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WELCOME ADDRESS

Dear Colleagues,

We are glad to welcome you to the First International Workshop on Hemispherectomy at the University Medical Center Utrecht!

We will critically review 20 years of experience in cerebral hemispherectomy around the world and discuss new developments in both clinical and research areas.

This meeting is the first workshop to merge neurologists and neurosurgeons with neuropsychologists, neuroscientists and rehabilitation specialists.

We hope that the Workshop will bridge clinical knowledge with insights into cortical plasticity and reorganization from basic science.

We anticipate that with your help this Workshop will start a tradition of regular meetings aiming to present new insights and progress obtained by the international community.

We hope that you will enjoy the scientific programme of the Workshop, but also the warm hospitality of Utrecht and The Netherlands.

The Organizing Committee

PROGRAMME

Thursday September 30th , 2010

8.45 Opening Remarks
Onno van Nieuwenhuizen, University Medical Center, Utrecht, The Netherlands

9.00 – 10.30 **Session 1 (invited speakers 30 min)**
Chair: Onno van Nieuwenhuizen, University Medical Center, Utrecht, The Netherlands

Keynote Address: Cortical Plasticity and Hemispherectomy in the 1970s: What Were We Thinking?
Maureen Dennis, Hospital for Sick Children, Toronto, Canada

The Spectrum of Etiologies for Cerebral Hemispherectomy
Gary W. Mathern, University of California, Los Angeles, USA

Neurophysiological Workup
Frans Leijten, University Medical Center, Utrecht, The Netherlands

10.30-11.00 Coffee Break

11.00-12.00 **Session 2 (invited speakers 30 min)**
Chair: Gary W. Mathern, University of California, Los Angeles, USA

Outcome after Hemispherectomy in Adults
Arthur Cukiert, Hospital Brigadeiro, São Paulo, Brazil

Antiepileptic Drug Withdrawal after Epilepsy Surgery in Children
Kees Braun, University Medical Center, Utrecht, The Netherlands

12.00-13.00 Lunch

13.00-14.30 **Short Communications (15 min)**
Chair: Frans Leijten, University Medical Center, Utrecht, The Netherlands

Hemispherectomy in Adults
Daniel Delev, University of Bonn, Germany

Hemispherotomy in 3 Adult Patients. Indication and Follow-Up
A. Hermsen, Philipps University, Marburg, Germany

Hemispherectomy: Considerations for Seizure Freedom
Y.D. Park, Medical College of Georgia, Augusta, USA

Contralateral MRI Abnormalities Affect Seizure and Cognitive Outcome after Hemispherectomy
Kim Boshuisen, University Medical Center, Utrecht, The Netherlands

Long-term Efficacy of Modified Anatomical Hemispherectomy for Treatment of Epilepsy in Patients with Infantile Hemiplegia with 302cases
Yulun Xu, Beijing Tiantan Hospital Capital Medical University, Beijing, China

14.30-15.00 Tea Break

15.00-17.30 **Workshop 1: Surgical Techniques**
Chair: Peter van Rijen, University Medical Center, Utrecht, The Netherlands

Surgical Techniques (invited speaker, 30 min)
Georg Dorfmuller, Fondation Rothschild Hospital, Paris, France

When We Should **NOT** Remove S1M1 in Hemispheric Epilepsy? (invited speaker, 30 min)
Hans Holthausen, Schön Klinik for Neuropediatrics and Neurological Rehabilitation Epilepsy Center for Children and Adolescents, Day clinic for Neuropediatrics, Vogtareuth, Germany

Disconnection of the Entire Hemisphere (Hemispherotomy) without Hemiplegia. A New Technique (short comm., 15 min)
Flavio Giordano, Anna Meyer Pediatric Hospital, Florence, Italy

Partial Disconnection Procedure in Treatment the Patient with Bilateral Malformation of Cortical Development (case report) (short comm., 15 min)
Alexey Stepanenko, N.N. Burdenko Neurosurgery Institute, Moscow, Russia

Panel Discussion
Georg Dorfmüller, Peter Gosselaar, Hans Holthausen, Gary W. Mathern, Taisuke Otsuki, Peter van Rijen

PROGRAMME

Friday October 1st , 2010

8.45 Opening Remarks

9.00 – 10.30 **Session 1 (invited speakers 30 min)**
Chair: Kees Braun, University Medical Center, Utrecht, The Netherlands

Catastrophic Epilepsy of Early Onset: Indications for Hemidisconnection
Helen Cross, University College, London, UK

Life after Hemispherectomy in Infancy or Childhood
Monique van Schooneveld & Dr. Aag Jennekens-Schinkel, University Medical Center, Utrecht, The Netherlands

Quality of Life after Hemispherectomy
Adam Hartman, Johns Hopkins, Baltimore, USA

10.30-11.00 Coffee Break

11.00-12.00 **Session 2 (invited speakers 30 min)**
Chair: Harry Chugani, Children's Hospital of Michigan, Michigan, USA

PET and DTI Studies of Brain Plasticity in Hemispherectomy Subjects
Harry Chugani, Children's Hospital of Michigan, Michigan, USA

Volume Based Morphometry of the Remaining Hemisphere
Stella de Bode, University Medical Center, Utrecht, The Netherlands

12.00-13.00 Lunch

13.00-15.00 **Short Communications (15 min)**
Chair: Helen Cross, University College, London, UK

Predicting Favorable Motor Outcome after Hemispherectomy: TMS versus fMRI
Andrea Zsoter, Universitätsklinikum, Tübingen, Germany

Motor Performance and Activities of Daily Life after Hemispherectomy
Ron van Empelen, University Medical Center, Utrecht, The Netherlands

Neuro-cognitive and Epileptic Long-Term Follow-Up After Early Hemispherectomy in Children with Catastrophic Epilepsy:
The Experience at Catholic University in Rome
Domenica Battaglia, Catholic University, Rome, Italy

Hemispheric Disconnection and Developmental Cognitive Plasticity: Neuropsychological and fMRI of Language Studies in a Population of Children Treated by Hemispherotomy
Christine Bulteau, Fondation Rothschild Hospital, Paris, France

Functional connectivity after experimental hemispherectomy
Wim Otte, University Medical Center, Utrecht, The Netherlands

Hemispherotomy for Hemimegalencephaly in Early Infancy
Taisuke Otsuki, National Center of Neurology and Psychiatry, Tokyo, Japan

Outcomes of Functional Hemispherotomy in Refractory Epilepsy of Childhood: The Freiburg Experience
Georgia Ramantani, Epilepsy Center, University of Freiburg, Freiburg, Germany

Hemispherectomies in Children. Experience from Gothenburg, Sweden
Ingrid Olsson, Queen Silvia Children's Hospital, Gothenburg, Sweden

15.00-15.30 Tea Break

15.30-17.30 **Workshop 2: Workshop 2: Reorganization and Animal Models (invited speakers 30 min)**
Chair: Stella de Bode, University Medical Center, Utrecht, The Netherlands

Functional Reorganization Following Hemispherectomy, Cortical Crowding?
Frederique Liegeois, University College, London, UK

Effects of Perinatal Hemispherectomy in Monkeys (Aethiops Sabeus)
Maurice Ptito, Université de Montréal and McGill University,Montreal, Canada

Neural Substrates of Blindsight in Hemispherectomized Human Subjects
Alain Ptito, Université de Montréal and McGill University, Montreal, Canada

.

Panel Discussion
Harry Chugani, Helen Cross, Adam Hartman, Frederique Liegeois, Alain Ptito, Maurice Ptito, Monique van Schooneveld

GENERAL INFORMATION

Local Organizing Committee
Stella DeBode
Kees Braun
Frans Leijten
Aag Jennekens
Peter van Rijen
Onno van Nieuwenhuizen

International Committee
Chair: Gary W. Mathern, University of California Los Angeles, USA.

Registration Desk
The registration and information desk is situated in the Educatorium, University of Utrecht.
Opening hours registration desk: 08.00 – 17.30 hours.

Registration Fee (after final deadline and on-site)

Participants	EUR 495
1 day registration	EUR 250
Students, Residents	EUR 95
Parent of Hemispherectomy child	EUR 50

Name Badge
All participants are requested to wear their name badges throughout the symposium

Congress Venue
Educatorium, University of Utrecht
De Uithof, Leuvenlaan 19
Utrecht, The Netherlands

Public Transport
From the Central Station Utrecht.
Bus no 11 and 12 drive from Central Station Utrecht to De Uithof. The busses leave every 3-5 minutes. The bustrip takes about 20 minutes and costs 2 zone fare. (You can buy the ticket from the bus driver). Get off at the "Willem C. van Unnik Building", Heidelberglaan 2. The easiest way to get to the Educatorium is to walk trough the Willem C. van Unnik Building. Green Level Up signs will lead you to the registration desk.
You can also take a taxi from the taxi-platform at the Central Station.
By Bus
Take bus 11, 12 or 12S (direction Uithof/WKZ) and get off at bus stop ‘Langeveldgebouw’ (bus 12, 12S) or ‘Heidelberglaan’ (bus 11) after 15 minutes. Cross the street (and walk about 100 meters back if you have taken bus 11). At your right you will see the ‘Willem C. van Unnik Building’. Through the main entrance of the ‘Willem C. van Unnik Building’ you walk to the main entrance of the ‘Educatorium’.

Accreditation

The European Accreditation Council for Continuing Medical Education (EACCME) has granted the International Workshop on Hemispherectomy with 12 European CME credits (ECMEC). This accreditation will be endorsed by the European Union of Medical Specialists (UEMS) ensuring that the CME credits awarded to the participants are recognized by the national medical authorities who have agreed to co-operate in this European system. EACCME credits are recognized by the American Medical Association towards the Physician's Recognition Award (PRA). To convert ECMEC's credit to AMA PRA category 1 credit, please contact the AMA.

Accreditatie (for Dutch participants only)

Nederlandse Vereniging voor Kindergeneeskunde (NVK) 12 punten
Nederlandse Vereniging voor Neurologie (NVN) 13 punten
Accreditatie is in aanvraag bij het Koninklijk Genootschap voor Fysiotherapeuten (KNGF)

Certificate of Attendance

Certificates of attendance will be available for all participants at the registration desk.

