Hemispheric surgery for refractory epilepsy: a systematic review and meta-analysis with emphasis on seizure predictors and outcomes

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OBJECTIVE Conflicting conclusions have been reported regarding several factors that may predict seizure outcomes after hemispheric surgery for refractory epilepsy. The goal of this study was to identify the possible predictors of seizure outcome by pooling the rates of postoperative seizure freedom found in the published literature.

METHODS A comprehensive literature search of PubMed, Embase, and the Cochrane Library identified English-language articles published since 1970 that describe seizure outcomes in patients who underwent hemispheric surgery for refractory epilepsy. Two reviewers independently assessed article eligibility and extracted the data. The authors pooled rates of seizure freedom from papers included in the study. Eight potential prognostic variables were identified and dichotomized for analyses. The authors also compared continuous variables within seizure-free and seizure-recurrent groups. Random- or fixed-effects models were used in the analyses depending on the presence or absence of heterogeneity.

RESULTS The pooled seizure-free rate among the 1528 patients (from 56 studies) who underwent hemispheric surgery was 73%. Patients with an epilepsy etiology of developmental disorders, generalized seizures, nonlateralization on electroencephalography, and contralateral MRI abnormalities had reduced odds of being seizure-free after surgery.

CONCLUSIONS Hemispheric surgery is an effective therapeutic modality for medically intractable epilepsy. This meta-analysis provides useful evidence-based information for the selection of candidates for hemispheric surgery, presurgical counseling, and explanation of seizure outcomes.

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KEY WORDS hemispheric surgery; hemispherectomy; hemispherotomy; hemidecortication; meta-analysis; epilepsy

Hemispheric surgery is a well-accepted treatment modality for medically refractory epilepsy induced by hemispheric abnormalities, such as Rasmussen encephalitis, cortical dysplasia, Sturge-Weber syndrome, hemimegalencephaly, or encephalomalacia. Since the anatomical hemispherectomy (AH) procedure was performed by Dandy for glioma in 1928 and introduced by McKenzie for epilepsy in 1938, several hemispheric surgical techniques have been developed, including functional hemispherectomy (FH) and hemispherotomy.^{16,50} The AH technique was classically applied in the 1950s and the 1960s. The popularity of the AH technique declined in

the late 1960s because of its delayed complications such as obstructive hydrocephalus, superficial hemosiderosis, and intracranial hematomata.⁵⁶ The advent of FH, which was first described by Rasmussen in 1983,⁵⁶ has increased the use of hemispheric surgery for drug-resistant epilepsy. However, in 1995, both Schramm et al.⁶¹ and Villemure and Mascott⁷⁷ simultaneously introduced a modified version of the FH technique, termed “hemispherotomy,” that has replaced traditional FH in many epilepsy centers.

In published studies, seizure outcomes in patients who underwent hemispheric surgery for refractory epilepsy have varied, with rates of seizure freedom ranging from

ABBREVIATIONS AH = anatomical hemispherectomy; EEG = electroencephalography; FCD = focal cortical dysplasia; FH = functional hemispherectomy; OR = odds ratio; PET = positron emission tomography; WMD = weighted mean difference.

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33% to 92%.^{22,71} Given the substantial variability in seizure outcomes after surgery, many studies have attempted to identify prognostic variables that may predict postoperative seizure outcomes. Most of these studies focused on predictors such as the etiology of epilepsy,⁵¹ contralateral MRI^{4,51} and electroencephalography (EEG) findings,⁵¹ or surgical techniques.⁶³ However, conflicting results have been reported from these studies. Moreover, little attention has been paid to other possible factors that may correlate with seizure freedom, including seizure semiology or epilepsy duration. In the present study, we performed a systematic review and meta-analysis of published studies involving hemispheric surgery in patients with refractory epilepsy induced by hemispheric diseases. The goals of our study were 1) to calculate the postoperative seizure-free rate pooled from published studies and 2) to identify possible prognostic indicators for seizure outcomes after hemispheric surgery.

