Global Outcomes of Epilepsy Surgery in Drug-Resistant Focal Epilepsy: A Longitudinal Survey

Jedsada Thaweepoksomboon MD*, Yotin Chinvarun MD, PhD*,
Siraruj Sakoolnamarka MD**, Chesda Udommongkol MD, PhD*, Pasiri Sithinamsuwan MD*

** Division of Neurology, Department of Medicine, Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand*
*** Division of Neurosurgery, Department of Surgery, Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand*

Objective: *Epilepsy surgery has been established for treatment of drug-resistant focal epilepsy. We aimed to determine long-term outcomes of epileptic surgery in various aspects including seizure outcome, quality of life, and psychosocial consequences after surgery.*

Material and Method: *A single center, cross-sectional study was conducted. The patients with drug-resistant focal epilepsy who underwent epileptic surgery for at least one year were recruited.*

Results: *Thirty-seven adult drug-resistant epilepsy patients after epileptic surgery were enrolled with an average follow-up period of 5.8 years. Twenty-three (62.2%) had temporal lobe epilepsy (TLE) and 14 (37.8%) had neocortical epilepsy. Four were (10.8%) compatible with lesional negative refractory epilepsy. Hippocampal sclerosis was the most common etiology (45.9%), followed by focal cortical dysplasia/gliosis (21.6%) and brain tumor (21.6%). The three commonest postoperative complications were any medical illnesses (18.9%), memory impairment (18.9%), and visual filed defect (13.5%). Twenty patients (54.1%) had no complications. Seizure outcomes, employment status, quality of life, depression, frank psychosis, and number of antiepileptic drug (AED) between pre- and post-surgical period (interviewing time) were compared. Engel Class I (seizure freedom) was persistently achieved in 19 (51.4%) patients. There were nine (24.3%) patients in Engel Class II, eight (21.6%) in Engel Class III, and one (2.7%) in Engel Class IV. Seizure outcome, quality of life, and self-assessment were improved after epileptic surgery at any age groups, duration of epilepsy, epileptogenic zone, and side of operation. In some subgroups, it was found that income was increased and number of AED was reduced. However, depression and frank psychosis did not change the outcome. On self-assessment, global impression of change in memory showed 27% improvement and 32.4% no change. For language and communication skills, 29.7% was improved but 21.6% was worsened.*

Conclusion: *In this longitudinal study, epilepsy surgery showed improvement in seizure control, quality of life, and some neuropsychological aspects.*

Keywords: *Global outcome, Epilepsy surgery, Drug resistant focal epilepsy*

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Epilepsy is the second most common neurological disorder, more than 50 million people worldwide have epilepsy (World Health Organization, 2001). There are a lot of burdens to patients and caregivers. Those are not only physiological dysfunctions but also psychosocial impairments[1,2]. Patients with epilepsy have significantly poorer health-related quality of life and higher rates of comorbidities compared to general population. The physical hazards of unpredictable seizures and social stigma associated with seizures contribute to lower rates of employment, lower education levels, and self-esteem, result in many consequences to this population[1,2].

Correspondence to:
Sithinamsuwan P, Division of Neurology, Department of Medicine, Phramongkutklao Hospital and College of Medicine, Bangkok 10400, Thailand.
Phone: +66-2-3547600 ext. 93027, Fax: +66-2-3547637
E-mail: pasiripmk@gmail.com

Epileptic patients whose seizures do not successfully respond to antiepileptic drug therapy are considered to have drug-resistant epilepsy. This condition is also called intractable, medically refractory, or pharmacoresistant epilepsy. Approximately 20 to 40% of patients with epilepsy are likely to have refractory epilepsy[3]. A task force of the International League against Epilepsy proposes that drug-resistant is defined as the failure of adequate trials of two tolerated, appropriately chosen, and administered antiepileptic drugs to achieve seizure freedom[4]. Resective epilepsy surgery is the treatment of choice for drug-resistant focal epilepsy and gain the most likely chance of producing seizure remission[5-8].

