 0.037) revealed a trend of patients’ 2 years postoperative VIQ in the right-side was better than that in the left-side (U = 5.30, p = 0.048). Furthermore, the pattern of the PIQ results with all groups performing below the average range had a mean score of 75 or below (Table 4). There was a significant effect on the changes before and after the operation (F = 10.38, p = 0.003) and a significant interaction between the effects of the side of the brain and the changes before and after the operation (F = 4.79, p = 0.03). Overall, the PIQ of patients before the operation was better than that at the 2 years follow-up; however, this difference was significant only in the right-side group (U = 0.01, p = 0.007). Therefore, operation side had an effect on VIQ and PIQ, and patients’ VIQ and PIQ with a right-sided hemispherectomy were better than those with a left-sided hemispherectomy at a 2 years of follow-up.

Results from the VOCAB and LANG components were analyzed for language measurement. In all groups except the right-side group with the preoperative examination, mean VOCAB scores were within or just below the average range. No significant main or interaction effects (p > 0.15 in all cases) were detected within the average range. For LANG, the right-side group performed the examination within the average range at the 2 years follow-up. Significant effects of the changes before and after the operation (F = 6.37, p = 0.020), side of the brain the operation was performed (F = 4.15, p = 0.036), as well as their interactions (F = 12.38, p = 0.002), were detected. Overall, Mann-Whitney with a Bonferroni correction-familywise (p = 0.019) revealed that right-side patients performed better than left-side patients especially patients examined in LANG. Therefore, just like VIQ and PIQ, operation side had an impact on LANG, and patients’ LANG with a right-sided hemispherectomy were better than those with left-sided hemispherectomy at a 2 years of follow-up.

### 3.5. Seizure outcomes and surgical complications

All patients had a follow-up of at least 2 years. According to Engel’s criteria, the seizure outcomes at 3 months and 2 years were the same, with 40 patients achieving an Engel class I score.

Postoperative neurological deficits were evaluated in all patients, and the primary manifestations being language and motor impairment. At a 2 years follow-up, 2 patients had aphasia, and both were over the age of 10 at the time of surgery. The hemiparesis in 18 RE patients is as follows: 4 patients (22.22%) were unchanged, 3 patients (16.67%) became worse, and 11 patients (61.11%) health improved. The muscle strength of the contralateral limb in 35 patients (87.50%) reached grade IV and they could walk independently. It is worth noting that with rehabilitation exercise, 4 of the 6 patients in our series between 2 and 5 years old, who were unable to walk at assessment achieved independent walking after more than 1 year of exercise.

### Table 3. Descriptive data for the left (Left-side) and right (Right-side) hemispherectomy in RE patients with two years follow-up.

| Variable                        | Left-side group | S.D. (months) | Range (years; months) | Right-side group | S.D. (months) | Range (years; months) |
|---------------------------------|-----------------|---------------|-----------------------|------------------|---------------|-----------------------|
| Age at seizure onset            | 1; 5            | 26            | Birth to 9            | 3; 8             | 24            | Birth to 8; 4         |
| Age at onset of habitual seizures | 3; 6           | 36            | 0; 2 to 8             | 3; 9             | 34            | 0; 3 to 8; 6          |
| Age at surgery                  | 8; 10           | 40            | 4; 5 to 16; 10        | 9; 2             | 56            | 1; 3 to 13; 8         |
| Age at testing                  | 12; 8           | 52            | 8; 11 to 36; 5        | 13; 4            | 49            | 7; 8 to 32; 10        |

