Université de Lausanne - Faculté de biologie et de médecine

Département Médico-Chirurgical de Pédiatrie

Service de Pédiatrie

Reversible acquired epileptic frontal syndrome and CSWS suppression in a child with congenital hemiparesis treated by hemispherotomy

THESE

préparée sous la direction du Professeur associé Eliane Roulet-Perez
et présentée à la Faculté de biologie et de médecine de l'Université de Lausanne
pour l'obtention du grade de

DOCTEUR EN MEDECINE

par

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Originaire de Saint-Sulpice (VD)

Lausanne

2009

UNIL | Université de Lausanne
Faculté de biologie
et de médecine

Ecole Doctorale
Doctorat en médecine

Imprimatur

Vu le rapport présenté par le jury d'examen, composé de

Directeur de thèse	*Madame le Professeur associé*	***Eliane Roulet-Perez***
Co-Directeur de thèse		
Expert	*Monsieur le Professeur ad personam*	***François Ansermet***
Directrice de l'Ecole doctorale	*Madame le Professeur*	***Stephanie Clarke***

la Commission MD de l'Ecole doctorale autorise l'impression de la thèse de

Madame Christine Kallay-Zetchi

intitulée

Reversible acquired epileptic frontal syndrome and CSWS suppression in a child with congenital hemiparesis treated by hemispherotomy

Lausanne, le 31 mars 2009

pour Le Doyen
de la Faculté de Biologie et de Médecine

Madame le Professeur Stephanie Clarke
Directrice de l'Ecole doctorale

Rapport de synthèse

Reversible acquired epileptic frontal syndrome and CSWS suppression in a child with congenital hemiparesis treated by hemispherotomy

Cette thèse a étudié en détail le cas d'un enfant souffrant d'une hémiplégie congénitale sur un infarctus prénatal étendu qui a développé une forme particulière d'épilepsie, le syndrome des pointes ondes continues du sommeil (POCS), associé à une régression mentale massive. Les caractéristiques de cette détérioration pointaient vers un dysfonctionnement de type frontal. Une chirurgie de l'épilepsie (hémisphérotomie) a, non seulement, permis la guérison de l'épilepsie mais une récupération rapide sur le plan comportemental et cognitif, suivie d'une reprise plus lente du développement, avec finalement à l'âge de 11 ans un niveau de déficience intellectuelle modérée.

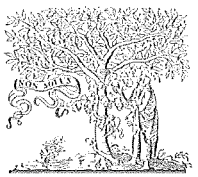
L'intérêt de cette étude réside dans le fait que l'enfant a pu être suivi prospectivement entre l'âge de 4.5 ans et 11 ans par des enregistrements électro-encéphalographiques (EEG) ainsi que des tests neuropsychologiques et des questionnaires de comportements sériés, permettant de comparer les périodes pré-, péri- et postopératoires, ce qui est rarement réalisable. Un enregistrement EEG de surface a même pu être effectué durant l'opération sur l'hémisphère non lésé, permettant de documenter l'arrêt des décharges épileptiformes généralisées dès la fin de l'intervention.

L'hypothèse que nous avons souhaité démontrer est que la régression comportementale et cognitive présentée par l'enfant après une période de développement précoce presque normale (retard de langage) était de nature épileptique : nous l'expliquons par la propagation de l'activité électrique anormale à partir de la lésion de l'hémisphère gauche vers les régions préservées, en particulier frontales bilatérales. L'hémisphérotomie a permis une récupération rapide en déconnectant l'hémisphère gauche lésé et épileptogène de l'hémisphère sain, qui a ainsi pu reprendre les fonctions cognitives les plus importantes. Les progrès plus lents par la suite et l'absence de rattapage au delà d'un niveau de déficience mentale modérée sont plus difficiles à expliquer: on postule ici un effet de l'épilepsie sur le développement de réseaux neuronaux de l'hémiphère initialement non lésé, réseaux qui sont à la fois à un stade précoce de leur maturation et en cours de réorganisation suite à la lésion prénatale.

La littérature sur les déficits cognitifs avant et après hemisphérotomie s'est surtout préoccupée du langage et de sa récupération possible. À notre connaissance, notre étude est la première à documenter la réversibilité d'une détérioration mentale avec les caractéristiques d'un syndrome frontal après hémisphérotomie.

La chirurgie de l'épilepsie a offert ici une occasion unique de documenter le rôle de l'activité épileptique dans la régression cognitive puisqu'en interrompant brusquement la propagation de l'activité électrique anormale, on a pu comparer la dynamique du développement avant et après l'intervention. La mise en relation des multiples examens cliniques et EEG pratiqués chez un seul enfant sur plusieurs années a permis d'obtenir des informations importantes dans la compréhension des troubles cognitifs et du comportement associés aux épilepsies focales réfractaires.