There was only one randomized controlled study published in short-term efficacy and safety of epilepsy surgery related to medication[9]. To date, data available on long-term seizure control and quality of

life outcomes after surgery is negligible[8,10,11]; therefore, we conducted a longitudinal survey studying on the aspects of global long-term outcome of epileptic surgery in medical resistant focal epilepsy at our Epilepsy center. We hypothesized that the benefit of epilepsy surgery through seizure burdens and psychosocial outcomes are durable over a patient's lifetime.

Material and Method

General description

This was a single center, cross-sectional study to determine seizure outcomes, quality of life and psychosocial consequences of patients underwent epilepsy surgery for treatment of drug-resistant focal epilepsy at Phramongkutklao Hospital between 2002 and 2012. Medical record reviews and direct interviews were performed.

Study population

All patients, whose seizures were poorly controlled by medication, operated by a neurosurgeon (S.S.) were eligible. Patients had regularly followed-up at Neurological Clinic, Phramongkutklao Hospital for more than one year before enrolment. The patients who consented to the study were directly interviewed in person and/or by telephone. They also completed questionnaires. There were different pre-surgical evaluations i.e., lesionectomy of pathologic foci, standard anterior temporal lobectomy, neocortical temporal lobe resection, focal neocortical epilepsy such as frontal lobe and parietal lobe. Informed consent was done in every patient.

Data collection

A direct interview during follow-up visit by telephone visit obtained current information on demographic data, seizure status, functional or neurological performance, quality of life, and psychological aspects was performed by one interviewer (J.T.). All eligible patients were retrospectively reviewed their information during pre-surgical evaluation, operative note, and postoperative complications by using hospital-based electronic medical records and inquiry to each patient. Telephone visits were performed on some patients.

Outcomes assessment

Seizure outcomes were evaluated using the Engel Classification System, seizure frequency during pre-surgical evaluation as well as the present seizure status and global impression of change reported by each patient. Engel Class I indicates freedom from disabling seizures, Engel Class II indicates rare disabling seizures, and Engel Class III and IV indicate worthwhile improvement and no worthwhile improvement, respectively[5]. Therefore, we evaluated both objective outcome (seizure frequency and Engel Classification) and subjective outcome (self-rating questionnaires).

To measure quality of life and psychosocial outcomes, we incorporated the Short Form (SF) Health Surveys by SF8 questionnaire [http://www.sf-36.org/demos/SF-8.html], depression scores by Patient Health Questionnaire-9 (PHQ-9)[12], employment status and monthly income, working performance, self-reporting of global impression of change in several aspects including activity of daily living (ADL), mental status, physical ability, memory function, language and communication, feeling independence, self-esteem, driving capability, social interaction, and caregiver burden in our survey. The patients were asked to estimate their conditions at present compared to before surgery. Postoperative complications were reviewed from medical records and personal interviews.

We assessed seizure outcomes, employment status, quality of life, depression, frank psychosis, and number of antiepileptic drug (AED) between pre- and post-surgical periods (at interviewing time). Subgroup analysis included: 1) age at surgery (less than 40 and more than 40 years), 2) duration of epilepsy before surgical treatment (less than 10 years and more than 10 years), 3) epileptogenic zone [mesial temporal lobe epilepsy (mTLE) and neocortical epilepsy], and 4) side of surgery (left or right) were also compared between pre- and post-surgical periods.

Statistical analysis

Continuous data were reported as mean, standard deviation (SD) and nominal and ordinal data as number and percent. Chi-square and independent sample t-test were analyzed between groups and paired t-test was compared for pre and post treatment analysis. Characteristics of patients with and without follow-up data were compared using Wilcoxon signed rank test (for continuous variables) and Chi-square test or Fisher's exact test (for categorical variables). The p-value <0.05 indicates statistically significant difference. The data analysis was generated using SPSS software version 15.0.