### Table 4. Pre-and postoperative (2 years) intelligence and language scores in the four hemispherectomy subgroups.

| Variable | Mean score (S.D.) | Left-side group | Right-side group | Postoperative (Postoperation) |
|----------|-------------------|-----------------|------------------|-----------------------------|
|          |                   | Preoperation    | Postoperation    | P                           | Preoperation    | Postoperation    | P             |
| VIQ      | 69 (15)           | 63 (14)         | 59 (15)          | 85 (10)                     | 0.018*          | 0.048*           |
| PIQ      | 65 (12)           | 69 (15)         | 54 (5)           | 75 (11)                     | 0.023*          | 0.007*           |
| VOCAB    | –1.38 (1.6)       | –1.52 (1.2)     | –2.26 (0.7)      | –1.08 (1.3)                 | 0.051           | 0.054            |
| LANG     | –1.27 (0.5)       | –1.95 (0.1)     | –1.89 (0.2)      | –0.36 (1.2)                 | 0.022*          | 0.019*           |

*VIQ, Verbal intelligence; PIQ, Performance intelligence; VOCAB, Receptive Vocabulary; LANG, Composite language score*

*p < 0.05
4. Discussion

Hemispherectomy is ultimately used to control seizures and achieve an improved cognitive status [14-16]. Patients who undergo a hemispherectomy usually have uncontrollable seizures and present with a compromised cognitive capacity [17,18]. Regarding the IQ score, observing the effects of a predominantly unilateral brain insult, the findings of an almost parallel decline in both domains of the brain during follow-up were unexpected [14,19]. This may be due to the epileptiform abnormalities spreading from the affected to the unaffected hemisphere [8]. Moreover, RE patients who underwent a hemispherectomy not only controlled the seizures but also protects cognitive function. The study involved 40 RE patients who received a hemispherectomy with at least a 2 years follow-up. This study enables us to delineate the predictors of long-term clinical outcomes in patients with RE especially changes in cognitive function.

The cognitive outcome remains challenging due to insufficient data on intellectual abilities postoperatively. For children, the neuropsychological assessment is different from adults because of developmental, maturational, and reorganizational processes [20]. Therefore, our goal is to analyze the cognitive changes before and after a hemispherectomy and provide treatment strategies for these patients. In our study, 40 RE patients had their pre-and postoperative cognitive outcomes measured. The qualitative analysis of these patients showed that the duration of seizures, age at surgery, and MRI score were correlated with postoperative cognitive outcomes. As for total IQ, there was a correlation between total IQ, VIQ, PIQ, and duration of seizures preoperatively. Patients under 6 years old achieved IQ improvement after the operation. However, little improvement or a worsening of IQ was observed among patients older than 10 who received a hemispherectomy. Some scholars hypothesized that some brain tissues of the affected hemisphere that were still healthy could have been removed in the operation [21,22]. Patients with a good VIQ and PIQ preoperatively were more likely to have a better cognitive outcome postoperatively. These results, like other studies, have shown a shorter interval to seizure onset after surgery. This may protect brain function in the unaffected hemisphere. Moreover, having the surgery before the age of 6 significantly improves motor and cognitive functions [8,18,23,24]. Postponing or avoiding surgery might result in an increase in seizure frequency as well as cognitive deterioration.

The present study also investigated the effects of the hemispheric side of injury on IQ and language. As for VIQ and PIQ, patients presenting with right hemisphere pathology of postoperative examination scored within the average range. However, patients’ VIQ and PIQ with a right-sided pathology of preoperative origin performed worse than the other patients’ groups. From the above results, we can summarize that the right hemisphere contributes to cognitive development. However, VIQ was more impaired in the left than in the right hemisphere group and is consistent with other reports on children who underwent a hemispherectomy. As previous studies have shown, low VIQ was the predictor of poor syntactic abilities [25,26]. Our data is also consistent with previous studies. As for language evaluation, postoperative patients performed better on VOCAB and LANG examinations than preoperative patients. Furthermore, the right-side group performed better than the left-side group. In our study, 2 of the 18 patients who underwent a left hemispherectomy presented with aphasia symptoms. The aphasia was due to the course of the disease before operation in these patients was short and thus, language function had not yet transferred to the right side of the brain [27,28]. Therefore, once the patients are diagnosed with RE, a hemispherectomy should be done as soon as possible.