EUROPEAN JOURNAL OF PAEDIATRIC NEUROLOGY XXX (2008) 1–9



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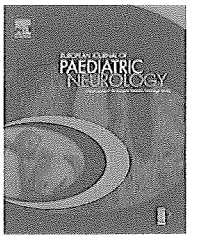

Reversible acquired epileptic frontal syndrome and CSWS suppression in a child with congenital hemiparesis treated by hemispherotomy

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ARTICLE INFO

Article history:
Received 22 January 2008
Received in revised form
3 August 2008
Accepted 19 August 2008

Keywords:
Epilepsy
CSWS
Hemispherotomy
Frontal syndrome
Development
Regression

ABSTRACT

A boy with a right congenital hemiparesis due to a left pre-natal middle cerebral artery infarct developed focal epilepsy at 33 months and then an insidious and subsequently more rapid, massive cognitive and behavioural regression with a frontal syndrome between the ages of 4 and 5 years with continuous spike-waves during sleep (CSWS) on the EEG. Both the epilepsy and the CSWS were immediately suppressed by hemispherotomy at the age of 5 years and 4 months. A behavioural-cognitive follow-up prior to hemispherotomy, an per-operative EEG and corticography and serial post-operative neuropsychological assessments were performed until the age of 11 years. The spread of the epileptic activity to the "healthy" frontal region was the cause of the reversible frontal syndrome. A later gradual long-term but incomplete cognitive recovery, with moderate mental disability was documented. This outcome is probably explained by another facet of the epilepsy, namely the structural effects of prolonged epileptic discharges in rapidly developing cerebral networks which are, at the same time undergoing the reorganization imposed by a unilateral early hemispheric lesion. Group studies on the outcome of children before and after hemispherectomy using only single IQ measures, pre- and post-operatively, may miss particular epileptic cognitive dysfunctions as they are likely to be different from case to case. Such detailed and rarely available complementary clinical and EEG data obtained in a single case at different time periods in relation to the epilepsy, including per-operative electrophysiological findings, may help to understand the different cognitive deficits and recovery profiles and the limits of full cognitive recovery.

1. Introduction

The direct effects of epilepsy on cognitive functions are best demonstrated when effective medical or surgical therapy rapidly interrupts the abnormal focal bioelectric activity and its propagation.[1] Hemispherectomy, or one of its newer variants, peri-insular hemispherotomy,[2] is the most immediate and radical example of such a therapy. It is a widely practiced

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doi:10.1016/j.ejpn.2008.08.006

Please cite this article in press as: Kallay C et al., Reversible acquired epileptic frontal syndrome and CSWS suppression in a child with congenital hemiparesis treated by hemispherotomy, European Journal of Paediatric Neurology (2008), doi:10.1016/j.ejpn.2008.08.006

and efficient procedure for intractable partial epilepsies arising from a unilaterally damaged and highly epileptogenic hemisphere.[3] Full control of seizures, improved behaviour and the arrest of cognitive decline are often successfully obtained.[4] However, it is not clear if, and to what point, the behavioural and cognitive improvement is due to the cessation of the clinical seizures and the epileptic activity, better quality of life and sleep, a decrease of anti-epileptic drugs or reduced family tensions. These effects, which may be quite variable and possibly specific in individual children, can only be disentangled if a certain amount of rarely available and complementary information on the epilepsy can be gathered and precisely documented at different periods in relation to surgery. They are of two main kinds, (1) the immediate or at least fairly rapid behavioural and cognitive improvement seen post-operatively and (2) the longer-term cognitive recovery, which is much slower to manifest itself and often with persistent and unpredictable permanent deficits. Whether the latter is related to the epilepsy or to the underlying brain pathology most often remains unsettled.

In a prospective study on the cognitive-behavioural effects of epilepsy surgery in children, we followed a child with partial epilepsy and continuous spike-waves during sleep (CSWS) and a severe cognitive and behavioural deterioration due to a pre-natal ischemic hemispheric lesion treated by peri-insular hemispherotomy at the age of 5 years and 4 months. Serial neuropsychological and EEG data including a per-operative recording, from 8 months before to 6 years after surgery were obtained.

Such information has not, to our knowledge, been previously reported and sheds new light on the above-mentioned complex questions, which cannot be answered with only single IQ measurements before and after surgery.

2. Patient and methods

2.1. *Case report*

This child was the second son of healthy non-consanguineous parents and was born at term after an uneventful pregnancy and a normal delivery (Fig. 1). His mother had had a therapeutic abortion for fetal anencephaly a few years previously, without further investigations. There was no relevant family history except for expressive language delay in the older brother. At the age of 8 months, a right spastic hemiparesis was diagnosed. Early cognitive development was considered normal except for a delay in expressive language. Independent walking was achieved at 17 months. At the age of 33 months, he had a first right-sided focal motor seizure lasting 30 min and an EEG, including a short sleep period record, revealed intermittent left frontal spikes. He was put on carbamazepine and he only had a few short focal seizures until the age of 4 years when child carers became worried about his behavioural problems: the child was increasingly irritable, impulsive and agitated with a poor attention span. A second EEG at 4 years of age revealed CSWS with discharges in the left temporo-parietal and bifrontal areas. Soon after, brief episodes of activity arrest with head deviation to the right and a slight loss of axial tone as well as episodes of falls were reported and carbamazepine was replaced by valproic acid. Clobazam and ethosuximide were later added, but the