Results

Over 11 years' experience, between 2002 and 2012, we collected 37 patients who underwent surgical treatment for drug-resistant focal epilepsy at Phramongkutklao Hospital. Mean age was 38.6 years old (SD 10.1). Seventeen (45.9%) patients were male and 20 (54.1%) were female. Thirty-five patients (94.6%) were right handed. The mean age at the epilepsy onset was 18.1 (SD 11.5) years old. The mean interval of the epilepsy onset to resection time was 15.2 (SD 9.2) years. The mean interval between postoperative and interviewing period was 5.8 (SD 3.2) years (range 13-134 months). The clinical features of the entire group were summarized in Table 1.

Table 1. Demographic characteristics and operative finding (n = 37)

Variables	Number (%) or mean ± SD
Age (years)	38.6±10.1
Male:female	17.0 (45.9):20.0 (54.1)
Right handedness	35.0 (94.6)
Age at epilepsy onset (years)	18.1±11.5
Duration of epilepsy before surgery (years)	15.2±9.2
Duration of epilepsy after surgery to interviewing time (years)	5.8±3.2
Multiple seizure (≥3) types	5.0 (13.5)
MRI positive lesion	33.0 (89.2)
Special investigation performed	
PET scan	4.0 (10.8)
SPECT scan	10.0 (27.0)
Subdural electrodes implantation	13.0 (35.1)
Location	
mTLE (left:right)	13.0 (35.1):10.0 (27.0)
Neocortical epilepsy (left:right)	7.0 (18.9):7.0 (18.9)
Type of surgery	
ATL	20.0 (54.1)
Lesionectomy	6.0 (16.2)
Focal cortical resection	11.0 (29.7)
Pathological finding	
HS	17.0 (45.9)
- Unilateral HS	15.0 (40.5)
- Bilateral HS	2.0 (5.4)
Gliotic change and FCD	8.0 (21.6)
Tumor (DNET & ganglioglioma)	6.0 (16.2)
Vascular anomaly	3.0 (8.1)
Dual pathology	3.0 (8.1)
Undetermined	4.0 (10.8)

ATL = anterior temporal lobectomy; HS = hippocampal sclerosis; MRI = magnetic resonance imaging; mTLE = mesial temporal lobe epilepsy; FCD = focal cortical dysplasia, DNET = dysembryoplastic neuroepithelial tumor; PET = positron emission tomography; SPECT = single photon emission computed tomography

Pre-surgical evaluations including MRI brain and video-EEG monitoring were investigated in all patients. Thirty-three patients (89.2%) had focal abnormalities detected by MRI brain, 3/33 patients (8.1%) showed multiple lesions. MRI-negative refractory seizures were identified in four patients (11.8%). Special investigations were performed in some selective patients [4 (10.8%) for PET and 10 (27%) patients for SPECT scan]. Pre-operative intracranial subdural electrode implantation was performed in 13/37 patients (35.1%). All patients were identified ictal onset zones for resection, which were frontal lobe (frontal lobe epilepsy nine cases, 24.3%), temporal lobe (mesial temporal lobe epilepsy (TLE) 23 cases, 62.2% and neocortical TLE two case, 5.4%), parietal lobe (parietal lobe epilepsy two cases, 5.4%), and occipital lobe (occipital lobe epilepsy one case, 2.7%). The ictal onset zone were analyzed to left side 20/37 and right side 17/37.

Resective surgery was performed based on both non-invasive and invasive data available. Type of surgery comprised of 20 (54.1%) patients with standard anterior temporal lobectomy, six (16.2%) lesionectomy, and 11 (29.7%) focal cortical resection. Pathological finding showed 17 (45.9%) hippocampal sclerosis, eight (21.6%) gliotic change and focal cortical dysplasia (FCD), six (16.2%) tumor (dysembryoplastic neuroepithelial tumor and ganglioglioma), three (8.1%) vascular anomaly, three (8.1%) dual pathology, and four (10.8%) undetermined pathological reports (Table 1).