The decision to operate on RE patients is based on the progression and severity of the symptoms. Total and regional brain volumes as an objective indicator is a significant determinant of intellectual ability in healthy and neurodevelopmental populations [9,29]. This study discussed the correlation between the duration of seizures, VIQ and PIQ and brain atrophy. Moreover, brain atrophy was stratified across the MRI scores. With a prolonged duration of seizures, the brain atrophy of the patients progressively worsened. The longer the duration of seizures, the more severe the brain atrophy; therefore, a correlation between VIQ and PIQ and brain atrophy was observed. The results showed that the more severe the brain atrophy, the lower the VIQ and PIQ. From the above results, we can infer that RE patients with minor brain atrophy and good VIQ and PIQ preoperatively have better clinical outcomes, especially in cognitive function. Our data also shows that language and cognitive dysfunctions are interrelated, both of them can improve after a hemispherectomy, and is consistent with the conclusion from the Silva research results, which reported improved cognitive outcomes after hemispheric surgery in children [7,16,30].

4.1. Limitations

This study had several limitations. First, it was a single-center retrospective study, and the biases inherent to its retrospective design cannot be avoided. Second, seizure outcomes were subjective and were obtained from medical records or telephone interviews without seizure diaries. Third, due to the limited number of patients with complete pre-and postoperative assessment of developmental quotient and
behavior, the research data is inevitably skewed, and long-term follow-up of cognitive progress in our cohort remains to be explored. Despite these limitations, our data may also provide useful information on the surgical treatment of RE.

5. Conclusion

Our research results in cognitively impaired patients contributes encouraging information for RE children who are worried about cognitive impairment postoperatively. Patients with cognitive function impairment must receive a hemispherectomy as soon as possible. The earlier the patients receive a hemispherectomy, the better the postoperative cognitive function outcomes especially in right-sided operations of RE patients.