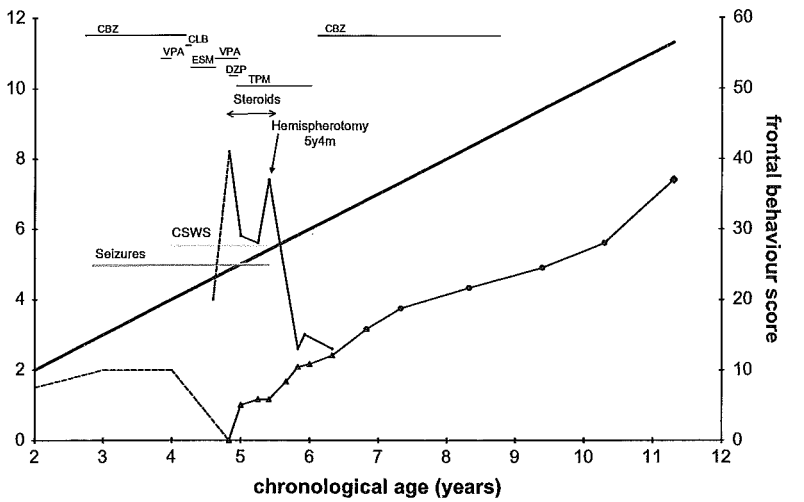

Fig. 1 – Evolution of cognitive development (mental age, left side) and behaviour (behaviour score, right side) correlated with epilepsy before and after hemispherotomy. In dotted lines cognitive stagnation between 2 and 4 years of age, followed by regression obtained from retrospective anamnestic data. Bayley scores (▲,●,◆) were obtained from ages of 4 years and 8 months to 6 years and 10 months, WPPSI-R (▲,●,◆) from the ages of 7 years and 4 months to 10 years and 4 months and WISC III (▲,●,◆) at 11 years and 3 months. The "target" behavioural items from which scores were derived are reported in Table 1 (see also methods). CSWS: continuous spike-waves during sleep, CBZ: carbamazepine, CLB: clobazam, VPA: valproic acid, ESM: ethosuximid, DZP: diazepam, TPM: topiramate. Note that at first evaluation at 4 years and 8 months, the child had no measurable mental development, corresponding to a period of non-convulsive status epilepticus (see text). This was no more the case later.

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situation gradually worsened from the epileptic and cognitive-behavioural point of view. At the age of 4 years and 8 months, the child was referred to us for further evaluation. At this time, he showed a massive deterioration with alternating phases of either apathy or agitation, almost mute or echolalic, unable to play and taking everything he could into his mouth. CSWS persisted despite trials of high dose diazepam, topiramate and steroids. A pre-surgical evaluation was decided. A brain MRI (Fig. 2) showed a voluminous porencephalic lesion in the territory of the left middle cerebral artery with atrophy of the left hemisphere. The left basal ganglia and thalamus were also atrophic as well as the left hippocampus and the corpus callosum. A left peri-insular hemispherotomy was performed at the age of 5 years and 4 months. Neuropathology of the removed amygdala and pericystic tissue revealed atrophy with astrogliosis but no dysplastic changes. The boy became seizure free on carbamazepine. The severe behavioural disorder disappeared and cognitive development resumed. Carbamazepine was finally withdrawn at the age of 9 years.

2.2. *Special investigations and methods*

As part of a research on the impact of epilepsy on cognition and behaviour, the child was followed prospectively from the age of 4 years and 8 months to 11 years and 3 months with 19 EEG records and 18 neuropsychological assessments.

2.2.1. *Electrophysiology*

The first four EEGs carried out before admission were reviewed. Standard (most with video) EEG recordings were performed (with an afternoon nap whenever possible) with 21 electrodes (Deltamed or Micromed) according to the international 10–20 system except for two EEGs. One was a 4-day-video-EEG recording with 28 electrodes performed in the laboratory for pre-surgical evaluation. The other was a per-operative recording, including corticography on the left side (electrodes 2–16) and scalp electrodes on the right side (electrodes 17–21). Localization and frequency of the epileptic discharges were determined by visual analysis by the neurophysiologist. A semi-quantitative score of the focal epileptic activity was attributed ranging from 0 to 3 (0 = no discharges, 1 = occasional, 2 = intermittent, 3 = frequent).

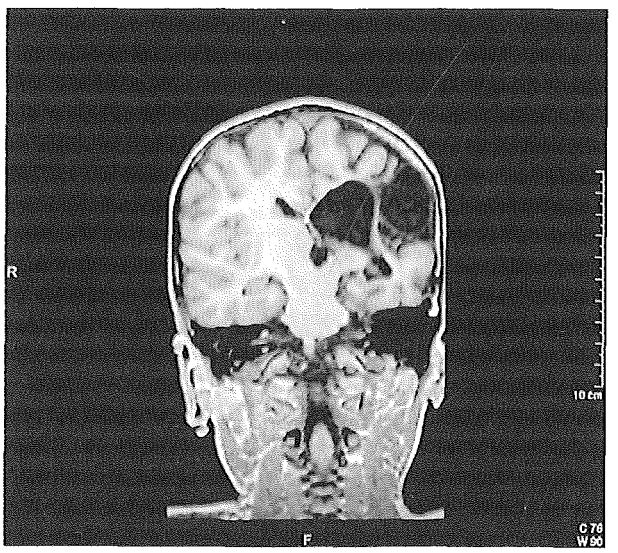

Fig. 2 – MRI (coronal view) at the age of 5 years and 2 months. Large left middle cerebral artery infarct. The left thalamus is atrophic and the right hemisphere is uninvolved.