Symposium Language

The official Symposium language will be English. No simultaneous translation will be available.

Insurance

In registering for the First International Workshop on Hemispherectomy 2010, delegates agree that neither the organization nor the congress agency Congress Care is responsible for individual medical, travel or personal insurance. Participants are requested to make their own travel and health insurance. The organizers cannot assume liability for changes in the programme due to external circumstances

Website

Further information will be available on the website:
www.umcutrecht.nl/subsite/Hemispherectomy-workshop

Messages

You may leave and collect messages at the registration desk.

Congress Secretariat

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ABSTRACTS

PROGRAMME: THURSDAY, SEPTEMBER 30th, 2010

9.00 – 09.30 **Session 1**

KEYNOTE ADDRESS: CORTICAL PLASTICITY AND HEMISPHERECTOMY IN THE 1970s: WHAT WERE WE THINKING?

M. Dennis
Hospital for Sick Children, Toronto, Canada

The results of the first hemispherectomy surgeries for intractable seizures were reported in 1950 and early studies were largely descriptions of the radical procedure. By the early 1970s, a group of studies emerged that were concerned less with describing the surgical details and gross outcome than with using the outcomes of hemispherectomy to explore theoretical questions about the nature of functional brain representation. Today, I would like to review a selected set of research studies from that time in relation to the intellectual landscape of the early 1970 and the theoretical questions the data from the studies were used to address.

Intellectual Landscape In Early 1970s

1. Plasticity for brain structure and cognitive function is not solely a function of age
    a. Adult neurogenesis
    b. Early and late lesions may produce equivalent effects
    c. Brain rewiring after early lesions may be maladaptive
2. Hemispheric asymmetry
    a. Chomsky's revolution
    b. Historical data on language and early lesions
    c. Infant EEG work
    d. Right hemisphere specialization

Theoretical Issues And Data In 1970s Studies

1. Age-based plasticity of function
    a. Chronological age, age at surgery, time since surgery
    b. Medical issues: Seizure history and etiology
2. Covert functionality: discriminating without feeling, without seeing
    a. Agnostic gnosis
    b. Blindsight
3. Hemispheric asymmetry
    a. Limitation of IQ as index of function and/or hemispheric asymmetry
    b. Left hemisphere and language
        i. Syntactic processes: structure building, checking agreement, mapping thematic roles, non-canonical word orders
    c. Right hemisphere and visuo-spatial function
        i. Dorsal vs. visual stream visual processing
4. Intrahemispheric reorganization
    a. Functionality of ipsilateral tracts
    b. Intermanual transfer
    c. "Crowding" of function
    d. Do early left hemisphere seizures drive right hemisphere language representation?
    e. "Release"of function?: music and affect

Conclusions

9.30 – 10.00 **Session 1**

THE SPECTRUM OF ETIOLOGIES FOR CEREBRAL HEMISPHERECTOMY

G. W. Mathern
Prof., Dept. of Neurosurgery and Psychiatry & Biobehavioral Sciences, The Intellectual and Developmental Disabilities Research Center, and The Brain Research Institute, David Geffen School of Medicine, University of California, Los Angeles, USA

The etiologies for cerebral hemispherectomy have evolved over the past 50 years, and patients with different histopathology have dissimilar clinical characteristics and outcomes. In the 1950's to 1970's the most common etiology was perinatal strokes producing porencephalic cysts and diffuse hemispheric damage. From the mid-1980's and with improved neuroimaging the etiologies have evolved to include more cases of cerebral dysgenesis. For this presentation, the 2004 ILAE Survey of pediatric epilepsy surgery centers (n=46; 158 patients) and the UCLA data base from 1986 to 2010 (n=200) were used. In the 2004 ILAE Survey, 35 centers (76%) reported they performed cerebral hemispherectomy. The median was 2 procedures per year with a range of 1-20 operations in 2004. The UCLA data set averaged of 8 cases per year. These studies were compared with the survey conducted by Holthausen et al, 1977. For the two recent data sets, the most frequent etiology was cortical dysplasia (CD; 25-33%), hemimegalencephaly (HME; 15-23%), atrophy (stroke, infection; 26-30%), and Rasmussen encephalitis (RE; 13-19%). These four groups accounted for 91-93% of all etiologies and are similar to the results reported in 1995 by Holthausen et al. Centers performing 3 or fewer cerebral hemispherectomy operations per year had a higher incidence of HME (38% vs. 18%) and Sturge-Weber (12% vs. 4%) compared with centers performing 4 or more operations per year. Rarer etiologies included patients with Sturge-Weber (5%), Tuberous Sclerosis Complex (TSC, 2%), tumor (1.5%), trauma (1.5%) and unusual infections such as herpes encephalitis. For the four most frequent etiologies, age at seizure onset and surgery were older for patients with infarcts and RE compared with HME and CD ($P<0.0001$). Epilepsy duration was longer for patients with infarcts, and a history of infantile spasms was greater for those with CD and HME ($P<0.0001$). There were no differences in the types of etiology by region of the world, and centers used similar pre-surgery evaluations involving video/EEG and MRI. SPECT/PET was used in 48% and intracranial electrodes in 1% (n=2) patients in the 2004 ILAE Survey. Similar findings by etiology were found in the UCLA data set spanning 25 years. After hemispherectomy, seizure freedom varied by etiology. From the 2004 ILAE Survey, 59% of cerebral hemispherectomy patients were seizure free with an average follow-up of 3.2 years. This is lower than the 70% seizure free rate in the 1995 survey. More patients with cortical dysplasia (74%) and atrophy (68%) were seizure free compared with those with HME (50%) and RE (42%; $P=0.009$). More seizure free patients were off medications for those with CD (38%) and atrophy (47%) compared with patients with HME (23%) and RE (50%; $P<0.0001$). From the UCLA cohort, the decrease in seizure freedom for HME and RE cases was observed at 2 and 5 years after surgery with outcomes similar at 0.5 and 1 year. Analysis of the UCLA series also suggests that the chance of becoming seizure free was higher if the operation was performed in the last decade compared with the 1990's at 0.5 (91% vs. 75%), 1 (88% vs. 73%), 2 (85% vs. 66%) and 5 years (85% vs. 52%) after surgery. These findings support the notion that etiologies have evolved since cerebral hemispherectomy was introduced for control of intractable epilepsy in the 1950's but have remained largely stable over the past 20 years. Patients with HME and CD present at younger ages and those with HME and RE have slightly poorer outcomes. However, there are signs that over time

outcomes have improved as techniques and presurgical evaluations protocols have evolved with better outcomes in the current decade.

This study was supported by National Institutes of Health Grant R01 NS38992.

10.00 – 10.30 **Session 1**

NEUROPHYSIOLOGICAL WORKUP

F. Leijten
University Medical Center, Utrecht, The Netherlands

In this presentation I will discuss the role of EEG, both interictal and ictal, in the clinical decision making towards hemispherotomy. First, I will present 2 cases illustrating the most important dilemma's: one in which bilateral EEG abnormalities are evident, and one in which the choice is between a multilobar resection and hemispherotomy. Then, I will show from the records of the National Dutch Epilepsy Surgery Taskforce how during the last 15 years EEG analysis has influenced the clinical path in 43 hemispherotomy patients, and how we see the current role of EEG. Finally, I will touch upon some issues on which the literature is unclear and need clarification in future research, and propose a role for early interictal EEG in the decision making process.

11.00-11.30 **Session 2**

OUTCOME AFTER HEMISPHERECTOMY IN ADULTS

A. Cukiert
Hospital Brigadeiro, São Paulo, Brazil

We present the outcome after hemispherectomy (HP) in adult patients and more specifically in a homogeneous adult patient population with refractory hemispheric epilepsy associated with early middle cerebral infarcts. Twenty-one adult patients submitted to HP were studied. Patients had to be at least 18 years old, had refractory epilepsy, clearly focal lateralized seizures. They had either unilateral porencephalus consistent with early middle cerebral artery infarct or other different hemispheric pathology on MRI. All patients were submitted to functional hemispherectomy. We analyzed age of seizure onset, age by the time of surgery, gender, seizure type and frequency, interictal and ictal EEG findings, MRI and IQ scores pre-operatively; seizure frequency, drug regimen and IQ outcome were studied post-operatively. All patients had frequent daily seizures pre-operatively. All patients had unilateral simple partial motor seizures (SPS); 14 patients had secondarily generalized tonic-clonic seizures (GTC) and 7 patients had complex partial seizures (CPS), pre-operatively. All patients had hemiplegia and hemianopsia. Fifteen patients had unilateral EEG findings and in 6 epileptic discharges were seen exclusively over the apparently normal hemisphere. Eighteen patients were seizure-free after surgery and three patients had at least 90% improvement in seizure frequency. Pre- and post-operative mean general IQ was 84 and 88, respectively. Eight of the fifteen Engel I patients were receiving no drugs at last follow-up. There was no mortality or major morbidity. Our results suggest that well selected adult patients might also get good results after HP. Although good results were obtained in our adult series, the same procedure yielded a much more striking result if performed earlier in life.

11.30-12.00 **Session 2**

ANTIEPILEPTIC DRUG WITHDRAWAL AFTER EPILEPSY SURGERY IN CHILDREN

K.P.J. Braun, K. Boshuisen
University Medical Center, Utrecht, The Netherlands
For the TimeToStop study group

Rationale: to evaluate current antiepileptic drug (AED) withdrawal policies after epilepsy surgery in children, to explore determinants of timing of AED discontinuation, and to study the relation between timing of withdrawal and seizure recurrences and eventual seizure outcome, we performed a multicenter European study on timing of AED withdrawal, the 'TimeToStop' study (TTS).

Methods: TTS is an international retrospective consecutive cohort study of 778 children (from 15 centers in 8 countries) operated between 2000 and 2008, in whom it was decided to start AED withdrawal after postoperative seizure freedom. Using uni- and multivariate linear regression analyses, preoperative variables that were previously described to independently predict postoperative seizure outcome, were first related to time intervals between surgery and start of AED withdrawal (I_start), and complete discontinuation of AED (I_stop). Second, timing of AED withdrawal was related to seizure recurrence during or after AED withdrawal, and to eventual outcome (Engel 1 > 1yr), using a Cox regression analysis. To this model we added previously identified other predictors of seizure outcome. For 111 children who underwent hemispherectomy, a subgroup analysis was performed.