Methods

Search Strategy

A comprehensive literature search of PubMed, Embase, and the Cochrane Library was performed by 2 authors using the following terms alone or in combination: hemispherectomy, hemispheric surgery, hemispherotomy, hemidecortication, hemicortectomy, epilepsy, and seizure. The literature search strategy used with PubMed was as follows: (hemispherectomy[TIAB] OR hemispheric surgery[TIAB] OR hemispherotomy[TIAB] OR hemidecortication[TIAB] OR hemicortectomy[TIAB]) AND (epilepsy[TIAB] OR seizure[TIAB]); the limits included publication years 1970–2013 and English-language articles. The bibliographies of original articles, reviews, and book chapters were also searched to find additional relevant studies. Searches were restricted to full-length English-language articles published from 1970 to 2013.

Study Selection, Data Extraction, and Quality Assessment

Two authors independently reviewed the abstract or full text of each retrieved article and applied the following study inclusion criteria: 1) papers contained postoperative seizure outcomes collected from at least 5 patients undergoing hemispheric surgery for refractory epilepsy, 2) papers contained seizure outcomes reported after a mean or median follow-up period ≥ 1 year, and 3) papers contained seizure outcomes measured using Engel's classification scale or other comparable schemes. Studies with possible overlapping patient populations from the same medical center were excluded, and only the most recent or complete study was included in our analysis. When possible, we divided data into dichotomous groups according to the following variables: sex (male vs female), etiology of epilepsy (developmental vs nondevelopmental), seizure semiology (partial only vs generalized), interictal EEG lateralization (present vs absent), ictal EEG lateralization (present vs absent), contralateral MRI abnormalities (present vs absent), surgery type (techniques based on complete cortical removal vs disconnective techniques, as proposed by De Almeida et al.),¹⁹ and side of resection (right vs left).

In the correlation analysis between etiology and seizure outcome, we classified cortical dysplasia, hemimegalencephaly, or tuberous sclerosis complex as developmental etiologies, and we classified other diseases such as encephalomalacia, Rasmussen encephalitis, Sturge-Weber syndrome, or cerebral tumor as nondevelopmental etiologies. In the analyses of dichotomous variables, data for individual variables in each study were excluded if dichotomous groups could not be formed. The primary outcome was seizure freedom as defined by the authors' description from the last reported follow-up in each study. We also extracted data from continuous variables, including patient age at onset, age at surgery, and epilepsy duration. Two authors independently extracted all the data, and discrepancies were resolved through discussion. Because all studies included in the analysis were case-control studies, the methodological quality of individual studies, which was associated with the risk of bias, was evaluated using the modified Newcastle-Ottawa Scale. This scale uses a star-rating system to assess 3 categories, including patient selection, comparability of the study groups, and exposure assessment.

Analysis

The unit of analysis was each published paper. The rates of seizure freedom were pooled from all papers included in the study. Seizure outcomes were compared within dichotomous groups to determine if a significant correlation existed between the variable and seizure outcomes. We also compared continuous variables between seizure-free (Engel Class I) and seizure-recurrent (Engel Class II–IV) groups. The odds ratio (OR) and weighted mean difference (WMD), along with their 95% confidence intervals (CIs), were used in the analysis of dichotomous and continuous variables, respectively. The heterogeneity between studies was assessed by means of Q statistics, and $I^2 \geq 50\%$ was considered substantial heterogeneity. Publication bias was assessed graphically by the use of funnel plots. The analysis of pooled rates of seizure freedom was performed with R version 3.0.2 (R Foundation for Statistical Computing), and the analyses of associations between the variables and seizure outcomes were performed with Review Manager version 5.2 (Revman; the Cochrane Collaboration). Random- or fixed-effects models were used in all analyses, depending on the presence or absence of heterogeneity. When variables were identified as prognostic factors, we performed sensitivity analysis to evaluate the stability of the results by changing the effects models. Statistical significance was set at $p \leq 0.05$.