2.2.2. *Neuropsychological evaluations*

A detailed developmental history was taken from the mother and the notes of the referring neuropaediatrician. Assessments included developmental (Bayley Developmental Scale from the age of 4 years and 8 months to the age of 6 years and 10 months) and intelligence scales (Wechsler scales i.e. WPPSI-R from the age of 7 years and 4 months to the age of 10 years and 4 months and WISC III at 11 years and 3 months), evaluation of early communication skills (ESCS from the age of 4 years and 8 months to 5 years and 10 months) as well as specific language tests (Batterie d'Evaluation Précoce du Langage, BEPL, from the age of 6 years and 4 months to 10 years and 4 months, Nouvelle Epreuve pour l'Examen du Language, N-EEL, from the age of 8 years and 4 months to 11 years and 3 months, lexical comprehension assessment, EVIP, at the ages of 10 years and 4 months and 11 years and 3 months) and various other specific cognitive tests. Tests often had to be used beyond the standardized age limit because of the low cognitive abilities but at least a mental age level could be obtained. An extensive behavioural questionnaire (222 questions, with answers to be given by 'never', 'sometimes', 'often' or 'always', corresponding, respectively, to scores 0, 1, 2 or 3) created for a study of children with CSWS and mental deterioration,[5] was also used. The full questionnaire was given 4 times from the age of 4 years and 8 months (the first for current behaviour and a retrospective one for behaviour 2 months prior to admission) until the age of 5 years and 3 months. Post-operatively, a selection of the 21 most relevant and easily observable abnormal behaviours (= target behaviours[5]) was given three times at home. In order to compare the results on a graph (Fig. 1 and Table 1), only these 21 target behaviours were drawn from each questionnaire and scored. The highest (worst) possible score is theoretically 63 but in fact was 60 since sometimes one question wasn't answered.

3. Results

3.1. *Electrophysiology*

3.1.1. *Retrospective review from the first seizure to hospital admission: 4 records (2 years and 9 months, 4 years, 4 years and 2 months, 4 years and 4 months), 3 with a sleep period (median duration, 36 min; range 20–40 min)*

The initial EEG (with sleep) at 2 years and 9 months showed only left frontal spikes (grade 1) and a background rhythm slowing in the left fronto-temporal region, but no CSWS. The next three records (age 4–4 years and 4 months) showed a main left centro-parietal focus (grade 2–3) and independent

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Table 1 – : Target behaviours before and after surgery

Questions	Before surgery					After surgery		
	4 years and 6 months	4 years and 8 months	5 years	5 years and 1 months	5 years and 3 months	5 years and 8 months	5 years and 9 months	6 years and 4 months
Relational – social								
Oppositional when asked to do something	1	2	1	2	2	2	1	1
Often interrupts work or games of other children	1	2	1	2	1	1	1	0
Destructive: Throws and brakes his own belongings	1	2	2	2	2	0	1	1
Intolerance to frustration: his wishes need to be satisfied immediately	1	2	2	2	0	0	1	1
Ignores other children; behaves as if they were not there	0	1	1	0	1	0	0	0
Attention-activity								
Constantly agitated	2	1	2	1	2	2	1	1
Jumps from one activity to an other	2	2	1	1	3	2	2	1
Dreamy: spends most of the time with staring nowhere	1	2	1	0	0	0	0	0
Impulsive, irritable	0	1	0	1	0	0	0	0
Curiosity: has no interest for his environment	0	2	1	2	1	0	0	0
Repetitive behaviours								
Chews clothes, blankets or other things	1	3	2	1	3	1	1	1
Takes to mouth or eats inedible material	0	3	2	2	3	0	0	1
Repetitively opens/closes doors, turns buttons	1	2	2	2	3	1	1	1
Unable to interrupt repetitive activity	0	0	0	1	3	0	0	0
Special liking for water; can play hours with tap, running water	2	2	2	0	0	1	2	2
Constantly aligns objects or to pulls them back and forth	2	1	2	1	1	0	0	0
Watches at length, fascinated by spinning or brilliant objects or particular sounds	2	2	2	0	2	1	0	1
Affect-emotions								
Does not openly expresses his feelings (joy, sadness)	0	2	1	1	2	0	0	0
Affection seeking: does not climbs on knees, does not ask to be carried or kissed	0	3	1	2	3	2	2	1
Independence: follows mother everywhere; likes to stay near her	2	3	1	2	2	0	0	0
Time concept								
Unable to keep schedule	1	3	2	3	3	?	2	1
Total Score	20/63	41/63	29/63	28/63	37/63	13/60	15/63	13/63

Target behaviours selected for a larger initial questionnaire ($n = 21$, see methods), which were the most abnormal or showed the most marked changes in relation to the epilepsy from the age of 4 years and 6 months to 6 years and 4 months. The frequency of each behaviour was reported by the parents as: never, sometimes, often or always, corresponding respectively to score 0, 1, 2 or 3.

left and right fronto-central spikes (grade 1–2). Diffuse CSWS were first found at the age of 4 years.