Results: Mean I_start (n=778) was 16.8 months (SD 13.8, range 0-82) and mean I_stop (n=446) 30.4 months (SD 18.0, range 0-105). The interval between start and complete discontinuation (I_withdrawal) was 13.6 months (SD 12.8, range 0-68). Time intervals were independently associated with: participating center, number of preoperative AEDs, direct postoperative seizure freedom, etiology, presence of bilateral MRI abnormalities, type of surgery, IQ scores, intracranial recordings performed, and presence of epileptic abnormalities on postoperative EEG. During or after AED withdrawal, 96 children had seizure recurrences. Eventually, only 26 children were not seizure free. Shorter I_start and I_stop, bilateral MRI abnormalities, older age at surgery, higher number of AEDs tried preoperatively, and incomplete resection were independently associated with seizure recurrence during/ after AED withdrawal. The risk of not regaining seizure freedom, when medication was restarted after seizure recurrences, tended to be lower in children who withdrew medication early. Time intervals were not associated with eventual seizure outcome. Predictors for unfavorable eventual seizure outcome were: higher number of preoperative AEDs, left sided surgery and incomplete resection. In children who underwent hemispherectomy, I_start was 14.9 months (SD 14.9, range 0-72), I_stop 24.0 months (SD 18.1, range 0-105), and timing of AED withdrawal was not related to seizure recurrences or eventual seizure outcome.

Conclusions: Although seizure recurrences are more frequent when AEDs are discontinued early after epilepsy surgery in children, the risk of not regaining seizure freedom after restart of medication is not increased in children who start discontinuation early. Furthermore, early discontinuation of AEDs does not predict poor eventual seizure outcome. After hemispherectomy, timing of AED withdrawal does not influence recurrence rate. We conclude that early AED discontinuation may unmask surgical failure sooner, but not at the expense of eventual seizure freedom. These results justify a future multicenter randomized trial to study benefits and safety of very early start of AED withdrawal after epilepsy surgery in children.

13.00-13.15 **Short Communications**

HEMISPHERECTOMY IN ADULTS

D. Delev, J. Schramm
Dept. of Neurosurgery, Univ. of Bonn, Bonn, Germany

Introduction: Hemispherectomies are performed less frequently in adults, little has been published and thus, knowledge about these patients and results for functional hemispherectomies are less well known. We therefore reviewed our data base for adult hemispherectomy patients with the intent to describe the patient group and outcome.

Methods and patients: This is an analysis of 27 adult patients who had functional hemispherectomy in a total series of 130 patients between 1989 and 2009. Data were collected prospectively usually by annual or bi-annual follow-up performed by a telephone call or letters or follow-up visits at the hospital. Mean age at operation was 29 years, range 19 to 54. Patients with follow up under 12 months (n=2) were excluded from most analyses. One patient died, having been seizure free four months after the surgery in a traffic accident as a pedestrian.

Etiologies were: Post-infarction cyst or porencephaly n=15 (58%), post encephalitic with or without cyst n=4 (15%), Rasmussen encephalitis or other acute encephalitis n=2 (8%), hemiatrophy n=2 (8%), hemimegalencephaly n=1 (4%), dysplasia or cortical malformations n=2 (8%).

Four patients were operated on using Rasmussen's functional hemispherectomy technique, three using our own perisylvian transcortical method, and 17 using the transsylvian keyhole disconnection procedure (Schramm et al).

Follow-up over one year was available in 24 cases (mean 6 yrs, range 2-12 yrs). Engel class I outcome was achieved in 88% of cases, 88% in the transsylvian technique, 100% in the transcortical perisylvian technique, and 75% in the Rasmussen technique. Of the 24 patients 17 (71%) were always Engel class I after surgery, four (16%) were initially not seizure free but became Engel class I later, and three (12%) were initially seizure free and later had seizures again. Thus, recurrent seizures occurred in 12% of all patients.

Two patients already had a shunt before the hemispherotomy. Five patients developed surgical complications related to the hemispherotomy: one wound infection, subdural hematoma, and infection of a pre-existing shunt. Two late surgical complications: one intraventricular cyst needed resection and one patient needed a later shunt with several revisions. One postoperative pneumonia and one recurrence of depressions and episodes of fear, known previously. None of the complications led to permanent sequelae except for the one case with a new shunt implantation. The shunt rate is thus 4%.

Conclusion: Outcome of functional hemispherectomy in adults appears to be rewarding with Engel class I outcome of 88%. There was a relatively high rate of complications, although significant deficits did not result from this. Later re-occurrence of seizures occurred in 12%. It appears worthwhile to perform functional hemispherectomies in adults.

Reference: Schramm J, Kral T, Clusmann H: Transsylvian Keyhole Functional Hemispherectomy. Neurosurgery 49:891-900; 2001

13.15-13.30 **Short Communications**

HEMISPHEROTOMY IN 3 ADULT PATIENTS. INDICATION AND FOLLOW-UP

A. Hermsen[1], H.M. Hamer[1], P.S. Reif[1], S. Bauer[1], A. Haag[1], J. Schramm[2], F. Rosenow[1]
[1]Neurology, Epilepsy Centre, Philipps University, Marburg, Germany, [2]Dept. of Neurosurgery, Bonn, Germany

We present Indication for and and follow-up after hemispherotomy in three adult patients

Case 1, female, 17yrs
A) right-hemispheric epilepsy since age 13 yrs & B) IGE
Focal deficits: left homonymous hemianopsia
Seizures (sz): I) Dialeptic sz-> GTCS, II) Dyscognitive status epilepticus
Etiology: Sturge-Weber-Syndrome
EEG: Interictal: A) sharp wave right temporal, B) spike-wave complex, generalized
Ictal: A) Seizure-pattern right parieto-occipital, B) Seizure-pattern generalized (polyspike&wave-complexes)
MRI: angiomatosis temporo-parieto-occipital, suspected hippocampal sclerosis, right hemiatrophy
Neuropsychology (restriction mother tongue): Right-handed, IQ still average though school for learning disabled, short term-memory below average, verbal & nonverbal memory unremarkable; No lateralising functional deficits, frontal or parietal dysfunctions.
11/09: modified lt hemispherotomy (parieto-occipito-temporal disconnection)

6-months-Follow-Up:
Three early postoperative sz, seizure free since (ILAE1).
New spastic hemiparesis left leg/foot
EEG: continuous slow and sharp wave, regional right temporal (T6, rare)
Neuropsychology: Improvement: short-term memory (especially verbal) Losses: nonverbal memory, new spatial perception deficit. Positive attitude about operation.

Case 2, male, 20 yrs
Right hemispheric epilepsy since age 14 yrs
Focal deficits: Left spastic hemiparesis, homonymous hemianopsia left, hydrocephalus, ventriculo-peritoneal shunt
Seizures: I) epigastric aura -> automotor sz -> clonic sz left face ->GCTS,
II) tonic sz left arm -> bilateral tonic sz
Etiology: early prenatal porencephalic cyst, DD schizencephaly

EEG: Interictal: Sharp wave right parietal (max.P8,P4), continuous slow, lateralized right
Ictal: EEG-seizure-pattern right parietal
MRI: right-hemispheric defect (MCA territory) with polymicrogyria.
Neuropsychology: Right-handed, secondary school, low average IQ, deficits in attention, verbal memory & executive functions, preserved visuospatial functions & nonverbal memory contrasting with the right hemispheric lesion.
Wada-Test (right injection only): no language deficit, preserved memory, no increase of hemiparesis
08/07: Rt. Hemispherotomy

2-yrs-Follow-Up:
Seizure free (ILAE 1)
No new neurological deficit.

EEG: Sharp wave, right temporal
Neuropsychology: vocational training for clerk, improvement in attention, decline in visuopatial short-term memory and nonverbal memory

Case 3, male, 28 yrs
Rasmussen syndrome since age 10 yrs
Etiology: Rasmussen encephalitis right,
Seizure: Unspecific aura->dialeptic sz->nystagmus to left -> tonic sz left arm->versive sz to left->GTCS
EEG: Interictal: Spike right parietal; asymmetry, decreased background activity right
Ictal: EEG-seizure pattern right frontal (F4/F8)
MRI: Rt. Hemiatrophy after Rasmussen encephalitis
Neuropsychology (restrictions: vigilance & hemi spastic): right-handed, normal school until 10 yrs, then Learning disabled school, now: sheltered workshop, low average IQ, better in figural material, deficits in verbal & nonverbal memory. No psychiatric comorbidity.
Wada-Test (right): no speech deficit, partial right-hemispheric representation of memory possible
08/08: Hemispherotomy

1-yr-follow-up:
Seizure outcome: none with loss of consciousness (Engel 1)
No new neurological deficits
EEG: Continuous slowing generalized & in basic activity, Sharp wave, regional right frontal (F8)
Neuropsychology: no standardized FU due to new anxiety & psychotic symptoms (wants to die, because of intense fear to die), currently under remission (psychotherapy, risperidone)

Discussion
Seizure onset was relatively late 10-14 yrs. All patients had a good seizure outcome (2 Engel 1a, 1 Engel 1). Quality of life has improved in two patients, one initially had severe psychiatric symptoms that are currently under remission.

13.30-13.45 **Short Communications**

HEMISPHERECTOMY: CONSIDERATIONS FOR SEIZURE FREEDOM

Y.D. Park, S.M. Strickland, B.S. Choi, A.M. Murro, J.R. Smith, M.R. Lee
Medical College of Georgia, Augusta, USA

Background: The concept of hemispherectomy was derived initially in 1928 for resection of glioblastoma. Due to complications of cerebral hemosiderosis, it was not adopted by epilepsy surgeons until years later when Rasmussen proposed the functional hemisperectomy. Our aim is to demonstrate the outcomes from our institution in an effort to identify any predictors for seizure freedom without significant complications.