Postoperative complications (n = 17) were shown as Fig. 1. Three commonest complications were any medical illnesses (18.9%), memory impairment (18.9%), and visual field defect (13.5%). Subdural electrode implantation did not increase postoperative complications. Twenty patients (54.1%) had no postoperative complications. All complications nevertheless were transient and not severe.

Outcomes after epilepsy surgery

Our patients were followed between 13 and 134 months after surgery (average 5.83 years). The most favorable seizure outcome, defined as an Engel Class I, was persistently achieved in 19 (51.4%) patients. Engel Class II and III were nine (24.3%) and eight (21.6%) patients respectively. Only one patient was compatible with the poorest seizure outcome

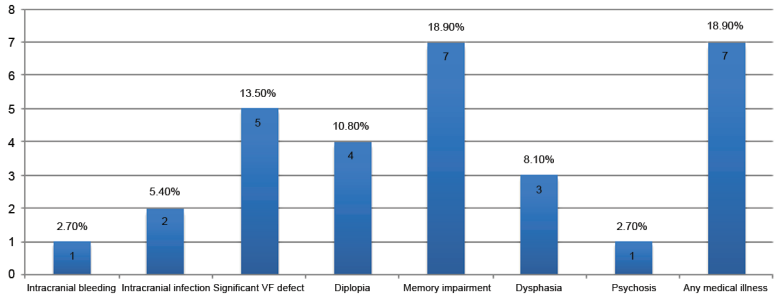

Fig. 1 Postoperative complications (n = 17), VF = visual field.

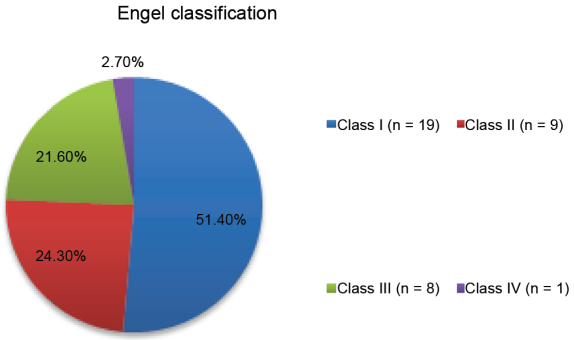

Fig. 2 Seizure outcome by Engel Classification at interviewing time.

(Engel Class IV) (Fig. 2). The average monthly seizure frequencies, determined 3-month before surgery vs. 3-month before interviewing period were reduced from 11.4 to 1.6/month, with the mean difference of 9.8/month and *p*-value <0.001 (Table 2).

In terms of global impression of change, as shown in Table 3, 35 (94.6%) patients had improvement of their seizure status and 26/35 patients (70.3%) had much better condition. Only one patient (2.7%) had no difference and one (2.7%) had worse seizure outcome. Patients had also improved in many aspects, including ADL (54% of the patients), mental status (59.4%), physical fitness (56.7%), memory function (27%),

Table 2. Comparison between pre- and post-operative: seizure outcome and psychosocial aspects

Outcomes	Before surgery (n = 37)	Interviewing period (present) (n = 37)	*p*-value
Seizure frequency(/month), assessed for 3 months			
Mean ± SD (range)	11.4±16.1 (2-90)	1.6±3.7 (0-20)	<0.001
Employment			
Number of unemployment, n (%)	7 (18.9)	3 (8.1)	0.162
Income (baht/month) (n = 24), median (range)	6,750 (0-60,000)	11,000 (0-70,000)	<0.001
Improved performance (self-rating)	-	59.5%	
Quality of life questionnaire (SF8)			
Mean total score	43.5±7.2	52.5±5.7	<0.001
Mean physical score	46.3±8.9	53.7±4.9	0.020
Mean mental score	40.7±10.0	50.4±9.0	<0.001
Good, n (%)	16 (43.2)	33 (89.2)	
Fair, n (%)	13 (35.1)	2 (5.4)	
Bad, n (%)	8 (21.6)	2 (5.4)	
Depression (PHQ-9)			
Mean depression score	7.0±5.4	6.0±4.5	0.242
No depression, n (%)	14 (37.8)	15 (40.5)	
Mild, n (%)	12 (32.4)	12 (32.4)	
Moderate, n (%)	6 (16.2)	9 (24.3)	
Moderately severe, n (%)	4 (10.8)	0	
Severe, n (%)	1 (2.7)	1 (2.7)	
Frank psychosis	6 (16.2)	4 (10.8)	0.160
Number of anti-epileptic drug	3.0±0.8	2.4±1.4	0.003