Results

Evidence Base

The initial literature search yielded 1282 records, of which 807 remained after duplication screening. In the title and abstract review, 242 potentially eligible papers were identified. After a full-text review, a total of 56 articles (representing 1528 patients) fulfilled the predefined inclusion criteria and were included in the study (Fig. 1).^{1,2,4–6,8,12,13,15,17,18,20–24,30–32,34–40,42,44–49,51–55,60,62–64,65,67–76,79–81} As shown in Table 1, all 56 articles are case-control stud-

FIG. 1. Summary of the literature search strategy.

ies that scored 6 or 7 stars on the modified Newcastle-Ottawa Scale.

Pooled Seizure Freedom Rate

The pooled rate of postoperative seizure freedom from the 56 papers was 73% (95% CI 71%–75%) with an I^2 value of 30.8%, which indicated that there was no significant heterogeneity. A funnel plot of the analysis showed that all papers were located within the funnel except for 4, and the distribution of papers included in the study was roughly symmetrical, suggesting a mild publication bias.

Factors Predicting Seizure Outcome

Table 2 shows the results of the 8 meta-analyses performed to assess correlations between dichotomous variables and seizure outcomes. Male and female patients had similar odds of being seizure-free after hemispheric surgery (OR 1.15, 95% CI 0.79–1.67, $p = 0.46$). Patients with epilepsy induced by developmental disorders had lower odds of achieving postoperative seizure freedom (OR 0.61, 95% CI 0.46–0.82, $p = 0.001$; Fig. 2A) than those with epilepsy induced by nondevelopmental diseases. With respect to seizure semiology, the absence of generalized seizures (partial only) was associated with favorable seizure outcomes (OR 1.84, 95% CI 1.18–2.89, $p = 0.008$; Fig. 2B). Lateralized findings on interictal or ictal EEG also appeared to correlate with improved seizure outcomes (interictal: OR 1.66, 95% CI 1.03–2.67, $p = 0.04$, Fig. 2C; ictal: OR

1.88, 95% CI 1.15–3.07, $p = 0.01$, Fig. 3A). The presence of contralateral MRI abnormalities reduced the odds of seizure control after surgery (OR 0.46, 95% CI 0.27–0.77, $p = 0.004$; Fig. 3B). Surgical technique did not affect postoperative seizure outcomes (OR 1.51, 95% CI 0.96–2.36, $p = 0.07$), nor did the side of resection (OR 1.17, 95% CI 0.79–1.73, $p = 0.43$). Q statistics and funnel plots showed there was no significant study heterogeneity or publication bias in each analysis. In the sensitivity analyses for seizure outcome predictors, the random-effects model was used, and the result of each study did not alter.

Table 3 shows comparison data between seizure-free and seizure-recurrent groups with respect to the above-mentioned 3 continuous variables. Patients with poor seizure control appeared to have had a history of earlier seizure onset (WMD 0.43, 95% CI 0.07–0.79, $p = 0.02$) and younger age at surgery (WMD 1.15, 95% CI 0.07–2.23, $p = 0.04$), while substantial heterogeneities across studies in the 2 analyses were noted ($I^2 = 66\%$ and 63% , respectively). The patients in seizure-free and seizure recurrent groups had similar epilepsy durations (WMD 0.55, 95% CI –0.32 to 1.41, $p = 0.22$), and significant study heterogeneity was also observed ($I^2 = 50\%$).

Discussion

In the present study, we performed a systematic review and meta-analysis identifying the rate and predictors of postoperative seizure freedom in 1528 patients (across 56 studies) who underwent hemispheric surgery for medically refractory epilepsy. We found the pooled rate of seizure freedom to be 73% with a 95% CI of 71% to 75%, and the factors associated with favorable seizure outcomes included an epilepsy etiology of nondevelopmental diseases, absence of generalized seizures, lateralized findings on interictal or ictal EEG, and the absence of contralateral MRI abnormalities.