Methods: We retrospectively reviewed the epilepsy surgery data base of children and adults who underwent functional hemisperectomy or hemispherotomy for intractable epilepsy between 1992 and 2009 at the Medical College of Georgia. We examined demographic data, clinical history, EEG, MRI, neuropathology, and clinic follow up at years one, two, three and five with Engle seizure outcome classification. We looked at variables such as age of onset of seizures, duration of epilepsy and etiology to determine outcome predictors. Statistical analysis was done by ANCOVA.

Results: Fifty cases were reviewed: 28 males and 22 females, 37 pediatric cases (<18 years) and 13 adult cases. The mean age of seizure onset was 4.6 years (0-26 ± 5 (SD)). The mean age of surgery was 13.6 years (1-40.6 ± 10.4 (SD)) The mean duration of epilepsy was 9.4 years (0.2 - 37 ± 9.2 (SD)). Forty patients had functional hemispherectomy and ten patients had hemispherotomy. Etiology was divided as cortical dysplasia, cerebral vascular accident, Rasmussan's encephalitis, Sturge-Weber syndrome, trauma, and gliosis (includes hypoxic ischemia and encephalomalacia). Combining all etiologies, at one year follow-up 76% (38/50) were seizure free, at three years 77% (28/36, with unavailable data for 14) remained seizure free, and similarly at five years 82% (23/28, with unavailable data for 22) remained seizure free. Unavailable data was attributed to noncompliant patient follow up or the patient follow up interval was not yet appropriate. Investigating each etiology separately, seizure freedom was rendered in cortical dysplasia 76% (9/12), CVA patients were rendered 75% seizure free (9/12), RS rendered 92% (11/12), SWS rendered 100% (1/1), trauma rendered 0% (0/1), and gliosis 66.7% (8/12).

Seizure freedom at one year follow up was not dependent upon age of the onset of hemiparesis, age of seizure onset, age of surgery, nor duration of epilepsy. At five year follow up, the duration of epilepsy and subsequent seizure freedom versus not seizure free did reach statistical significance (p=0.025).

Fourteen patients had a prior epilepsy surgery which was not successful prior to the hemispherectomy. Of those with a prior surgical history, following subsequent hemispherectomy, 78% (11/14) were seizure free at year one, and 85% (6/7 patients available) at year five. Complications occurred in 12 cases and included hemorrhage, stroke, diabetes insipidus, and a prolonged vegetative state.

Conclusion: We demonstrate that hemispherectomy can serve as a beneficial surgery for certain seizure etiologies as diffuse cortical dysplasia, Rasmussens or Sturge Weber Syndrome. Seizure freedom appears to remain over time. However, in those cases which a

preexisting hemiparesis occurs in the setting of a known global injury such as hypoxic ischemic encephalopathy, the likelihood of obtaining seizure freedom is less.

13.45-14.00 **Short Communications**

CONTRALATERAL MRI ABNORMALITIES AFFECT SEIZURE AND COGNITIVE OUTCOME AFTER HEMISPHERECTOMY

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Objective: To explore if EEG and MRI abnormalities in the 'healthy' hemisphere influence seizure and cognitive outcome after functional hemispherectomy.

Methods: This is a retrospective consecutive cohort study of 43 children who underwent functional hemispherectomy between 1994 and 2008. Results of preoperative EEG recordings were reviewed for the existence of (inter)ictal epileptic or background abnormalities in the contralateral hemisphere. Preoperative MRIs were re-examined for the existence of unequivocal contralateral abnormalities. Postoperative seizure status was assessed and of 34 children, intelligence quotient (IQ) or mental developmental index (MDI) scores were obtained pre- and postoperatively. Seizure freedom was defined as Engel 1A. Contralateral EEG and MRI abnormalities were studied in relation to seizure and cognitive outcome.

Results: Thirty-three children achieved seizure freedom (77%). Of the 11 patients with contralateral MRI abnormalities, only 45% were seizure free, compared to 88% of the 32 patients without contralateral MRI lesions (p=0.030). Children with contralateral MRI abnormalities more often were severely retarded after surgery (MDI/IQ <55; 90% versus 42%, p=0.030). Postoperative MDI/IQ scores improved in none of the children with, but in 38% of those without contralateral MRI abnormalities (p=0.034). Contralateral epileptic or background EEG abnormalities did not affect seizure outcome or postoperative cognitive performance. Four of six children with bilateral epileptic encephalopathy reached seizure freedom.

Conclusion: Unambiguous contralateral MRI abnormalities are significantly associated with seizure recurrence, severe mental delay and lack of cognitive improvement, and may be considered a relative contraindication for hemispherectomy. Contralateral EEG abnormalities do not negatively influence postsurgical outcome.

14.00-14.15 **Short Communications**

LONG-TERM EFFICACY OF MODIFIED ANATOMICAL HEMISPHERECTOMY FOR TREATMENT OF EPILEPSY IN PATIENTS WITH INFANTILE HEMIPLEGIA WITH 302CASES

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Key words: *Epilepsy, Evoked potential, fMRI, Hemosiderin, Modified anatomical hemispherectomy,*

Objective: To investigate the long-term efficacy of modified anatomical hemispherectomy for treatment of epilepsy in patients with infantile hemiplegia and resulting functional hemispheric plasticity.

Methods: The traditional method of anatomical hemispherectomy was modified.A total of 302 patients underwent this modified method of hemispherectomy from 1986 to 2009 in my department. The initial 31 patients who underwent the procedure before 1989 were studied. Follow-up included clinical physical examination, electrophysiological study, neuropsychological evaluation, and neurological imaging .

Results: No deaths resulted from the modified procedure. In 29 patients epilepsy disappeared completely and in the other 2 patients epilepsy was under control. Behavior disorders and hemiplegia improved. There was no significant difference in I-wave latency of brainstem auditory evoked potentials between the patients and a normal control group (P>0.05). The results of structural neurological imaging showed that the operative cavity was filled in by the hemisphere on the healthy side. Functional neurological imaging showed that this hemisphere can control the movemet of the ipsilateral side of the body.

Conclusion: Modified anatomical hemispherectomy resolves the pathological anatomical problem of a huge operative cavity that results from traditional anatomical hemispherectomy and thus helps overcome the problem of commonly occurring long-term complications. The healthy cerebral hemisphere has motor areas that control the ipsilateral side of the body.

15.00-15.30 **Workshop 1**
Workshop 1: Surgical Techniques

HEMISPHERECTOMY AND HEMISPHEROTOMY - SURGICAL TECHNIQUES

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Cerebral hemispherectomy is a radical but at the same time highly effective surgical technique in order to treat patients with drug-resistant hemispheric epilepsy from several etiologies. It was initially proposed and performed by Walter Dandy in a few patients with extensive right-sided gliomas, but later gained popularity as a surgical treatment for severe epilepsy following infantile hemiplegia.
Specific, partially life-threatening complications following this anatomical hemispherectomy lead to the development of different modifications, the most popular among them being Rasmussen's functional hemispherectomy, whose principal was a partial replacement of the hemispheric brain removal by disconnection of the remaining frontal and parieto-occipital lobes.
In recent years, this idea has been consequently pursued with the proposal of different hemispherotomy techniques, which consist in an even more limited brain tissue removal, from which on the epileptic hemisphere will then be entirely disconnected the from the level of the basal ganglia, the thalamus and the contralateral hemisphere.

Besides certain differences in the perioperative morbidity and hospital course, the currently worldwide applied hemispherectomy/hemispherotomy techniques do not seem to differ substancially in the success rates for seizure control when anatomically correctly performed. The single most influential factor is the underlying pathological substrate, with malformations of cortical development demonstrating consistently lower success rates.

15.30-16.00 **Workshop 1**
Workshop 1: Surgical Techniques

WHEN WE SHOULD NOT REMOVE S1M1 IN HEMISPHERIC EPILEPSY?

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Up to now there is no precise definition of what is meant, when an epilepsy is classified as „hemispheric". In a rather narrow definition the term "hemispheric epilepsy" would indicate that the entire cortex of one half of the brain is epileptogenic.
Many times however, epilepsies are labeled as "hemispheric epilepsies" in a more operational approach, in order to express the opinion that in case epilepsy surgery is considered, chances for a seizure-free outcome are seen only, when a hemispherectomy / hemispherotomy is carried out.
This surgical procedure will inevitably lead to a hemiparesis and a hemifield-cut, if these deficits are not present already prior to surgery.

Hemispherectomies / hemispherotomies are carried out in children with severe epilepsies, caused by a number of different etiologies, like Rasmussen encephalitis (RE), hemimegalencephaly (HME), congenital hemiplegia with porencephalic cyst, polymicrogyria of one hemisphere (PMG), "hemispheric" Sturge-Weber-syndrome, hemiatrophy, hemispheric dysplasia other than HME or PMG, and in children with post-traumatic or post-infectious "hemispheric epilepsies". Out of this long list of etiologies a diffuse epileptogenicity of the entire cortex of the affected hemisphere is known to be the case in 2 etiologies only: Rasmussen encephalitis and hemimegalencephaly.
In patients with a "hemispheric epilepsy", who do not present with a hemiparesis and in whom the epilepsy is caused by one of the other etiologies, the option of a tailored resection/ tailored disconnection must be considered in order to preserve sensory-motor functions.
Surgical options are e.g. a so-called "inverse hemispherectomy" or a so-called "EBM"-(= "Everything But Motor") procedure, in which the M1-/S1-areas and their descending and ascending fibers are left intact – with a variable extend of cortical areas surrounding the central sensory-motor area left on place.
Decision-making in this direction is most challenging in children with "hemispheric"-type I-FCDs – and no hemiparesis.

To the other hand that a patient with a severe epilepsy does already have a hemiparesis, which will not be changed by a hemispherectomy / hemispherotomy doesn't mean that he / she is automatically a candidate for this procedure.
Disconnecting / resecting cortical areas outside of the damaged central sensory-motor area may put patients at risk for a decline of cognitive and memory-functions as well as for problems in daily life with new visual field-cuts.
Decisions for one or the other procedure must be left to centers with a large experience in epilepsy surgery.

