Epilepsy & Behavior 47 (2015) 1–5

Contents lists available at ScienceDirect

Epilepsy & Behavior

journal homepage: www.elsevier.com/locate/yebeh

Academic achievement one year after resective epilepsy surgery in children

Klajdi Puka [a], Maryam Khattab [b], Elizabeth N. Kerr [a], Mary Lou Smith [a,b,c,*]

[a] Department of Psychology, The Hospital for Sick Children, 555 University Ave, Toronto, ON M5G 1X8, Canada
[b] Department of Psychology, University of Toronto Mississauga, 3359 Mississauga Rd, Mississauga, ON L5L 1C6, Canada
[c] Neurosciences and Mental Health Program, The Hospital for Sick Children, 555 University Ave, Toronto, ON M5G 1X8, Canada

ARTICLE INFO

Article history:
Received 26 March 2015
Revised 23 April 2015
Accepted 25 April 2015
Available online 15 May 2015

Keywords:
Reading
Spelling
Arithmetic
Cognition
Outcome
Pediatric

ABSTRACT

Purpose: Few studies have examined the academic functioning of children following pediatric epilepsy surgery. Although intellectual functioning has been more thoroughly investigated, children with epilepsy may experience additional difficulties with academic skills. This study examined the academic outcomes of a cohort of children who underwent pediatric epilepsy surgery on an average 1.2 (standard deviation [SD]: 0.3) years prior.
Methods: Participants were 136 children (mean age: 14.3 years, [SD]: 3.7 years) who had undergone resective epilepsy surgery. Academic functioning was assessed presurgery and postsurgery using standardized tests of reading, reading comprehension, arithmetic, and spelling.
Results: At baseline, 65% of the children displayed low achievement (1 SD below test mean), and 28% had underachievement (1 SD below baseline IQ) in at least one academic domain. Examining change over time revealed that reading, numeral operations, and spelling significantly declined among all patients; seizure freedom at follow-up (attained in 64% of the patients) did not influence this relationship. Reading comprehension and IQ remained unchanged. Similar findings were found when examining patients with a baseline IQ of ≥70 and when controlling for IQ. Regression analyses revealed that after controlling for IQ, demographic and seizure-related variables were not significantly associated with academic achievement at follow-up.
Conclusions: Results show baseline academic difficulties and deteriorations following surgery that go beyond IQ. Further investigations are required to determine whether the observed deteriorations result from the development of the child, the course of the disorder, or the epilepsy surgery itself. Long-term studies are warranted to identify the progression of academic achievement and whether the observed deteriorations represent a temporal disruption in function.

1. Introduction

There is an immense range of variability in the cognitive functioning of children with epilepsy, with IQ ranging from <1st percentile to >99th percentile [1]; however, even children with average intelligence are commonly found to have deficits in specific cognitive functions, such as academic achievement [2]. Additionally, academic difficulties have been found to predate the onset of seizures and persist over the long term even among children receiving academic support [3]. In fact, approximately 50% of children with epilepsy have been found to have academic difficulties [4], and, consequently, children with epilepsy are at a higher risk of academic underachievement. Underachievement, occurring when the child's performance falls significantly below what is expected based on the child's IQ, is distinct from low achievement, which is performance below the population mean and is independent of IQ. A recent population-based study in the United Kingdom found that 72% of children with new/recent onset of seizures displayed low achievement in at least one academic subtest and that 42% of children displayed underachievement in at least one subtest [5]. Hence, although academic difficulties may result from a low IQ, that is not always the case, and children with epilepsy may additionally experience specific deficits in academic skills that interfere with school achievement.

Few studies have examined academic functioning following pediatric epilepsy surgery. Of the studies that have examined some aspects of academic functioning, small samples were examined, making it difficult to identify factors associated with performance after surgery. One study examined reading and spelling in a group of patients who underwent temporal lobe (n = 9) and frontal lobe (n = 10) resections, finding no significant differences between the groups or over time [6]. Similar results were found among a group of surgical and nonsurgical patients with intractable epilepsy who were examined at baseline and at one-year follow-up on tests of reading decoding, reading comprehension, arithmetic, and spelling [7]. However, a more recent study found that among

* Corresponding author at: Department of Psychology, University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON L5L 1C6 Canada. Tel.: +1 905 828 3960; fax: +1 905 569 4326.
E-mail address: marylou.smith@utoronto.ca (M.L. Smith).

http://dx.doi.org/10.1016/j.yebeh.2015.04.062
1525-5050/

patients with temporal lobe resections, reading accuracy significantly declined the year following surgery, whereas reading comprehension and spelling remained unchanged [8]. Overall, the outcome of academic functioning following pediatric epilepsy surgery is unclear as the few studies conducted have evaluated small groups of children and have yielded inconsistent results. The current study examined the academic functioning of a large cohort of children before and, on average, one year following epilepsy surgery in childhood. The large sample size utilized by the current study allowed for the examination of factors potentially associated with change following surgery.

2. Methods

2.1. Patients

All patients underwent resective epilepsy surgery between 1995 and 2013 at the Hospital for Sick Children in Toronto, Ontario. Prior to surgical evaluations, seizures in all patients had failed to improve from at least two trials of antiepileptic drugs (AEDs). The inclusion criterion was that patients had to have had academic testing as part of neuropsychological evaluation in their presurgical and postsurgical follow-up assessments. Patients who underwent hemispherectomy or corpus callosotomy were excluded as these patients may have marked neurological impairments, and the procedures may be performed for reasons other than complete seizure control. One-hundred thirty-six children, 5.0 to 18.8 years of age at the time of surgery, were included in the study. Carbamazepine and levetiracetam were used most frequently at follow-up by patients with seizures (43.7% and 24.1%, respectively) and by patients without seizures (40.8% and 22.4%, respectively). A small subset of patients (≤40) included in this study have also been included in previous reports which have examined specific populations with epilepsy [6,8] or multiple cognitive and psychosocial outcomes [7].