Hemispheric surgical techniques, including AH, FH, hemispherotomy, and their associated modifications, have proven to be effective in refractory epilepsy control. However, according to previous studies and our own analysis, approximately 30% of patients still suffer from persistent seizures after surgery.^{12,20,30} A better understanding of seizure outcome predictors is crucial for neurosurgeons to identify surgical candidates and counsel patients and their families on the possibility of seizure recurrence after surgery. Previous studies have assessed epilepsy etiology as a prognostic indicator of seizure outcome, and conflicting conclusions have been reported.^{40,51,63} The results of the present study are consistent with the opinion of Kossoff et al.,⁴⁰ who reported that developmental disorders negatively influence seizure outcomes. There is a large spectrum of malformations in cortical development; cortical dysplasia was the most common developmental etiology in our analysis. Although the majority of cortical dysplasia is located on 1 hemisphere, bilateral cortical dysplasia was occasionally observed in some patients.^{27,28,41,66,82} Moreover, not all cortical dysplasia could be identified by routine MRI during the preoperative evaluation. A study by Lerner et al. showed that, on average, 37% and 15% of lesions from focal cortical dysplasia (FCD) Type I and

TABLE 1. Studies included in the analyses

Authors & Year	Study Origin	Patient Age at Op (yrs)*	Duration of Epilepsy (yrs)*	Follow-Up (yrs)*	No. & Rate of Seizure Freedom	Total No. of Patients
Basheer et al., 2007	Canada	3.47	NA	6.6	19 (79.17%)	24
Beardsworth & Adams, 1988	UK	11.5	4.37	3.88	7 (70%)	10
Boshuisen et al., 2010	Netherlands	4.1	2.9	6.9	33 (76.74%)	43
Bourgeois et al., 2007	France	6.1	3.64	7.97	8 (100%)	8
Caraballo et al., 2011	Argentina	8.5	4.25	9.5	33 (73.33%)	45
Cats et al., 2007	Netherlands	5.83	3.58	3.25	22 (78.57%)	28
Cook et al., 2004	USA	NA	NA	2	56 (70.89%)	79
Cukiert et al., 2009	Brazil	27	26.61	5.33	12 (85.71%)	14
Dagar et al., 2011	India	9.8	5.3	3.94	30 (85.71%)	35