The results of our experience with so-called "EBM-procedures" will be presented and examples will be demonstrated, in which this type of surgery may be wishful thinking - and examples, in which this difficult surgical option is worthwhile to try.

16.00-16.15 **Short Communications**

DISCONNECTION OF THE ENTIRE HEMISPHERE (HEMISPHEROTOMY) WITHOUT HEMIPLEGIA. A NEW TECHNIQUE

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Despite modern and less invasive techniques, functional and anatomical hemispherotomy may be complicated by hydrocephalus and worsening of hemiparesis. Functional hemispherotomy has been described by different authors to avoid gross hemisphere removal. The functional hemispherotomy achieves a complete disconnection by sectioning the principal commisural fibers i.e. 1) corpus callosum, 2) anterior commisural complex (anterior and posterior part), 3) posterior commisure, 4) forniceal interammonic commisure, 5) abenulae commissure, 6) septum pellucidum. However, this technique itself includes a direct manipulation of basal ganglia complex through a transventricular approach associated with risk of hydrocephalus, subdural collections and worsening of motor deficit. In some patients without pre-existing motor impairment, these complications may reduce the potential indications of hemispherotomy. On this basis we have conceived a new hemispherotomy technique with the goal of entire disconnection preserving the cortico-spinal tract and avoiding as much as possible the ventricular system.

Two children affected by severe drug-resistant post-traumatic epilepsy underwent hemispherotomy with this technique. They were two 15-years and 4 years old males that sustained a severe head injury ten and four years before respectively. In both cases the pre-operative neurological examination showed a mild hemiparesis controlateral to the damaged hemisphere.

Surgery was computer-assisted in all cases. After a 4 x 4 cm fronto-parietal right craniotomy with exposure of middle line a multi-step section of anatomical commissures was made to disconnect the hemisphere: 1) complete corpus callosotomy through a classic interhemispheric approach; 2) section of anterior portion of anterior commissure after anterior cut of corpus callosum joining the suprasellar cistern, and section of posterior portion of anterior commisure through a transcortical direct lateral approach to the interpeduncolar cistern; 3) section of posterior commissure by joining the ambiens cistern at the end of corpus callosotomy; 4) section of forniceal interammonic commisure through the same lateral approach joining the ambiens cistern; 5) section of abenulae commissure through the interhemisperic approach. The complete surgical exposition of the interpeduncolar, peripeduncolar and ambiens cistern confirms the complete lateral disconnection. The complete interhemispheric approach confirms the vertical disconnection.

In the early post-operative period none of the patients showed a worsening of pre-existing hemiparesis. At discharge the neurological examination was entirely equal to the pre-operative status. At sixteen and two months follow-up respectively the patients are seizure free.

This preliminary experience suggests the possibility to consider early functional hemispherotomy in drug resistant epilepsies without hemiparesis.

16.15-16.30 **Short Communications**

PARTIAL DISCONNECTION PROCEDURE IN TREATMENT THE PATIENT WITH BILATERAL MALFORMATION OF CORTICAL DEVELOPMENT (CASE REPORT)

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Purpose: Partial hemispherotomy was suggested by T. Rasmussen in 1983 and later it was applied in treatment of patients with monolateral widespread cortical damages localizing in temporo-parietal regions and preserved hand motor function (Daniel et al., 2004). We have not seen any data of usage this method in treatment of patient with bilateral lesions.

Case report: A girl 15 years old with medically refractory epilepsy was treated surgically in N. N. Burdenko Neurosurgery Institute, Moscow in October 2008. The patient suffered from complex partial seizures without aura appearing in loosing consciousness, adversion to the right, falling, sometimes with secondary generalization with frequency - 2 - 4 per month. She had no neurological deficit and only slight intellectual decreasing (learning in normal school). MRI revealed bilateral malformation of cortical development (fig. 1) - bilateral periventricular nodular heterotopy and bilareral cortical dysplasia associated with dysgyria in temporo-parietal regions. Mild atrophy of right hemisphere was noted. EEG recording showed bilateral interictal epileptic discharges, but invasive monitoring with usage inracerebrar electrodes placed in medial temporal and parietal regions and nodules of heterotopia on both sides showed icral onset zone in right medial temporal and parietal regions.

The surgical procedure consist in: anterior temporal lobectomy with opening the temporal horn by transsection throw the medial margin of the superior temporal gyrus to the trigonum; dissection of the parahippocampal gyrus and the medial part of the temporal lobe at the level of the ambient cistern; dissection of posterior part of the corpus callosum; detachment of the temporo-paieto-occipital complex by dissection throw the with matter of the parietal lobe behind the sensomotor cortex (fig. 2). Histological investigation revealed heterotopia and cortical dysplasia type 1 B. The patient got hemianopia, but no other permanent neurological or mental deficit. She has been seizure-free after surgery (more that 1.5 year).

Conclusion: Partial disconnection procedures may be effective surgical treatment in patients with bilateral lesions, but lateralized ictal onset zone if total hemispherotomy is not indicated.

ABSTRACTS

PROGRAMME: FRIDAY, OCTOBER 1st, 2010

9.00 – 09.30 **Session 1**

CATASTROPHIC EPILEPSY OF EARLY ONSET: INDICATIONS FOR HEMIDISCONNECTION

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Early onset epilepsy is associated with a poor prognosis for both seizure control and neurodevelopmental outcome. It is presumed that the neurodevelopmental compromise in many of these children is at least in part the result of ongoing epileptiform discharges – namely 'epileptic encephalopathy. On this premise, early cessation of seizures is desirable to optimise outcome. This is particularly true in children with early onset epilepsy the result of structural abnormalties of one cerebral hemisphere. Surgical series suggest seizure freedom in 40-80% of children dependent on pathology, with a significant improvement in the majority. There is little evidence of detriment in the absence of surgical complications, and neurodevelopmental outcome studies suggest a shorter duration of epilepsy to be associated with a better neurodevelopmental outcome.

The decision of when rather than if to operate is usually the question. Hemiparesis may not be apparent early in the first year, and therefore decision on the part of the parents difficult. Further, variability in seizure frequency may delay referaal or decision making. All children with onset of epilepsy in the first two years of life with a unilateral structural lesion should be evaluated by an epilepsy surgery centre. There may be a period of evaluation, even observation, but a decision can then be reached with the family that may be optimal for the child. However time may be of an essence in maximising outcome in these children.

09.30 – 10.00 **Session 1**

LIFE AFTER HEMISPHERECTOMY IN INFANCY OR CHILDHOOD

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In The Netherlands, the countrywide Dutch Collaborative Epilepsy Surgery Programme (DuCESP) considers the suitability for epilepsy surgery of children with pharmacologically intractable epilepsy. The intervention, including hemispherectomy, is performed at the University Medical Centre, Utrecht (UMCU). The children are assessed and followed according to a fixed protocol, by the department for paediatric neuropsychology of the UMCU. The presentation will be based on the experience, obtained with all children who were considered candidates for hemispherectomy between 1994 and 2007 and who could be assessed prior to hemispherectomy and followed during two years thereafter. Of the 29 children, 17 were infants and preschoolers (median age at epilepsy onset 0.0 years and at hemispherectomy 1.5 years; epilepsy duration 0.2-2.6 years) and 12 were school children (median age at onset 1.0 years and at hemispherectomy 8.3 years; epilepsy duration 1.1 – 11.7 years). The pathology was developmental (11 children), acquired (11 children) or progressive (7 children). The children were assessed according to a standard protocol with fixed intervals: shortly before hemispherectomy and approximately 6, 12 and 24 months thereafter. The aim of this longitudinal study was to detect change in very young and for the most part intellectually very low functioning children. With respect to cognition, separating results obtained with developmental scales from those obtained with intelligence scales, and not only addressing group data but also individual change, the analysis brought to light subtle improvements in very young, poorly functioning children, but also a variable course in older children. At the present date, at least five more years have passed. We started a call-back procedure to follow up neuropsychological and psychosocial functioning of children who had undergone hemispherectomy five years or longer ago. We now draw from these data. To order the complexities of “life”, we use the classification into functioning, activities and social participation that is offered by the ICF (International Classification of human Functioning, Disability and Health) (World Health Organization. International classification of functioning, disability and health. Geneva: WHO; 2001).

On the level of *functions*, freedom or reduction of seizures is an important outcome measure and a gate for further development of the infant or child. However, cognitive and motor functioning remain impaired.

1. But how the child is doing in every day life depends not only on nature and degree of the remaining impairments. On the level of *activities*, limitations abound, such as in domains of skill learning and independence.
2. *Social participation* is not really relevant for children, but in youngsters quite divergent outcomes have to be anticipated.
3. Very important influences are personal features and, particularly, environmental factors.

Life after hemispherectomy is the resultant of manifold factors that are not always easily disentangled. We selected two pairs of cases. One pair illustrates the far reaching effect of environmental (under)stimulation and the other pair illustrates that – notwithstanding significant cognitive impairments – a harmonious, responsive and rewarding life can be attained.

10.00 – 10.30 **Session 1**

QUALITY OF LIFE AFTER HEMISPHERECTOMY

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Measures of quality of life (QOL) have been described in adults and children after focal resections for epilepsy but have not been well delineated after hemispherectomy. Using written survey instruments, we collected demographic and QOL data on 31 patients after hemispherectomy. Overall QOL was lower for patients after hemispherectomy than for the general pediatric population and compared to children with other chronic diseases. Univariate regression analysis identified the following factors as predictors of higher QOL: age at seizure onset, pathology (malformation of cortical development vs. stroke/Rasmussen syndrome), ability to walk 20 min unassisted, and ability to walk 30 min unassisted. The final multivariate regression analysis indicated that ability to walk unassisted 20 min (P = 0.001), history of an orthopedic procedure after hemispherectomy (P = 0.006), and age of seizure onset (P = 0.016) predicted higher QOL. We conclude that functional mobility factors and age of onset contribute significantly to overall QOL. Other factors also may contribute to QOL and are the subject of our ongoing studies.