3.1.2. *Prospective study, before hemispherotomy: 6 records (from 4 years and 8 months to 5 years and 2 months) all with a sleep period (median duration, 32.5 min; range 25–67 min)*
The first record in our institution showed the boy in a non-convulsive status epilepticus: he was drowsy, mute and hypotonic and sometimes opened his eyes on command. His eyes deviated, at times, to the right with a nystagmus, lasting from 10 s to 1 min. The EEG showed a left centro-parietal focus and almost continuous generalized spike-waves, which predominated in both frontal regions and further increased in amplitude during the short episodes of eye deviation (Fig. 3). After a dose of 0.2 mg/kg intranasal midazolam, the generalized epileptic activity subsided but the left centro-parietal focus persisted. The child became more active and started to touch his mother's watch, trying to take it into his mouth.

All subsequent EEGs showed a main centro-parietal focus (grade 3) and asynchronous left and right frontal spikes of variable intensity (grade 1–3) in the wakeful state and diffuse CSWS during sleep (Fig. 4). There was no significant change with steroids. During the pre-surgical evaluation, at the age of 5 years and 2 months, 31 seizures were recorded during a 4 days period. Clinically, an activity arrest of 4–8 s with eye and head deviation to the right was observed and the EEG showed continuous left centro-parietal discharges with a spread to the left then to the right frontal regions, evolving into generalized discharges. No tonic or atonic seizures were recorded. Diffuse

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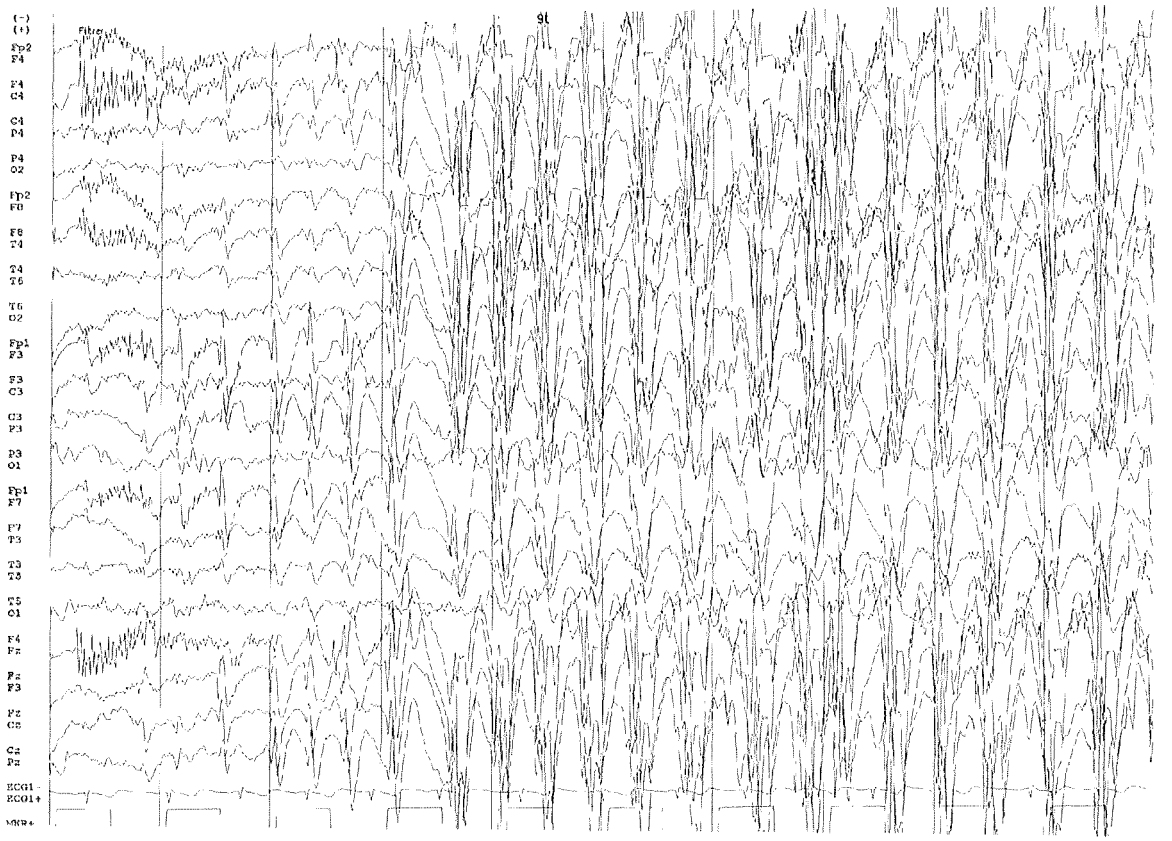

Fig. 3 – EEG sample on admission at the age of 4 years and 8 months. First standard EEG on admission, while the child was in a non-convulsive status epilepticus, drowsy and mute: left centro-parietal focus with burst of generalized spike and waves of very high amplitude corresponding to an episode of gaze deviation to the right and nystagmus (see text).