Daniel et al., 2001	India	10.2	7.2	1.14	5 (83.33%)	6
Davies et al., 1993	USA	18	NA	28	10 (58.82%)	17
Delalande et al., 2007	France	7.89	5.76	4.54	60 (74.07%)	81
Devlin et al., 2003	UK	4.25	NA	3.4	17 (51.52%)	33
Dorfer et al., 2013	Austria	5.5	3.8	3.7	34 (91.89%)	37
Duchowny et al., 1998	USA	1.53	1.48	4.6	9 (75%)	12
Dunn et al., 1995	UK	8.57	7.76	1.86	4 (57.14%)	7
Greiner et al., 2011	USA	8.5	7.6	5.3	42 (77.78%)	54
Honavar et al., 1992	UK	12.5	5.7	NA	9 (90%)	10
Honda et al., 2013	Japan	0.36	0.35	6.57	8 (66.67%)	12
Kanev et al., 1997	USA	NA	NA	3.17	7 (87.50%)	8
Kawai et al., 2014	Japan	14.8	12.65	5.36	6 (85.71%)	7
Kestle et al., 2000	USA	4.49	NA	3	14 (87.50%)	16
Kim et al., 2008	ROK	NA	NA	NA	6 (85.71%)	7
Kishima et al., 2013	Japan	1.2	NA	6.93	4 (66.67%)	6
Korkman et al., 2005	Finland	10.75	NA	1	6 (85.71%)	7
Kossoff et al., 2003	USA	6.78	3.57	4.5	68 (64.76%)	105
Lee et al., 2014	ROK	NA	NA	NA	9 (69.23%)	13
Lettori et al., 2008	Italy	2.25	2.01	6.5	14 (73.68%)	19
Lew et al., 2014	USA	9.1	7.0	3.5	40 (83.33%)	48
Liang et al., 2013	China	21.96	17.72	3.15	22 (88%)	25
Limbrick et al., 2009	USA	NA	NA	28.6	38 (77.55%)	49
Lindsay et al., 1987	UK	11.88	10.01	12.56	14 (82.35%)	17
Marras et al., 2010	Italy	7.3	3.2	4.5	8 (61.54%)	13
Moosa et al., 2013	USA	7.02	5.15	5.3	112 (65.88%)	170
Ogunmekan et al., 1989	Canada	2.16	1.84	NA	5 (50%)	10
Otsuki et al., 2013	Japan	NA	NA	NA	12 (66.67%)	18
Ramantani et al., 2013	Germany	6.7	4.9	3.3	43 (82.69%)	52
Ramesha et al., 2009	India	10.44	4.23	2.78	6 (66.67%)	9
Scavarda et al., 2009	Canada	7	5.25	0.875	7 (87.5%)	8
Schramm et al., 201262	Germany	30	20.41	10.33	22 (81.48%)	27
Schramm et al., 201263	Germany	7.3	5.1	8.25	78 (84.78%)	92
Schropp et al., 2006	Germany	1.28	0.99	7.1	5 (62.5%)	8
Shimizu & Maehara, 2000	Japan	6.9	5.5	NA	18 (66.67%)	27
Smith et al., 1991	Canada	13.5	9.4	5.8	18 (75%)	24
Sugimoto et al., 1999	Canada	1.31	0.9	3.08	8 (72.72%)	11
Tan et al., 2000	China	12	7	6.7	6 (75%)	8
Terra-Bustamante et al., 2007	Brazil	7.5	4.83	4.21	21 (55.26%)	38
Törmä et al., 1971	Finland	10.5	NA	5.67	2 (33.33%)	6