11.00-11.30 **Session 2**

PET AND DTI STUDIES OF BRAIN PLASTICITY IN HEMISPHERECTOMY SUBJECTS

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Cerebral hemispherectomy in infants and children is performed as a treatment for medically refractory epilepsy resulting from infantile hemiplegic cerebral palsy, unilateral brain malformations such as hemimegalencephaly or hemispheric cortical dysplasia, chronic focal encephalitis of Rasmussen, Sturge-Weber syndrome, and hemiplegia-hemiconvulsive syndrome. Surgical procedures vary across centers and include anatomical hemispherectomy, functional hemispherectomy and hemispherotomy. In all these procedures, the basal ganglia and thalamus of the affected side are left intact.

Children undergoing these large resections early in life show marked functional recovery. The hemiplegia is most pronounced in the forearm and hand, and shoulder strength can be normal. Ambulation is the rule, although with a hemiparetic gait. There is a hemianopsia contralateral to the side of surgery. Even complex cognitive and other skills such as language, visual processing, interfield visual discrimination, auditory-temporal processing, abstraction and reasoning can be served by a single hemisphere. These children provide unique opportunities for the study of functional brain reorganization and age-at-lesion effects.

We have used neuroimaging approaches to study these children and have reported a number of interesting observations. Using positron emission tomography (PET), we observed the initial loss of glucose metabolism in the ipsilateral basal ganglia and thalamus when scanned 3-6 months following hemispherectomy; however, when these children were rescanned 1-2 years later, glucose metabolism in the deafferented caudate nucleus had reappeared (Ann Neurol 1995; 36:794-7). In a more recent study, we used PET with alpha[^{11}C]methyl-L-tryptophan (AMT) to evaluate serotonergic alterations in subcortical structures following cortical resection in children with intractable epilepsy. AMT uptake in the thalamus and lentiform nucleus was evaluated postoperatively (1-89 months following resection) in 19 children (mean age: 8.7 years) with a previous cortical resection. There was increased AMT uptake in the lentiform nucleus ipsilateral to the resection as compared to the contralateral side (mean asymmetry: 4.2 $\pm$ 3.0%), and the asymmetries were significantly higher than those measured in normal and epileptic control groups ($p \leq 0.001$). Post-resection asymmetry indices in the lentiform nucleus correlated inversely with postoperative time ($r= -0.67$; $p=0.002$), but not with age ($p=0.29$) or the extent of resection ($p=0.77$). In contrast, thalamic AMT uptake asymmetries were not different among the three groups ($p=0.63$). Thus, cortical resection results in a sustained increase of AMT uptake in the lentiform nucleus, suggesting increased serotonin synthesis (Epilepsy Res 2008;78:124-130). Increased serotonergic activity in the deafferented striatum may play a role in the functional reorganization of cortico-striatal projections in humans.

In the monkey, the caudate and putamen receive bilateral projections from motor cortex and, following bilateral frontal cortical lesions in neonatal monkeys, the caudate appears to assume functions (e.g., delayed response) mediated by dorsolateral prefrontal cortex. In both rat and cat, sparing of contralateral motor function following neonatal motor cortex ablation is markedly diminished if the caudate-putamen is also removed. Indeed, the South African neurosurgeon Krynauw, in his classical description of the first series of hemispherectomy in human subjects, stated that the hemiplegia contralateral to the side of surgery is worse if the basal ganglia are also removed, although actual data to this effect were not included in his manuscript (J Neurol Neurosurg Psychiatry 1950;13:243-267).

We have suggested that these PET metabolic changes may be due to increased cortico-striatal projections from the contralateral hemisphere to the ipsilateral striatum. Recently, we used diffusion tensor imaging (DTI) and probabilistic tractography to test this hypothesis. We found a specific increase in fiber connectivity between caudate ipsilateral to the resection and contralateral frontal cortex and insula; this is consistent with our previous findings of functional changes in striatum following resection and supports the notion that, following large cortical resections, the ipsilateral caudate participates in functional reorganization.

11.30-12.00 **Session 2**

VOLUME BASED MORPHOMETRY OF THE REMAINING HEMISPHERE: GREY & WHITE MATTER ATROPHY FOLLOWING CEREBRAL HEMISPHERECTOMY

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Background and aims: By frequently achieving seizure control and preventing further cognitive deterioration cerebral hemispherectomy effectively leaves an individual with one functioning hemisphere to mediate postoperative development. We evaluated structural brain changes in individuals years post hemispherectomy to investigate whether the remaining hemisphere demonstrates atrophy and/or augmentation of gray and white matter as a result of massive endogenous and exogenous reorganization.

Methods: Structural MRI was performed in 16 chronic patients post hemispherectomy (age range 6-21 years). Crossectional voxel-based morphometry measures of gray and white matter were obtained, compared with age and gender matched controls (n=24) and correlated with a functional index reflecting improvement following a period of mobility training.

Results: Structural brain changes were identified in all sensorimotor areas including M1S1, sensorimotor integration areas in parietal and temporal lobe and subcortical white matter. In all areas the relationship between the chronological age and volumes of gray/white matter was opposite to what we saw in controls. Whereas controls demonstrated steady increase in volumes associated with age, children and young adults post-hemispherectomy showed decrease. This suggests that younger patients with earlier surgeries have less atrophy of the remaining hemisphere in comparison with the older patients who were also older at surgery. Furthermore, functional gains as a result of therapy were larger in participants with more spared volumes of gray and white matter.

13.00-13.15 **Short Communications**

PREDICTING FAVORABLE MOTOR OUTCOME AFTER HEMISPHERECTOMY: TMS VERSUS FMRI

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Introduction: Some, but not all patients with congenital hemiparesis can receive hemispherectomies without significant motor deterioration [1]. This phenomenon can be explained by reorganization of motor functions in the contra-lesional hemisphere induced by the lesion [2].
Transcranial magnetic stimulation (TMS) and functional MRI (fMRI) both can, non-invasively, monitor (re-)organization in the sensorimotor system. Indeed, both techniques have been used prior to hemispherectomies [3,4], but their different predictive validities have not yet been addressed.

Patients: Four boys, congenital hemiparesis with preserved function of the paretic hand (grasp function, selective finger movements), epilepsy onset 2.5 months - 4.5 years.
Etiology: Hemispheric polymicrogyria (n=3), hemiatrophy (n=1).
Hemispherectomies were performed at the age of 5 - 10 years.

Methods: TMS (single pulse, focal figure-eight coil), simultaneous recording of motor evoked potentials (MEPs) from first dorsal interosseus (FDI) muscles.
fMRI: active or passive opening / closing of the paretic hand versus rest, block design [5].

Results: fMRI of active movement of the paretic hand showed only ipsilateral activation in the contra-lesional central region in 1 / 3 patients, and activation in both central regions in 2 / 3 patients. One patient was not willing to perform active hand movements in the scanner; in him, fMRI of passive movement of the paretic hand showed only contralateral activation in the central region.
TMS of the lesioned hemisphere did not elicit MEPs in any patient, whereas TMS of the contra-lesional hemisphere elicited bilateral MEPs with similar fast latencies (< 30 ms) in all 4 patients.
After hemispherectomy, active grasping with the paretic hand was still possible in all 4 patients.

Conclusion: TMS showing ipsilateral projections from the contra-lesional hemisphere but no evidence of crossed cortico-spinal projections from the lesioned hemisphere correctly predicted favorable hand motor outcome in 4/4 patients.
Interestingly, preoperative fMRI during paretic hand movement showed activation in the lesioned hemisphere in 3 of these 4 patients. In analogy to similar cases with unilateral periventricular brain lesions [6], we therefore speculate that this activation could represent a contralaterally preserved primary somatosensory representation (S1) of the paretic hands. Consequently, such an isolated S1 is apparently not necessary for the paretic hand to still perform active grasping movements.

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13.15-13.30 **Short Communications**

MOTOR PERFORMANCE AND ACTIVITIES OF DAILY LIFE AFTER HEMISPHERECTOMY

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On behalf of the Dutch Collaborative Epilepsy Surgery Programme.

Purpose: Longitudinal 2 years follow-up study after hemispherectomy in 35 children (< 16 yr). The present study evaluates motor performance, activities of daily life (ADL), and independence in children before and after surgery in three different aetiology groups.

Method: Motor performance was measured using the Gross Motor Function Measure (GMFM-88). Gross Motor Functional Classification System (GMFCS) was used to classify self-initiated movement. For pre- and postoperative assessments, scores per aetiology group were depicted in a boxplot against the reference line of their age- and GMFCS-matched CP counterparts in order to visualize the developmental progress per aetiology group.

ADL-function and independence were measured using the Pediatric Evaluation of Disability Inventory (PEDI). Participants had assessments before surgery, and at 6, 12 and 24 months after surgery.

Results: Over the 2 years, motor function improved significantly ($p < .05$). Two years postoperative mean GMFM total scores (SD) per GMFCS level: Level 1 (n=4) 88,75 (11,4), Level 2 (n=9) 66,2 (12,6), Level 3 (n=9) 54,6 (11,3), level 4 (n=8) 25,4 (11,8), Level 5 (n=5) 9,6 (2,5). With respect to ADL-function and independence, 85% of the children improved significantly in more domains of the PEDI. The mean scores on the PEDI domains improved significantly in all domains ($p<0.001$).

Conclusions: Motor performance in children following epilepsy surgery improved significantly in the majority of the children. Scores are comparable with referent scores in children with Cerebral palsy, without epilepsy surgery. The postsurgical improvement of gross motor function development in acquired and progressive disorders is absent in children with in developmental lesions, suggesting a more diffuse pathology with involvement of the remaining hemisphere. Children improved on ADL-function and independence after epilepsy surgery. This means that epilepsy surgery is not only successful for reduction of seizures but also for improvement of motor function in children with acquired and progressive disorders.

Key words: Epilepsy, hemispherectomy, motor performance, GMFM scores, PEDI.