CSWS occupied up to 95% of a night's sleep. It is worth noting that this pattern was sometimes also seen during wakefulness, once for more than 3 h without any obvious clinical change, unlike when the child presented in status epilepticus.

3.1.3. *Per-operative record (at the age of 5 years and 4 months)*

Under general anesthesia, and before the surgery started, the scalp EEG on the right side showed a drug-related beta activity with intermittent posterior discharges. A baseline corticography on the left side showed epileptic spikes mainly at the posterior and mesial margins of the porencephalic cyst, sometimes synchronous with the right-sided discharges. During the procedure, the scalp electrodes showed intermittent bursts of spike-waves on the right hemisphere that disappeared after the disconnection was completed. The final corticography still showed intermittent spikes at the margins of the lesion.

3.1.4. *Post-operative follow-up records: 8 records (from the age of 5 years and 4 months to the age of 11 years and 3 months) 7 with sleep (median duration, 26 min; range 14–39 min)*

One week after surgery, the CSWS had disappeared but epileptic spikes were still present in the centro-parietal (grade 2) and fronto-central regions (grade 1) as expected after a disconnecting procedure[6] (Fig. 4). On the right hemisphere, there was no epileptic activity except rare isolated spike diffusing from the left fronto-central focus. The subsequent records did not show any further significant changes.

3.2. *Neuropsychological assessments*

3.2.1. *Developmental history*

Early cognitive development had caused little concern except for a mild delay in expressive language (first words at 2 years of age, first sentences at 3 years) (Tables 1 and 2). This was attributed to a multilingual exposure at home and a possible genetic predisposition. The child was strong-willed and very active but able to focus on play for a while. A few months before CSWS were discovered (4 years), the child was described as tired and difficult. At the age of 4 years, he spoke abundantly in 3-word sentences, imitated his mother in the kitchen, watched cartoons, and played a little with cars but not with blocks or puzzles. Within the next 6 months, he became increasingly agitated, opposing, screaming and crying without any reason. In the weeks before admission at the age of 4 years and 8 months, his language was reduced to a few words, he was unable to play or to take initiatives

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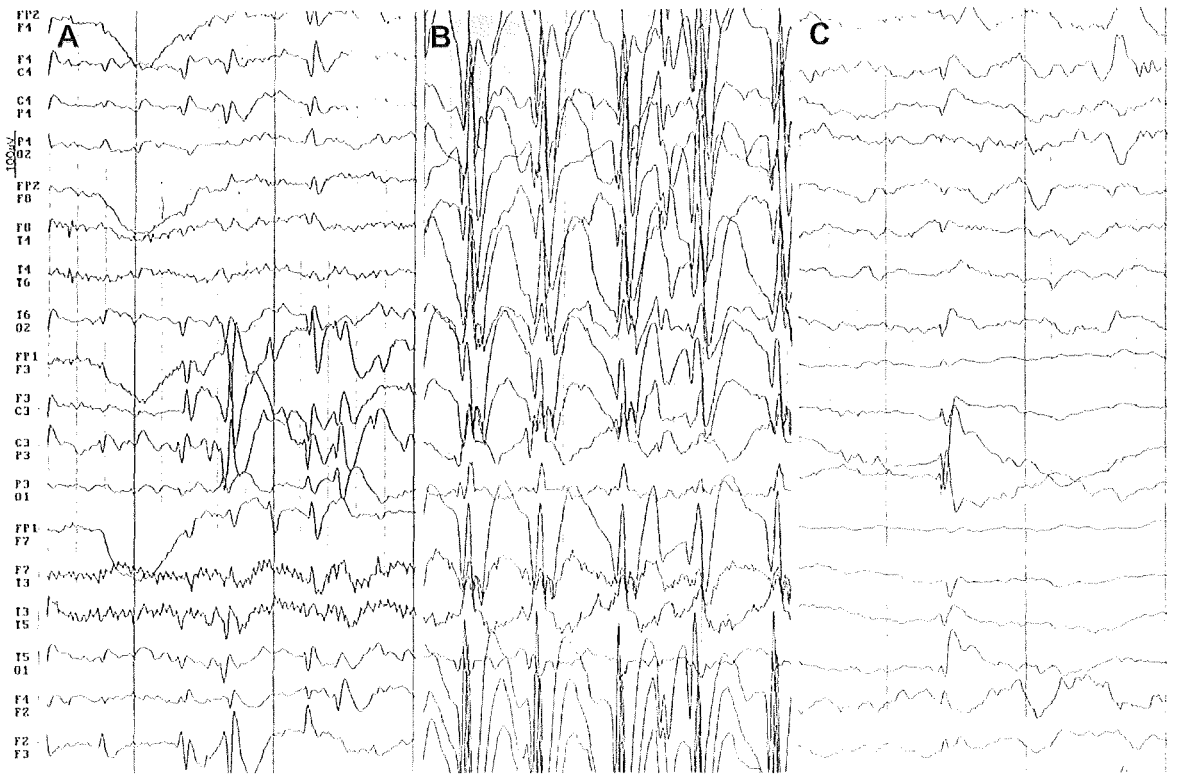