QoL = quality of life, good QoL ≥45, fair 39-44, bad ≤38; PHQ-9 = patient health questionnaire for depression, no depression 0-4, mild depression 5-8, moderate 9-14, moderately severe depression 15-19, severe depression 20-27

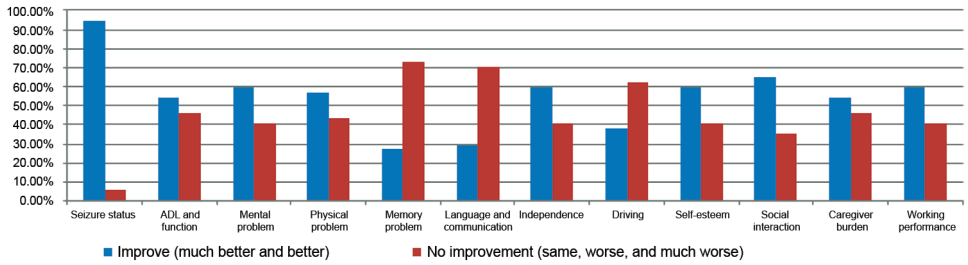

Fig. 3 Global impression of change (self-rating).

language and communication (29.7%), independence (59.4%), driving (37.8%), self-esteem (59.4%), social interaction (64.8%), and improved caregiver burden (54%). Some patients reported of getting worse in memory (40.5%) and language (21.6%). Overall self-ratings of global impression of change were summarized in Fig. 3 with more favorable outcomes in most aspects except memory function, language and communication, and driving capability.

One of the most important parts of daily living is the employment issue. Our data from intractable epileptic patients shows that 7/37 (18.9%) were unemployed before surgical treatment. The number of unemployment was decreased after surgery [3 (8.1%), *p*-value 0.162]. Furthermore, twenty-two (59.5%) patients improved their career performance and earned more income compared to before surgery (14,958.3 vs. 8,895.8 baht/month, *p*-value <0.001) (Table 2).

Quality of life (QoL) evaluated by SF8 questionnaire showed significantly more numbers of good QoL in patients after surgery [before surgery (43.2%) vs. present (89.2%)]. Depression by PHQ-9 seems to have no difference. We found six (16.2%) patients with frank psychosis before surgery and four (10.8%) any time after surgery.

Subgroup analysis of many factors, including age at surgery, duration of epilepsy before surgical treatment, location, and side of epileptogenic pathology, were analyzed and we compared outcomes between pre- and post-operation. In the aspect of seizure frequency and quality of life, it was found that there were statistically significant improvements after surgical treatment in all subgroups. Patients in every group significantly earned more income, except in neocortical epilepsy group, increased their income but no statistical significance. There was no significant change in depression and frank psychosis between each sub-group. Neocortical epilepsy seems to have less benefit than the other because only getting better in seizure frequency and quality of life but had no improvement in other aspects. Number of AED showed significantly decreased in subgroup of age more than 40 years, mTLE, short duration of epilepsy before surgery and right sided surgery. In summary, all subgroups showed benefits from epilepsy surgery

Table 3. Global impression of change (self-rating)