13.30-13.45 **Short Communications**

NEURO-COGNITIVE AND EPILEPTIC LONG-TERM FOLLOW-UP AFTER EARLY HEMISPHERECTOMY IN CHILDREN WITH CATASTROPHIC EPILEPSY

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We report the experience about a neuro-cognitive and epileptic long-term follow-up of children with catastrophic epilepsy treated with hemispherectomy at Catholic Univeristy in Rome. Nineteen children with resistant epilepsy that significantly interfered with their neuro-cognitive development underwent hemispherectomy within 5 years of life (mean: 2 years and 3 months; range: 5 months to 5 years). Our sample included three aetiological groups: patients with developmental pathology, with perinatal brain vascular injuries, and with progressive diseases. Developmental lesions included 13 hemimegalencephaly. Two cases presented with early acquired vascular pathology. They were affected with poroencephaly, one due to a MCA ischemic infarction and one from a grade IV intraventricular hemorrhage (IVH). The patients with progressive diseases were affected with Sturge-Weber disease (three cases) or Rasmussen Encephalopathy (one case). According to the ILAE classification, epileptic syndromes consisted of Symptomatic partial epilepsy (SPE) in all cases, one of which was associated with epilepsia partialis continua and one followed by continuous spike waves during slow sleep (CSWS). Eight cases were affected with West syndrome and the remaining six cases with Ohtahara syndrome, both associated with SPE. All patients were assessed before surgery and after, at least at the end of the follow-up (mean: 8 years and 7 months; range: 3-13 years and 10 months) with a full clinical examination including motor ability and functional status evaluation as well as behaviour observation, neuroimaging and an ictal/interictal prolonged scalp video-EEG. Fifteen out of 19 patients underwent anatomic hemispherectomy (four hemidecortications). Eleven of them (68.7%) were affected by hemimegalencephaly, while three presented Sturge-Weber syndrome. Another child suffered from Rasmussen's encephalitis. The remaining four children of the series (two with poroencephalic cysts and two with hemimegalencephaly) underwent functional hemispherectomy (two hemispherotomies). Only one child, who had undergone functional hemispherectomy for hemimegalencephaly, required a further surgical procedure (hemidecortication) because of the initially poor results. A seizure-free outcome was obtained in 73% of patients. The seizure outcome seemed dependent on aetiology and on surgical procedure. There was an optimal (Ia or Ib) outcome in all cases with vascular brain injuries and in those with progressive diseases. In developmental pathology, six out eight (75%) children who underwent classic anatomic hemispherectomy were in Engel's class I throughout all the follow-up. On the contrary, the percentage of children with good epileptic outcome after other kinds of hemispherectomy (functional and hemidecortication) decreased progressively to only 40% on final evaluation. The patients with persistent seizures belong all to the dysplastic group. Gross motility generally improved and cognitive competence did not worsen, with an evident progress in two cases. Consistently with previous reports, evolution was worse in cortical dysplasia than in progressive or acquired vascular cerebropathies. The excellent epileptic outcome and the lack of developmental deterioration in comparison with other more aged series seem to suggest a possible better evolution in earlier surgery treatment.

13.45-14.00 **Short Communications**

HEMISPHERIC DISCONNECTION AND DEVELOPMENTAL COGNITIVE PLASTICITY: NEUROPSYCHOLOGICAL AND FMRI OF LANGUAGE STUDIES IN A POPULATION OF CHILDREN TREATED BY HEMISPHEROTOMY

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Children with catastrophic epilepsy associated with extensive lesions of one hemisphere are the best candidates for hemispheric disconnection (HD) in order to treat epilepsy. Among the surgical technique of HD, the vertical parasagittal hemispherotomy (VPH) developped by Olivier Delalande (2002, 2007) at Fondation Rothschild (Paris) has been realized in more than 200 children for the lasts 20 years. We have developped a long term follow-up of this large population who underwent HD by the same surgical technique leading to the amazing situation of living and growing with a single hemisphere. Few functional MRI (fMRI) studies have emphasized on the neuronal networks that sustain cerebral plasticity. We used language fMRI in a group of 13 epileptic patients (7 female) who underwent HD. Etiology consisted of Rasmussen's encephalitis (8), ischemic sequelae (3), Sturge Weber syndrome (1) and hemispheric cortical malformation (1). They had undergone VPH at a mean age of 10.8 years on respectively the left (8 cases) or the right (5 cases) hemisphere. All were seizure free since surgery. They underwent fMRI at a mean age of 16.9 years. All the patients were hospitalized the day before fMRI for an extensive neuropsychological testing and special interest was taken to train these children for fMRI in order to obtain optimal participation. Four language fMRI tasks were tested which were adapted for delayed children. The protocol encompassed two receptive (words repetition: WR, listening sentences: LS) and two expressive (words generation: WG and sentences generation: SG). Individual fMRI analysis was dedicated to the activated clusters on the non-disconnected hemisphere; we used a non-corrected voxel-wise threshold of $p<0.00$, corrected at a cluster-level of $p<0.05$. Results on behavioural tasks performed the day before fMRI showed homogenous performances on WR and SG which were easily realized; WG performances were more variable. fMRI individual exhibited activations, localized in the superior and median temporal gyri (respectively, Broadman area 22 and 21) for both receptive and expressive tasks, and in the inferior, medium frontal gyrus and SMA for the SG tasks. A combined tasks analysis (CTA) was also performed in order to increase the chances of detecting activations common to these tasks. This contrast allowed us to detect activations in the perisylvian regions corresponding to the superior temporal gyrus (11/13), supramarginal gyrus (6/13) and inferior frontal gyrus (5/13); medium frontal gyrus (Broadman area 8, 6, 46) were also activated in 9/13 patients. We assumed that these activated regions were involved in the reorganisation of language networks after hemispheric disconnection in children involving homologous areas on both cerebral hemisphere as well as other regions distant from the usual language network.

14.00-14.15 **Short Communications**

FUNCTIONAL CONNECTIVITY AFTER EXPERIMENTAL HEMISPHERECTOMY

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Purpose: Hemispherectomy is a last resort treatment for catastrophic hemispheric epilepsy. The remarkable motor recovery after hemispherectomy reflects the plastic capacities of the brain. Graph theoretical analysis of brain networks improves our understanding of higher cerebral functioning, and the impact of focal lesions on global network configuration.

Method: We studied the remaining hemisphere in hemispherectomized rats (n=8), and age-matched controls (n=12), 7 and 49 days post surgery using resting-state fMRI, weighed graph and interregional connectivity analysis (ROIs were selected within the sensorimotor network; connectivity was measured using voxel-wise correlation coefficients). We quantified the local and global graph structures via the clustering coefficient *C* and the characteristic shortest path length *L*. Sensorimotor function was measured longitudinally by scoring sensorimotor performance (SPS).

Results: After significant acute neurological deficits, SPS largely normalized in all animals within two weeks ($P < 0.0001$). Removal of the right hemisphere resulted in significant enhanced functional connectivity in the left hemisphere between cortical and subcortical regions, as compared to controls. Graph analysis revealed that *L* was significantly lowered at 7 and 49 days, as compared to controls ($P = 0.03$). *C* was lower at 7 days, but recovered at 49 days post surgery.

Conclusions: We have shown that rs-fMRI, connectivity analyses and specific network measures can provide unique insights into functional reorganization in the remaining brain after experimental hemispherectomy. The rapid motor recovery is associated with enhanced contralesional functional connectivity. Graph analysis results suggest global changes in functional network efficiency (*L*) and local connectivity (*C*).

14.15-14.30 **Short Communications**

HEMISPHEROTOMY FOR HEMIMEGALENCEPHALY IN EARLY INFANCY

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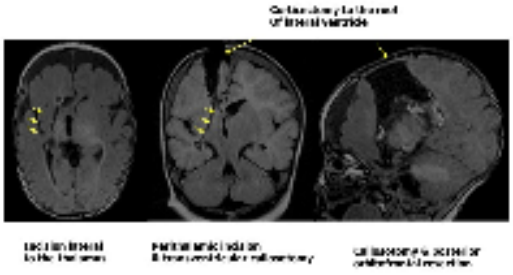
Hemimegalencephaly (HME) often exhibits sever epileptic encephalopathy with a catastrophic nature soon after birth associated with progressive developmental delay. In spite of the fact that hemispherotomy may be the only solution for cure, estimation of post-operative seizure and developmental outcome is difficult in early infancy since bilateral electrophysiological and metabolic abnormalities in both hemispheres are often demonstrated by presurgical evaluation such as EEG, MEG and PET.

We have operated 12 intractable epilepsy infants with hemimegalencephaly aged 2 -9 months (mean 4.5 months) at the time of surgery from 2003 to 2009 in our institute. Preoperatively, 11 patients (92%) exhibited early infantile epileptic encephalopathy with suppression-bursts (EIEE) and mean developmental quotient (DQ) was 33.5. Surgery was performed by one of the authors (TO) using a vertical approach, which was originally developed by Delalande, via a parasagittal 4cm x 2 cm cortical window disconnecting the whole pathological cortex from the healthy hemisphere and the brain stem. Postoperatively, both EEG and metabolic abnormalities were recovered at the healthy side of the brain in all the cases. With a minimum post-operative follow-up of 1 year, 8 patients (67%) were classified as Engel Class I but 4 patients continued to have seizures; i.e., Class II (1 case), III (1 case), IV (2 cases). Patients with favorable seizure outcome (Class I+II) showed an increase in DQ. No surgical complications were experienced except post-operative hydrocephalus treated by VPS in 1 patient.

Conclusion: Hemispherotomy for hemimegalencephaly in early infancy is a choice of treatment even if bilateral electrophysiological and metabolic abnormalities are demonstrated.