2.2. Procedure and neuropsychological tests

All patients underwent a comprehensive neuropsychological assessment before and, on average, 1.17 years after surgery (SD: 0.30 years; range 0.75 to 2.75 years). As part of these clinical evaluations, patients completed standardized tests of academic skills using the Wechsler Individual Achievement Test (WIAT or WIAT-II) [9,10], the Wide Range Achievement Test [11], or the Woodcock–Johnson Test of Achievement [12] to assess reading decoding (reading), reading comprehension, spelling, and arithmetic. Reading and reading comprehension were assessed by the patients' ability to read individual words and their ability to respond orally to questions regarding the content of passages, respectively. Spelling and arithmetic were assessed by the ability to spell (in writing) dictated words and by solving paper-and-pencil math computations, respectively. Patients were included in the study if they had data on at least one of these academic tests. Additionally, Full Scale IQ was assessed using the Wechsler Intelligence Scales [13,14]. Raw scores from the IQ and all academic tests were converted to standard scores, with a population mean of 100 and a standard deviation (SD) of 15. All patients were tested by an experienced psychometrician. Some patients did not finish all tests because of noncooperation or time limitations. The study was approved by the Research Ethics Board of the Hospital for Sick Children.

3. Results

Demographic and seizure-related variables and results of independent samples *t*-tests and χ^2 analyses are presented in Table 1. At follow-up, seizure-free patients (64%) were using fewer AEDs compared with patients who continued to experience seizures. However, the majority of patients continued to use at least one AED, following the institution's practice of weaning medications after a two-year seizure-free period. Patients with continued seizures and seizure-free patients did not significantly differ on other demographic and epilepsy-related variables.

Table 1
Demographic and epilepsy characteristics of patients with continued seizures and seizure-free at follow-up.

	Seizure-free (n = 87)	With seizures (n = 49)	*p*-Value
Sex, male n (%)	40 (46)	22 (45)	.903
Age at epilepsy onset, year, mean (SD)	6.6 (4.6)	6.9 (4.1)	.665
Age at surgery, year, mean (SD)	13.0 (3.6)	13.3 (3.4)	.690
Age at baseline, year, mean (SD)	12.3 (3.6)	12.5 (3.7)	.788
Age at follow-up, year, mean (SD)	14.2 (3.7)	14.5 (3.7)	.621
Follow-up period, year, mean (SD)	1.1 (0.3)	1.2 (0.4)	.232
Duration of epilepsy, year, mean (SD)[a]	6.4 (4.2)	7.5 (4.2)	.134
Percent of life with epilepsy, mean (SD)	45.7 (26.5)	51.9 (4.2)	.179
No. of AEDs at follow-up, n (%)			.009
0	6 (6.9)	0 (0.0)	
1	37 (42.5)	12 (24.5)	
≥2	44 (50.6)	37 (75.5)	
Side of focus, right n (%)[b]	42 (48)	21 (43)	.543
Site of focus, temporal n (%)[c]	40 (46)	21 (43)	.725
Pathology[d], n			
Malformation of cortical development	18	11	
Tumor	21	13	
Vascular malformation and infarct	4	1	
Gliosis	14	5	
Dual pathology	21	13	
Other[e]	6	2	
No discernible pathology/unknown	3	4	

[a] Calculated as age at onset subtracted from age at surgery (for seizure-free patients) or from age at follow-up (for patients with seizures).
[b] No cases of bilateral/generalized seizure focus.
[c] Categorized as temporal vs. extratemporal, the latter also including patients with a focus in temporal and extratemporal regions.
[d] Pathology was determined by histopathological analysis.
[e] Other includes 2 tuberous sclerosis, 2 cysts, 1 mesial temporal sclerosis, 1 neurofibromatosis type I, 1 encephalitis, and 1 augmented population of oligodendrocyte-like cells.

Table 2 shows the percentage of participants who, at baseline, presented with low achievement (≥1 SD below test mean) and underachievement (≥1 SD below baseline IQ), and Table 3 presents the academic and IQ scores at baseline and follow-up. Before surgery, 65% of the patients showed low achievement in at least one academic test, whereas 28% showed underachievement in at least one academic test. Examining change from baseline to follow-up, 2 × 2 (seizure status × time) analyses of variance (ANOVA) were conducted for each academic subtest and for IQ. A significant effect of time revealed that patients with continued seizures and seizure-free patients declined in reading ($F(1,127) = 28.25$, $p < .001$, $\eta_p^2 = .182$), arithmetic ($F(1,122) = 8.25$, $p = .005$, $\eta_p^2 = .063$), and spelling ($F(1,120) = 7.84$, $p = .006$, $\eta_p^2 = .061$) from baseline to follow-up. Significant interactions or main effects of seizure status were not found. Similar results are found when using change in IQ as a covariate or when examining patients with a baseline IQ of ≥70.

In examining significant change at the individual level, a meaningful clinical change was categorized as an improvement or decline in the scores of at least 10 points; this criterion has been used previously in studies examining cognitive outcomes after surgery [15,16]. The results were similar to those emanating from the group analyses, in that more patients showed declines compared with improvements, irrespective of seizure status, for reading ($\chi^2(1) = 17.16$, $p < .001$) and arithmetic

Table 2
Percentage of children at baseline presenting with low achievement (≥1 SD below test mean) and underachievement (≥1 SD below assessed IQ) on academic tests.

	Low achievement	Underachievement
Any subtest	65%	28%
Reading	35%	8%
Reading comprehension	41%	7%
Arithmetic	58%	22%
Spelling	39%	9%