Fig. 4 – EEG samples prior and after surgery. A and B: standard scalp EEG at the age of 5 years, 3 months prior to surgery, while on oral prednisone. A: A left-sided fronto-central focus (F3) and an independent parietal focus (P3) can be seen in the waking state (A) and diffuse CSWS during sleep (B). C: standard EEG 6 months after surgery (sleep): complete disappearance of CSWS. Low voltage slow background activity with a residual parietal epileptic focus on the left hemisphere (grade 2) and few central sagittal spikes (grade 1).

except for some impulsive acts (running away from school...).

3.2.2. *Prospective assessments, before hemispherotomy (4 years and 8 months to 5 years and 3 months)*
The initial picture was of an agitated, stimulus-driven child who shouted at the slightest frustration, took everything into his mouth and engaged only in repetitive manipulations (such as pushing buttons or twisting the ear of a fluffy dog). Speech was mainly limited to a few echolalic productions and he did not react to verbal orders. Visual contact could, however, be obtained as well as smiles to a peek-a-boo game. Some fluctuations occurred in correlation with the seizure frequency and a mild improvement was documented after the introduction of steroids, but the picture remained globally unchanged until surgery.

3.2.3. *Assessments after hemispherotomy (at the age of 5 years and 5 months to the age of 11 years and 3 months)*
Already 6 weeks after surgery, mouthing and repetitive activities had decreased while attention skills had improved followed by a progressive cognitive catch-up. During the following 1.5–6 year period post-surgery, the rate of progress remained quite stable (developmental quotient around 50–55, moderate mental disability range). At the age of 11 years and 3 months, the child's social contact was good and the language adequate for his mental level, but his attention remained poor, with impulsiveness and opposition when faced with some difficulty. No specific executive or memory deficit was found. He was still unable to read or write but simple additions with finger counting were possible.

4. Discussion

The observations made on this child help us to understand how the cognitive and behavioural regression seen in an intractable partial epilepsy, and which was so improved by hemispherotomy, relates to the different aspects of the epileptic disorder. First of all, the major and increasing behavioural regression seen in the months preceding surgery had the features of a frontal syndrome, with severe agitation, inattention, very limited spontaneous verbal initiatives, loss of play, mouthing, absence of goal-directed behaviour ("stimulus-bound") which all rapidly and permanently improved after hemispherotomy. This regression was initially an insidious and progressive behavioural disorder associated with cognitive stagnation that led to the discovery of CSWS followed by a rapid cognitive

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Table 2 – Summary of major behavioural and cognitive findings before and after surgery

	5 years (6 weeks after prednisone)	5 years and 9 months (6 months post-surgery)	6 years and 4 months (1 year post-surgery)	7 years and 4 months (2 years post-surgery)	11 years and 3 months (6 years post-surgery)
"Frontal" behaviours	Stimulus-driven, perseverations, mouthing, apathy/agitation	Rare mouthing and perseverations	Rare perseverations	None	None
Behaviour scale	29/63	15/63	13/63	ND	ND
Communication (ESCS)	8–12 months	>22 months	Adequate for mental level	–	–
Cognition	Bayley (only non verbal items): 12 months attention deficit	Bayley (developmental age): 25 months attention deficit	Bayley (developmental age): 29 months attention deficit	WPPSI-R[a] (mental age): 3.5–4 years attention deficit	WISC III: TIQ 54 (VIQ: 58, PIQ 59) (mental age): 7 years and 4 months attention deficit Executive Functions: level 5–6 years
Language	Rare spontaneous word productions, echolalia, verbal perseverations, answers yes or no only	Level about 2 years and 6 months. Spontaneous 2–3 words utterances, no echolalia	Level 3–4 years. Fluent adequate productions	Level 4–5 years	Level 6–7 years. Major problems in spelling and writing

ESCS: Early Social Communication Scale.
ND: Not done.
a The WPPSI-R, standardized up to the age of 7 years was deliberately used here because of the child's low mental age, but an IQ could not be calculated.

deterioration to the point that the child was left without functional language and only repetitive environmental-driven actions. Despite his very low level, it was clear that he had neither verbal apraxia nor auditory agnosia, since he produced at times well articulated single words and was echolalic; he was also neither autistic since some basic social contact was always present despite his massive loss of skills in other cognitive domains.

Superficially, this profile may easily have passed as a global regression due to frequent seizures and/or anti-epileptic medication, but the characteristics of the behaviour described above clearly spoke for a more specific abnormality related to a frontal dysfunction.

The neuropsychological and behavioural assessments were often done on the same day as the EEGs, so that we know that the very low results before hemispherotomy were not caused by an unrecognized non-convulsive status epilepticus.