(continued)

TABLE 1. Studies included in the analyses (continued)

Authors & Year	Study Origin	Patient Age at Op (yrs)*	Duration of Epilepsy (yrs)*	Follow-Up (yrs)*	No. & Rate of Seizure Freedom	Total No. of Patients
Torres et al., 2011	Canada	5.5	3.42	2.55	10 (76.92%)	13
Tubbs et al., 2005	USA	9.8	5.8	15.6	5 (100%)	5
Verity et al., 1982	Canada	7.5	6.12	10	6 (85.71%)	7
Villarejo-Ortega et al., 2013	Spain	5.9	4.63	3.1	10 (58.82%)	17
Villemure et al., 2006	Switzerland	8	NA	5	34 (91.89%)	37
Winston et al., 1992	USA	5.6	5.0	7.8	8 (72.72%)	11
Wyllie et al., 1997	USA	NA	NA	NA	11 (68.75%)	16
Yu et al., 2012	China	NA	NA	NA	17 (89.47%)	19

NA = not available; ROK = Republic of Korea; UK = United Kingdom.

* Mean or median value.

TABLE 2. Associations between dichotomous variables of interest and seizure outcomes

Variable	Outcome		OR (95% CI)	p Value	I ²	Included Studies*
	Seizure Free	Seizure Recurrence				
Sex						
Male	239	94	1.15 (0.79–1.67)	0.46	0%	6 stars on NOS: 2, 31, 38, 44, 46, 55, 60, 64, 68, 71, 72
Female	170	72				7 stars on NOS: 8, 18, 20, 22–24, 32, 39, 48, 51, 70, 74, 75
Etiology						
Developmental	239	121	0.61 (0.46–0.82)	0.001	0%	6 stars on NOS: 21, 35, 38, 44, 46, 62, 68, 72
Nondevelopmental	529	152				7 stars on NOS: 1, 8, 12, 20, 22–24, 30, 39, 40, 45, 49, 51, 54, 63, 70, 75, 76
Seizure semiology						
Partial only	160	57	1.84 (1.18–2.89)	0.008	0%	6 stars on NOS: 2, 13, 31, 35, 44, 52, 62, 64, 68, 71, 72
Generalized	119	67				7 stars on NOS: 45, 51, 70, 75
Interictal EEG						
Lateralized	197	58	1.66 (1.03–2.67)	0.04	0%	6 stars on NOS: 72
Nonlateralized	111	47				7 stars on NOS: 4, 30, 45, 51, 54
Ictal EEG						
Lateralized	237	71	1.88 (1.15–3.07)	0.01	0%	6 stars on NOS: 72
Nonlateralized	67	39				7 stars on NOS: 4, 30, 45, 47, 51, 54
Contralateral MRI						
Abnormal	50	36	0.46 (0.27–0.77)	0.004	10%	6 stars on NOS: 64
Normal	189	57				7 stars on NOS: 4, 45, 51, 54, 75
Surgical technique						
Disconnective	202	70	1.51 (0.96–2.36)	0.07	45%	6 stars on NOS: 5, 44, 46
Cortical removal	102	51				7 stars on NOS: 1, 12, 36, 45, 51, 70
Side of resection						
Right	188	56	1.17 (0.79–1.73)	0.43	0%	6 stars on NOS: 2, 5, 13, 31, 35, 44, 46, 52, 55, 60, 62, 64, 68, 71, 72
Left	217	78				7 stars on NOS: 8, 18, 20, 22–24, 32, 39, 48, 54, 67, 70, 74, 75

NOS = Newcastle-Ottawa Scale.

* Numbers to the right of the colon indicate reference numbers.

FIG. 2. Meta-analysis of seizure freedom with regard to epilepsy etiology (A, developmental vs nondevelopmental), seizure semiology (B, partial only vs generalized), interictal EEG findings (C, lateralized vs nonlateralized).

II, respectively, were MRI negative.⁴³ The contralateral lesions from MRI-undetectable cortical dysplasia could be independently epileptogenic, and we postulate that they might account for the observed seizure recurrences after

hemispheric surgery. Based on the above-mentioned evidence, comprehensive preoperative evaluation, including neuroimaging or neuroelectrophysiological examinations, should be performed on patients with suspected devel-

FIG. 3. Meta-analysis of seizure freedom with regard to ictal EEG findings (A, lateralized vs nonlateralized) and contralateral MRI abnormalities (B, present vs absent).

opmental disorders. Great efforts have been made to improve the detection of cortical dysplasia in patients with epilepsy.^{9,11,58,78} These novel techniques might be helpful for identifying bilateral cortical dysplasia in candidates for hemispheric surgery.

There are only 2 reports addressing the correlation between seizure semiology and seizure outcomes after hemispheric surgery, and no significant correlation was found because of the relatively small patient populations.^{45,51} In the present article, data extracted from 14 studies involving 391 patients indicate that patients with preoperative generalized or secondary generalized seizures were more likely to suffer from recurrent seizures than those without a history of generalized seizures. Similar to our findings, previous studies investigating epilepsy surgery for FCD,⁵⁷ temporal lobe epilepsy,³³ extratemporal lobe epilepsy,²⁵ and tuberous sclerosis complex²⁶ have suggested that generalized seizures appear to be a predictive factor for poor seizure control. We speculate that generalized seizures may be a manifestation of diffuse epileptogenic lesion(s), which may affect the contralateral hemisphere. Previous neuroelectrophysiological and neuroimaging studies suggest that generalized seizures are associated with multifocal irritative areas and more extended hypometabolism on fluorodeoxyglucose positron emission tomography (PET).^{3,59}