	Much better	Better	Same	Worse	Much worse
Seizure status	26 (70.3%)	9 (24.3%)	1 (2.7%)	0	1 (2.7%)
ADL and function	15 (40.5%)	5 (13.5%)	16 (43.2%)	1 (2.7%)	0
Mental problem	10 (27.0%)	12 (32.4%)	9 (24.3%)	5 (13.5%)	1 (2.7%)
Physical problem	10 (27.0%)	11 (29.7%)	15 (40.5%)	1 (2.7%)	0
Memory problem	5 (13.5%)	5 (13.5%)	12 (32.4%)	12 (32.4%)	3 (8.1%)
Language and communication	6 (16.2%)	5 (13.5%)	18 (48.6%)	7 (18.9%)	1 (2.7%)
Independence	12 (32.4%)	10 (27.0%)	15 (40.5%)	0	0
Driving	9 (24.3%)	5 (13.5%)	22 (59.5%)	1 (2.7%)	0
Self-esteem	12 (32.4%)	10 (27.0%)	14 (37.8%)	1 (2.7%)	0
Social interaction	9 (24.3%)	15 (40.5%)	13 (35.1%)	0	0
Caregiver burden	15 (40.5%)	5 (13.5%)	17 (45.9%)	0	0

ADL = activity of daily living

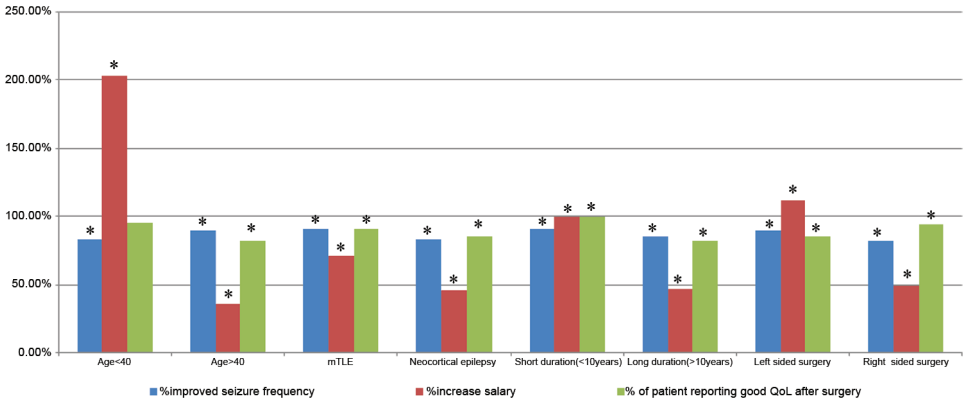

Fig. 4 Percent of improvement between subgroup analysis, * *p*-value <0.05.

especially in seizure status and quality of life and earned more income, as shown in Fig. 4.

Discussion

The elimination of seizures by surgical intervention would be expected to decrease morbidity and mortality, in addition to provide opportunities for improving self-esteem, independence, greater social opportunity and less caregiver burden[3,6]. Outcome of epilepsy surgery affects not only on the seizure freedom but also on psychosocial consequences. Accordingly, quality of life has been recognized as an important component of epilepsy care, especially as the potential influence on the patient's life[7,8,12]. Assessment of global long-term outcomes is essential in brain surgery for epilepsy, which is an irreversible intervention for a chronic condition[2].

Previous studies revealed that 48 to 84% of patients were seizure-free after temporal lobe resection, 66 to 70% at short-term (less than 5 years) and 41 to 79% at long-term (more than 5 years) follow-up[13,14]. On the other hand, 36 to 76% of patients were seizure-free after neocortical resection[14,15]. Comparing to the present study, 15 patients (65.2%) achieved seizure free or Engel Class I after temporal lobectomy and four patients (28.6%) after neocortical resection. The overall seizure freedom in both groups was 51.4%, as Fig. 2. Direct comparison of seizure freedom rates derived across various surgical series may appear to be conflicting with difference in pre-surgical investigation especially in source-limited country. In addition, the lack of long-term follow-up in many of the previous studies may lead to be inconclusive in surgical outcomes because the results may not be sustained over a period of more than five years[2].