Figure 1: Vertical hemispherotomy for HMC



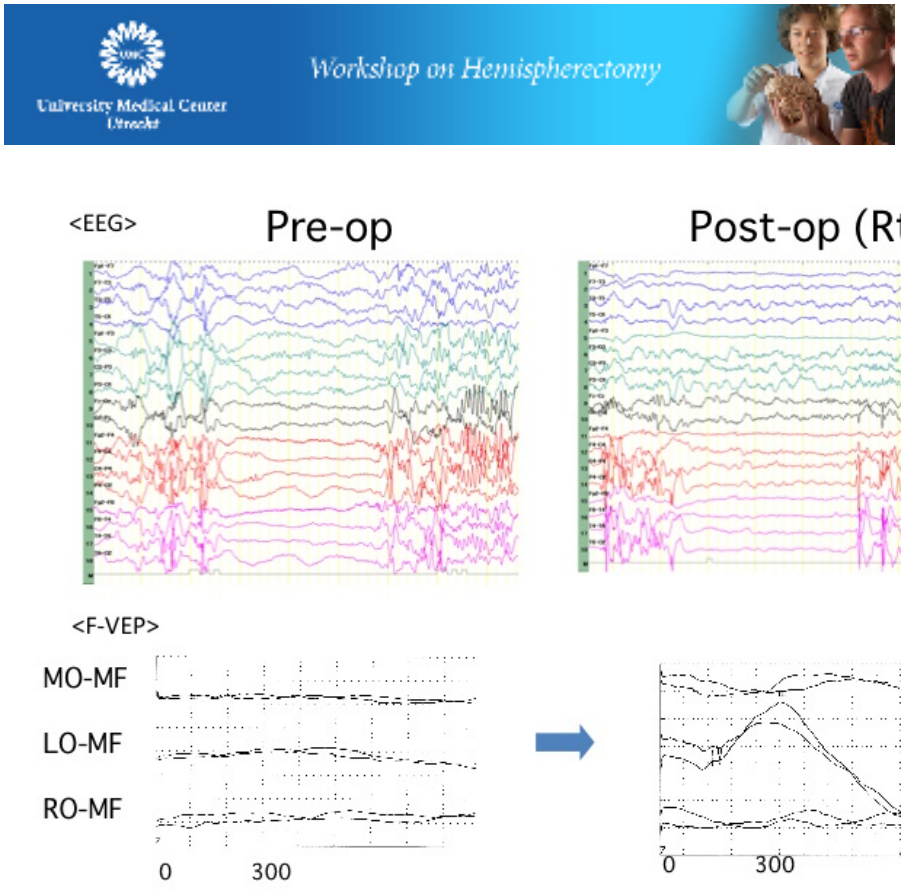


Figure 2: Electrophysiological changes after hemispherotomy

14.30-14.45 **Short Communications**

OUTCOMES OF FUNCTIONAL HEMISPHEROTOMY IN REFRACTORY EPILEPSY OF CHILDHOOD: THE FREIBURG EXPERIENCE

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Introduction: Hemispheric surgery has been applied as early as 1938 in unilateral refractory epilepsy. Patients considered for this intervention commonly present with extensive brain lesions associated with neurological deficit and early onset of catastrophic epilepsy with deleterious effects on cognitive development. Functional hemispherotomy enables functional isolation of a single or multiple unilateral epileptogenic regions and has gained ground as an effective and justifiable procedure in the last decade. *Methods:* The records of 25 pediatric patients that underwent hemispherotomy in the Department of Neurosurgery, University of Freiburg in the decade 1999-2009 were retrospectively analyzed regarding clinical, neuroradiological and electroencephalographic findings, surgical complications and neurological deficits, as well as postoperative seizure freedom and psychomotor development. Etiology included focal cortical dysplasia in 2 cases, hemimegalencephaly in 4, hypoxic-ischemic lesions in 15, Rasmussen encephalitis in 3 and infection in 2 cases. The 3 patients with Rasmussen encephalitis manifested at 2 and 4 years respectively, while another child suffered meningitis at age 4. 21 children presented with perinatal pathology and 13 with epilepsy in infancy. Duration of epilepsy prior to surgery varied from 8 months to 17 years. In 3 patients, hemispherotomy was performed following unsuccessful temporal lobectomy or multilobectomy. Follow-up ranged from 6 months to almost 10 years. *Results:* Postoperative complications included deterioration of hemiparesis with spasticity in almost half of patients, while 5 developed hydrocephalus and 3 had meningitis. No cases of incomplete disconnection were noted. In our cohort, seizure recurrence was associated with pathology such as hemimegalencephaly and Rasmussen encephalitis, although the limited size of our sample does not allow for statistical analysis. Bilateral MRI pathology, evident in postoperative imaging, grossly correlated with poor outcome. On the other hand, bilateral EEG findings preoperatively did not preclude seizure freedom. Children with perinatal stroke profited the most presenting an Engel I outcome. Seizure recurrence occurred after an initial 3 months to over one year of seizure freedom in 3 cases. *Conclusion*: Despite the risk for permanent neurologic deficits and surgical complications, hemispherotomy has proven a reliable surgical procedure in reducing seizure burden. Outcome depends on etiology, as previously reported, but even seizure reduction may be crucial in some cases, especially regarding severe or disabling seizure types. Early intervention may be essential in preserving developmental outcomes. Choosing the candidates more likely to profit from hemispherotomy and the appropriate time point for such a procedure constitutes a major challenge in epilepsy surgery nowadays.

14.45-15.00 **Short Communications**

HEMISPHERECTOMIES IN CHILDREN. EXPERIENCE FROM GOTHENBURG, SWEDEN

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Purpose: To describe the group of children going through hemispherectomy and the seizure outcome two years after surgery.

Methods: Data on children operated with hemispherectomy in Gothenburg during the period 1987-2006 will be presented. Data is reported following a protocol as part of the Swedish National Epilepsy Surgery Register, which is prospective since 1995. The protocol includes data on preoperative assessments, type of operation, complications, histopathological diagnoses and a two-year follow-up.

Results: 15/152 procedures were hemispherectomies. Four were reoperations, in one case as a planned staging procedure, in two cases after multilobe resections and after frontal lobe resection in one case. Eight had an IQ < 50, six 50-69 and one >70. All had a motor impairments, the majority cerebral palsy. One had a diagnosis of autism and five had problems with hyperactivity and attention. Median age at hemispherectomy was 5.4 years (range 0.9-18.3 years). Eleven became seizure-free (80%), two had >75% reduction of seuzure frequency, and two <50% reduction of seizure frequency. Eight had malformation of cortical development, five gliosis, one Sturge Weber syndrome and one hemimegalencephaly. There were no major complications. Three had a gain in full scale IQ of more than 5 points.

Conclusion: 80% in the Gothenburg series of hemispherectomies became seizure free after operation. Most of the children have severe neurological impairments but may have a lot to gain from hemispherectomy.

15.30-16.00 **Workshop 2**
Workshop 2: Cortical Plasticity, Reorganization and Animal Models

FUNCTIONAL REORGANIZATION FOLLOWING HEMISPHERECTOMY, CORTICAL CROWDING?

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Reorganization of language functions following hemispherectomy has been the focus of numerous studies since the mid 20th century, with early reports testifying that the isolated right hemisphere has the potential for “remarkable” preservation of speech functions. Subsequent studies have refined this finding, and shown that some but not all language functions can be taken over by the isolated right hemisphere. Our data from children operated on in London (Great Ormond Street Hospital and King’s College, UK) have shown that factors such as intelligence and memory play an important role in language outcome after both right and left hemispherectomy. More recently, we have examined the cost of language reorganization, and tested the “crowding hypothesis” in the domains of intelligence, working memory, and visuo-spatial functions usually attributed to the right hemisphere. Results indicate that, firstly, the impairment of nonverbal functions following hemispherectomy is not uniform, with some skills more impaired than others. Secondly, as seen for language outcome, nonverbal outcome is influenced by age at onset of pathology. The extent and limits of functional plasticity during development will be discussed.

16.00-16.30 **Workshop 2**
Workshop 2: Cortical Plasticity, Reorganization and Animal Models

EFFECTS OF PERINATAL HEMISPHERECTOMY IN MONKEYS (AETHIOPS SABEUS)

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In the past year we have provided a unique model of perinatal anatomical hemispherectomy in the vervet monkey to study brain reorganization and behavioural recovery. Monkeys were subjected to a battery of neurobehavioural tests every 6 months until adulthood. These tests included sensory (Vision,somesthesis), sensory-motor (tactile and visual placing) and motor (spontaneous behaviour, locomotion, equilibrium etc..) functions. Thereafter, they were prepared for anatomical evaluation of the visual system (retina, lateral geniculate nucleus and superior colliculus), the basal ganglia and the dorsal column nuclei. Our results showed a remarkable recovery in most of the behavioural functions tested that have neuroplastic substrates. At the anatomical level, visual structures, although altered by the lesion, maintain viable connexions. Deeper structures such as the basal ganglia and the dorsal column nuclei seem normal. These results indicate that hemispherectomy performed at an early age is a viable approach to relieve intractable epilepsy while having beneficial effects on behaviour.

16.30-17.00 **Workshop 2**
Workshop 2: Cortical Plasticity, Reorganization and Animal Models

NEURAL SUBSTRATES OF BLINDSIGHT IN HEMISPHERECTOMIZED HUMAN SUBJECTS

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Blindsight is a visual phenomenon whereby hemianopic subjects are able to process visual information in their blind visual field without awareness. Previous research demonstrating the existence of blindsight in hemianopic subjects has been criticised for the nature of the paradigms used, for the presence of methodological artefacts as well as for the possibility that spared islands of visual cortex may have sustained the phenomenon since the subjects generally had small circumscribed lesions. In order to respond to these criticisms, we have been investigating for several years now, residual visual abilities in the blind field of hemispherectomized subjects in whom a whole cerebral hemisphere has been removed or disconnected from the rest of the brain,. These subjects have offered a unique opportunity to establish the existence of blindsight and to investigate its underlying neuronal mechanisms since in these cases spared islands of visual cortex cannot be evoked to explain the presence of visual abilities in the blind field. In addition, we have been using precise behavioural paradigms, strict control for potential methodological artefacts such as light scatter, fixation, criterion effects and macular sparing and we have utilized new neuroimaging techniques such as Diffusion Tensor Imaging Tractography to enhance our understanding of the phenomenon. In this talk, we will review our research on the involvement of the superior colliculi in blindsight in hemispherectomized subjects.The aim was to test the processing abilities of separate visual pathways that may be involved in blindsight by using the achromatic properties of collicular cells, which receive no input from S-cones (color-blind to blue/yellow stimuli). Our results demonstrated that blindsight in hemispherectomized subjects is color-blind to blue/yellow stimuli, suggesting a collicular involvement in the phenomenon. We confirmed the contribution of the superior colliculi in hemispherectomized subjects with blindsight using Diffusion Tensor Imaging Tractography.

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