In several pre-operative EEGs and during the pre-surgical investigations, two independent foci surrounding the left porencephalic cyst were identified, one in the centro-parietal and one in the frontal region with a contra-lateral spread. Intra-operatively, immediately after the disconnection procedure and later on follow-up, the scalp EEG on the right healthy hemisphere showed the disappearance of the epileptic discharges indicating that this hemisphere was indeed intact and had "only" been functionally involved.

An "epileptic frontal syndrome" has previously been reported in partial epilepsies with frontal foci and CSWS[1,5,7] without an evident brain lesion. We believe that a part of the spectacular and rapid behavioural improvement, often reported in post-operative follow-ups of hemispherectomy cases, may be explained by this reversible frontal dysfunction. In fact, this improvement, so striking clinically and gratifying to parents, is usually not so rapidly accompanied by a measurable cognitive catch-up, especially in young children.[8] Recovery of some attentional and communication abilities are so powerful and rewarding indices of human presence that they are experienced as a major progress. Prefrontal dysfunction may, of course, only be one among other possible cognitive deficits seen pre-operatively, depending on the propagation pathways from the main epileptic focus (or foci), either unilaterally or to homologous contra-lateral areas. Studies of these cognitive deficits and their evolution after hemispherotomy have mainly focused on language with the questions which, how much and how fast the language functions are affected and how they recover according to which hemisphere was removed and at what age.[9–12] The interruption of the epileptic spread to the healthy hemisphere is considered a crucial factor. Comparing pre- and post-operative specific abilities is one way to document the direct role of epilepsy, but is hardly ever done. When hemispherectomy is decided upon, unique methodological problems arise in testing each case because the sensory-motor,[13,14] social and cognitive level of the child at that time are never the same and must dictate which comparative investigations are feasible and potentially relevant.

Another point of interest is the discovery of CSWS on the EEG one and a half years after the child's first epileptic seizure and coincident with the behavioural deterioration. The CSWS decreased only slightly during steroid therapy but were permanently suppressed by the surgical disconnection procedure. This was recently reported in a child with a lesion similar to ours.[15] It conforms the view that CSWS are a manifestation of a secondary generalization of EEG discharges. The

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propagation through the corpus callosum and to the thalamus is interrupted by the disconnection procedure. Interestingly, thalamic lesions are now considered an important factor in the development of CSWS.[16,17] In our case, the thalamus was clearly involved as shown on the MRI and as often seen in large middle cerebral artery infarcts. CSWS can contribute to cognitive stagnation and poor learning (probably by interfering with memory consolidation during slow wave sleep), but the specific cognitive-behavioural syndrome itself is likely due to the cortical site/function involved in the epileptic process. In a series of children with unilateral ischemic hemispheric lesions and intractable epilepsy undergoing hemispherectomy, the presence and role of CSWS have not been specifically studied,[18] but in those children studied because of a "CSWS syndrome" or because of early thalamic lesions shown on the MRI, unilateral ischemic hemispheric lesions are often found (symptomatic partial epilepsy with CSWS).[17,19]

The long-term follow-up until the age of 11 years showed an incomplete cognitive recovery with a probable permanent moderate mental deficiency. This occurred despite an anatomically intact right hemisphere, the absence of seizure relapse after surgery and a complete withdrawal of medication 2 years before the last cognitive evaluation raising, again the question of the role of the epilepsy itself. A small number of studies have shown that the IQ of children with a congenital unilateral vascular hemispheric lesion (similar to that seen in our child) but without epilepsy can be normal.[20–22] When epilepsy or EEG abnormalities are present (but not a severe intractable epilepsy) in an otherwise comparable group, a significantly lower IQ is found. Permanent mental retardation is thus difficult to explain as only due to the pre-natal brain infarct. In our child, the role of epilepsy is all the more likely that early cognitive development was fairly normal before seizures started. It is reasonable to conclude here that the prolonged continuous epileptic activity with frontal involvement was a major factor preventing full recovery after surgery. It probably interfered with the development of neural networks which are crucial for higher cognitive functions and perhaps also with the cerebral reorganization that follows early unilateral hemispheric lesions.[23]

In summary, the combination of clinical and EEG data collected pre-, intra- and post-operatively allowed us to go a step further in understanding the various types of cognitive and behavioural epileptic dysfunctions and outcomes in young children with surgically treatable partial epilepsies and beyond the famous saying of Penfield "no brain is better than a bad brain".[24] Group studies on the outcome of children with a hemispherectomy using single IQ measures pre- and post-operatively can miss the original and unique epileptic cognitive dysfunctions which are likely to be different from case to case.

Acknowledgments

Thanks are due to the Swiss National Fund for Scientific Research (Grent n° 3200-068105.02) for support to Prof. Eliane Roulet-Perez, to Dr. Danielle Gubser-Mercati, Paediatric Neurologist who referred the child and also to Mrs C. McEvoy for her assistance in the preparation of the manuscript. Professor Jean-Guy Villemure, former Head of the Neurosurgical Department in Lausanne operated on the child and provided continuous support and ideas for this and other studies. His help is most gratefully acknowledged.

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