Disclosure statement

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References

[1] Varadkar S, Bien CG, Kruse CA, et al. Rasmussen’s encephalitis: clinical features, pathobiology, and treatment advances. Lancet Neurol. 2014;13(2):195–205.
[2] Liu D, Wang X, Wang Y, et al. Detection of EBV and HHV6 in the brain tissue of patients with Rasmussen’s encephalitis. Virol Sin. 2018;33(5):402–409.
[3] Hoffman CE, Ochi A, Sneed OC 3rd, et al. Rasmussen’s encephalitis: advances in management and patient outcomes. Childs Nerv Syst. 2016;32(4):629–640.
[4] Bulteau C, Grosmaire C, Save-Pédebos J, et al. Language recovery after left hemispherotomy for Rasmussen encephalitis. Epilepsy Behav. 2015;53:51–57.
[5] Pradeep K, Sinha S, Mahadevan A, et al. Clinical, electrophysiological, imaging, pathological and therapeutic observations among 18 patients with Rasmussen’s encephalitis. J Clin Neurosci. 2016;25:96–104.
[6] Olson HE, Lechpammer M, Prabhu SP, et al. Clinical application and evaluation of the Bien diagnostic criteria for Rasmussen encephalitis. Epilepsia. 2013;54(10):1753–1760.
[7] Griessennauer CJ, Salam S, Hendrix P, et al. Hemispherectomy for treatment of refractory epilepsy in the pediatric age group: a systematic review. J Neurosurg Pediatr. 2015;15(1):34–44.
[8] Granata T, Matricardi S, Ragona F, et al. Hemispherotomy in Rasmussen encephalitis: long-term outcome in an Italian series of 16 patients. Epilepsy Res. 2014;108(6):1106–1119.
[9] Lange N, Froimowitz MP, Bigler ED, et al. Associations between IQ, total and regional brain volumes, and demography in a large normative sample of healthy children and adolescents. Dev Neuropsychol. 2010;35(3):296–317.
[10] Save-Pédebos J, Pinabiaux C, Dorfmuller G, et al. The development of pragmatic skills in children after hemispherectomy: contribution from left and right hemispheres. Epilepsy Behav. 2016;55:139–145.
[11] Rudebeck SR, Shavel-Jessop S, Varadkar S, et al. Pre- and postsurgical cognitive trajectories and quantitative MRI changes in Rasmussen syndrome. Epilepsia. 2018;59(6):1210–1219.
[12] Guan Y, Chen S, Liu C, et al. Timing and type of hemispherectomy for Rasmussen’s encephalitis: analysis of 45 patients. Epilepsy Res. 2017;132:109–115.
[13] Engel Jr JR., Wiebe S, French J, et al. Practice parameter: temporal lobe and localized neocortical resections for epilepsy: report of the quality standards subcommittee of the American Academy of Neurology, in association with the American Epilepsy Society and the American Association of Neurological Surgeons. Neurology. 2003;60(4):538–547.
[14] Cao K, Liu M, Wang C, et al. Five-year long-term prognosis of epileptic children after hemispheric surgery: a systematic review and meta-analysis. Medicine (Baltimore). 2016;95(23):e3743.
[15] Villani F, Didato G, Deleo F, et al. Long-term outcome after limited cortical resections in two cases of adult-onset Rasmussen encephalitis. Epilepsia. 2014;55(5):e38–43.
[16] Moosa AN, Jehi L, Marashly A, et al. Long-term functional outcomes and their predictors after hemispherectomy in 115 children. Epilepsia. 2013;54(10):1771–1779.
[17] Lettori D, Battaglia D, Sacco A, et al. Early hemispherectomy in catastrophic epilepsy: a neuro-cognitive and epileptic long-term follow-up. Seizure. 2008;17(1):49–63.
[18] Korkman M, Granstrom ML, Kantola-Sorsa E, et al. Two-year follow-up of intelligence after pediatric epilepsy surgery. Pediatr Neurol. 2005;33(3):173–178.
[19] Pulsifer MB, Brandt J, Fau - Salorio CF, et al. The cognitive outcome of hemispherectomy in 71 children. Epilepsia. 2004;45(3):243–254.
[20] Costa DI, Azambuja LS, Portugal MW, et al. Neuropsychological assessment in children. J Pediatr (Rio J). 2004;80(7):S111–116.
[21] McGovern RA, A NVM, Jehi L, et al. Hemispherectomy in adults and adolescents: seizure and functional outcomes in 47 patients. Epilepsia. 2019;60(12):2416–2427.
[22] Hu WH, Zhang C, Zhang K, et al. Hemispheric surgery for refractory epilepsy: a systematic review and meta-analysis with emphasis on seizure predictors and outcomes. J Neurosurg. 2016;124(4):952–961.
[23] Kossoff EH, Vining EP, Pillas DJ, et al. Hemispherectomy for intractable unihemispheric epilepsy etiology vs outcome. Neurology. 2003;61(7):887–890.
[24] Northam GB, Liégeois F, Chong WK, et al. Total brain white matter is a major determinant of IQ in adolescents born preterm. Ann Neurol. 2011;69(4):702–711.
[25] Liégeois F, Cross JH, Polkey C, et al. Language after hemispherectomy in childhood: contributions from memory and intelligence. Neuropsychologia. 2008;46(13):3101–3107.
[26] Dennis M, Kohn B. Comprehension of syntax in infantile hemiplegics after cerebral hemidecortication: left-hemisphere superiority. Brain Lang. 1975;2:472–482.
[27] Gröppel G, Dorfer C, Mühlebner-Fahrngruber A, et al. Improvement of language development after successful hemispherotomy. Seizure. 2015;30:70–75.
[28] Silva JR, Sakamoto AC, Thomé Ú, et al. Left hemispherectomy in older children and adolescents: outcome of cognitive abilities. Childs Nerv Syst. 2020;36(6):1275–1282.
[29] Northam GB, Liégeois F, Fau - Chong WK, et al. Total brain white matter is a major determinant of IQ in adolescents born preterm. Ann Neurol. 2011;69(4):702–711.
[30] Silva JR, Sakamoto AC, Thomé Ú, et al. Left hemispherectomy in older children and adolescents: outcome of cognitive abilities. Childs Nerv Syst. 2020;36(6):1275–1282.