Determination of long-term relapsed risk and prognosis are still inconclusive because of small number of the available information[2,10,14]. Various factors may influence the early and the long-term seizure control[14,16]. Although the probable reason for seizure recurrence is still obscure, the initial early seizure recurrence may be explained by incorrect localization of the epileptic focus, leading to inappropriate or even incomplete resection. On the other hand, the later recurrence with slow rate is more likely attributed to the progressive manifestation of potential epileptogenicity, new development of epileptogenesis or the influence on habit changes after surgery that can aggravate seizure such as the usage of antiepileptic drugs, sleep cycle, alcohol consumption, and psychosocial impact[10,16]. This suggests that the epileptic focus is not stable over time because the initial success in seizure control will be followed by the delayed development of active epileptic foci[10,16].

Our data from patients who had experience surgical treatment with mean interval of 5.8 years after surgery showed relatively good long-term outcomes in many aspects, but did not indicate any subgroup or significant predicting factors for better outcome. This may be due to the limited number of patients and mixed study groups with many types of epilepsy. Generally, the long-term effectiveness and safety of epilepsy surgery cannot be concluded due to absence of randomized controlled trial. Nevertheless, our data strongly supported that the benefit of epilepsy surgery in the aspect of seizure control and quality of life relatively remained durable over the patient's lifetime. In our study, all patients revealed statistically significant improvement after epilepsy surgery in various aspects in particular seizure status and quality of life. For employment status, especially income and number of

AED were improved in most subgroup. However, there was no benefit of surgery in the aspects of depression and frank psychosis. Regarding safety concern, no serious long-term complication was reported in the present study.

Epilepsy surgery is associated with specific cognitive changes. Nonetheless, it may also improve cognition in some patients[17]. In systematic review and pooled estimates of neuropsychological outcomes after epilepsy surgery revealed that an estimated risk to verbal memory decline with left-sided temporal surgery is 44%, twice as high as the rate for right-sided surgery (20%) and language outcomes assessed by Boston naming test have reduced naming capability 34% in left-sided temporal patients and only 4% patients with gains[17]. Comparing to the present study, self-rating of memory function reported by each patient showed 27% improved vs. 40.5% unfavorable outcomes. On the same way, language, and communication were 29.7% improved vs. 21.6% worse outcomes. Indispensably estimates the risk of decline in neuropsychological consequences after epilepsy surgery would assist surgical decision making in clinical practice and should be carefully applied to the patient individually. Longitudinal data to assess the consequences of surgical treatment needed to be explored in further studies particularly in randomized controlled study.

Conclusion

Epilepsy surgery should be considered to all patients with drug-resistant focal epilepsy. It is acceptable for long-term outcomes that patients would receive some benefits after epilepsy surgery, especially in seizure control, quality of life and some neuropsychological outcomes.

What is already known on this topic?

From the previous study, it was found that the outcome especially seizure-free after epileptic surgery depended on location of the epileptic focus. Temporal lobe resection in temporal lobe epilepsy showed 48 to 84% seizure free, while resection in neocortical epilepsy showed 36 to 76%[13-15].

What this study adds?

There is no data available in Thailand although there have been many epileptic centers in Thailand. We found that seizure-free after temporal lobe resection was 65.2% and neocortical resection was only 28.6%. Overall seizure freedom in both groups was 51.4%. Therefore, this should alert us to improve our pre-surgical evaluation and surgical techniques in order to improve the outcome especially in epilepsy surgery in neocortical area.

Potential conflicts of interest

None.