Although scalp EEG is a routine preoperative examination for epilepsy surgery, there were conflicting opinions on the value of EEG in the evaluation of hemispheric surgery candidates. Some studies have suggested interictal or ictal bilateral EEG abnormalities did not predict poor outcomes following hemispherectomies.^{29,30} Moreover, Ciliberto et al. performed hemispherotomy on 7 patients with bilateral seizure onset, and they found that all patients improved in seizure control and overall quality of life.¹⁰ However, when taking seizure freedom into account, only 3 of the 7 patients were seizure-free after surgery, indicating that the seizure-free rate (43%) in their series was much lower than the pooled rate (73%) in our analysis. Carmant et al. suggested that preoperative EEG examinations were helpful in assessing the risk of seizure recurrence in patients undergoing an evaluation for hemispherectomy.⁷ Similar results were observed in our study; patients with lateralized interictal or ictal EEGs were more likely to be seizure-free after surgery as compared with those patients with bilateral abnormalities in EEGs.

Boshuisen et al. first reported that contralateral MRI abnormalities negatively affected postoperative seizure outcomes in patients who underwent hemispherectomy.⁴ Although other studies disagreed with their report, the majority of studies showed considerable, but not statistically significant, trends that the presence of contralateral

TABLE 3. Comparisons of continuous variables between seizure-free and seizure-recurrent groups

Variables	WMD (95% CI)	p Value	I ²	Included Studies
Age at seizure onset (yrs)	0.43 (0.07–0.79)	0.02	66%	6 stars on NOS: 2, 13, 44, 46, 52, 62, 64, 72
Age at op (yrs)	1.15 (0.07–2.23)	0.04	63%	7 stars on NOS: 0, 22–24, 48, 51, 54, 67, 70, 75
Epilepsy duration (yrs)	0.55 (–0.32–1.41)	0.22	50%	

MRI abnormalities were associated with seizure recurrence.^{51,54,75} In the present study, we pooled the above-mentioned studies together and found statistical significance without substantial heterogeneity.

At least 3 limitations should be noted in the present meta-analysis. First, although the etiology of epilepsy, EEG, and MRI findings were identified as seizure outcome predictors in our study, we were not able to analyze the correlations among the 3 predictors in a meta-analysis. A study by Döring et al. demonstrated that bilateral EEG abnormalities were more common in hemispherectomy candidates with developmental etiology than in candidates with nondevelopmental etiology, both interictally and ictally.¹⁴ These studies raised the question of whether EEG or MRI findings could independently affect the postoperative seizure outcome. Moosa and colleagues identified lateralized ictal EEG onset as a positive predictor of seizure freedom in their univariate analysis, but the multivariate analysis confirmed that it was not an independent predictor.⁵¹ Second, studies published in the non-English literature were not included in this analysis, which may lead to selection bias. Third, moderate-to-substantial heterogeneity was observed in some analyses, which was probably explained by the varieties of participants, preoperative evaluation, and surgical techniques in different epilepsy centers.

An important point we want to emphasize here is that although developmental disorders, generalized seizures, nonlateralization on EEG, and contralateral MRI abnormalities were identified as relative risk factors of seizure recurrence, each single factor should not be exclusively considered as an absolute contraindication to hemispheric surgery. The decision to perform hemispheric surgery must be made on the basis of the clinical evidence in its entirety, including epilepsy etiology, seizure semiology and severity of the epilepsy, EEG, MRI, cognitive conditions, and risk of neurological deficits after surgery.

Conclusions

In conclusion, hemispheric surgery for medically intractable epilepsy leads to favorable seizure outcomes, with a seizure-free rate of 73%. Developmental disorders, generalized seizures, nonlateralization on EEG, and contralateral MRI abnormalities are relative risk factors of seizure recurrence after hemispheric surgery. However, given the limitations of the present study, more studies should be performed to examine our conclusions. In addition to the above-mentioned risk factors, other factors including the severity of the epilepsy, cognitive conditions, and the risk of new neurological deficits should be considered when making surgical decisions.

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Disclosure

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Conception and design: JG Zhang. Acquisition of data: Hu, C Zhang. Analysis and interpretation of data: Hu, C Zhang, K Zhang. Drafting the article: Hu. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: JG Zhang. Statistical analysis: Hu, C Zhang.

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