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ผลลัพธ์ในภาพรวมของการผ่าตัดรักษาโรคลมชักที่ดื้อยา: การติดตามระยะยาว

เจษฎา ทวีโภคสมบูรณ์, โยธิน ชินวลัญช์, สิรรุจน์ สกุลณะมรรคา, เจษฎา อุดมมงคล, พาสิริ สิทธินามสุวรรณ

ภูมิหลัง: *การผ่าตัดรักษาโรคลมชักจะทำในโรคลมชักชนิดเฉพาะที่ที่มีการดื้อยารักษา ผู้นิพนธ์ต้องการศึกษาผลลัพธ์ระยะยาวของการผ่าตัดรักษาโรคลมชักดื้อยาในแง่ผลการควบคุมชัก คุณภาพชีวิต และสภาพทางจิตหลังจากผ่าตัด*

วัสดุและวิธีการ: *ศึกษาในแนวตัดขวางจากโรงพยาบาลพระมงกุฎเกล้าในผู้ป่วยโรคลมชักที่ดื้อต่อการรักษาที่ได้รับการผ่าตัดรักษาติดตามผู้ป่วยอย่างน้อย 1 ปี*

ผลการศึกษา: *จากผู้ป่วย 37 ราย ที่เป็นโรคลมชักชนิดเฉพาะที่ที่ดื้อยาได้รับการผ่าตัดรักษาโรคลมชัก ระยะเวลาเฉลี่ยในการติดตามคือ 5.8 ปี 23 ราย (ร้อยละ 62.2) เป็นโรคลมชักจากเทมเพอรอลโลบ (temporal lobe epilepsy, TLE) 14 ราย (ร้อยละ 37.8) เป็นโรคลมชักจากนีโอคอร์ติคอล (neocortical epilepsy) มี 4 ราย (ร้อยละ 10.8) เข้าได้กับโรคลมชักดื้อยาที่ไม่พบรอยโรคในสมอง (lesional negative refractory epilepsy) ภาวะ hippocampal sclerosis เป็นสาเหตุที่พบบ่อยที่สุด (ร้อยละ 45.9) รองลงมาคือภาวะ focal cortical dysplasia/gliosis (ร้อยละ 21.6) และเนื้องอกสมอง (ร้อยละ 21.6) ภาวะแทรกซ้อนจากการผ่าตัดที่พบบ่อย คือ ภาวะผิดปกติทางอายุรกรรม (ร้อยละ 18.9) ความจำแย่ลง (ร้อยละ 18.9) และลานสายตาผิดปกติ (ร้อยละ 13.5) ไม่พบภาวะแทรกซ้อนร้อยละ 54.1 ผลการผ่าตัดพบสามารถควบคุมอาการชักแบบ Engel Class I (ปราศจากชัก) 19 ราย (ร้อยละ 51.4) แบบ Engel Class II 9 ราย (ร้อยละ 24.3) แบบ Engel Class III 8 ราย (ร้อยละ 21.6) และ แบบ Engel Class IV 1 ราย (ร้อยละ 2.7) ผลการผ่าตัดทำให้คุมอาการชักได้ดี เพิ่มคุณภาพชีวิต ในทุกอายุ ผู้ป่วยบางรายพบว่ามีรายได้จากการประกอบอาชีพเพิ่มขึ้น หรือ สามารถลดยากันชักลง ยกเว้นกรณีที่ผู้ป่วยมีภาวะซึมเศร้าจะไม่เปลี่ยนแปลงผลการรักษาทางด้านการควบคุมอาการชัก เมื่อให้ผู้ป่วยประเมินผลลัพธ์โดยรวมทางด้านความจำ พบว่าดีขึ้นร้อยละ 27 และไม่เปลี่ยนแปลงร้อยละ 32.4 และผลประเมินด้านการใช้ภาษาและการสื่อสารพบว่าดีขึ้นร้อยละ 29.7 และแย่ลงร้อยละ 21.6*

สรุป: *การติดตามในระยะยาวพบว่าการผ่าตัดรักษาโรคลมชักสามารถคุมอาการชักได้ดี เพิ่มคุณภาพชีวิต และทำให้สภาพทางจิตบางอย่างดีขึ้น*