Hemispheric surgery for refractory epilepsy in children and adolescents: Outcome regarding seizures, motor skills and adaptive function

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A B S T R A C T

Purpose: The aim of the study was to report the seizure outcome, motor skills and adaptive motor functions in a series of children and adolescents who underwent hemispheric surgery, analysing the risk-benefits of surgery.

Methods: The clinical course, seizure and motor function outcomes of 15 patients who underwent hemispheric surgery were reviewed.

Results: The mean age at surgery was 9.5, with 1–9 years follow-up. The underlying pathologies were Rasmussen encephalitis, vascular disorders, and hemimegalencephaly. All the patients presented with severe epilepsy and different degrees of hemiparesis, although motor functionality was preserved in 80% of the patients. At last follow-up, 67% were seizure free, and 20% rarely experienced seizures. Antiepileptic drugs were reduced in 60%, and complete withdrawal from such drugs was successful in 20% of the patients. The motor outcome following the surgery varied between the patients.

Despite the motor deficit after surgery, the post-operative motor function showed unchanged for gross motor function in most (60%), while 27% improved. Similar results were obtained for the ability to handle objects in daily life activities. Sixty percent of the children were capable of handling objects, with somewhat reduced coordination and/or motor speed.

Conclusion: Pre-surgical motor function continues to play a role in the pre-surgical evaluation process in order to provide a baseline for outcome. Hemispheric surgery, once regarded as a radical intervention and last treatment resource, may become routinely indicated for refractory hemispheric epilepsy in children and adolescents, with oftentimes favourable motor outcomes.

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1. Introduction

Hemispheric surgery (HS) is an established treatment for medically refractory epilepsy resulting from diffuse hemispheric disease, and it provides remarkable results in seizure outcome and quality of life.1–3

HS can be considered for patients with seizures arising from one hemisphere, with pre-existing structural and functional abnormalities; the other hemisphere is usually normal. This approach is particularly suitable for those with pre-existing hemiplegia and visual field deficit, in whom coexisting cognitive and behavioural impairments are common.4 HS may be offered to patients without such disabilities, especially in circumstances in which intractable seizures are accompanied by the deterioration of motor and intellectual skills and in cases in which more conservative resections are unsuccessful.4,5

The decision making process and consideration of baseline motor function during the presurgical evaluation of patients considered for HS differs among epilepsy surgery centres. Certain centres are more conservative, limiting surgery to patients with preoperative hemiparesis.2,6 On the other hand, surgery may be indicated in patients with or without minor motor deficits.1,4,5,7,8

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Despite good seizure outcome, the anticipated loss of motor function may prevent a decision to perform the surgery.\(^5\)

The objective of this study is to report the seizure outcome, motor skills and adaptive motor functions in a series of children and adolescents who underwent HS at our centre, analysing the risks (residual motor deficit) and benefits (seizure reduction) of surgery.

2. Methods

We conducted a retrospective review of medical records in 15 children and adolescents (9 males) who underwent HS at Hospital São Paulo, Universidade Federal de São Paulo, between 2003 and 2011. The patients were assessed using a standard presurgical protocol, including clinical, neuroimaging and neurophysiological evaluations. Detailed clinical data were obtained from the patients and their families. All patients were examined by high-resolution magnetic resonance imaging and prolonged video-EEG recording. In the cases in which surgical treatment was indicated, the data were discussed during an interdisciplinary meeting. The records of the motor evaluation of muscle strength and motor function abilities, including the ability to sit, walk, and use both hands were reviewed, and these data were collected. The pre- and postoperative motor functions were assessed for presence and severity of hemiparesis. The muscle strength of the extremities was scored by manual muscle testing, with grades from 0 to 5. The functional level of each patient was evaluated through the Gross Motor Function Classification System (GMFCS) and the Manual Ability Classification System (MACS), which classify patients’ movement and manual abilities, respectively. These scores were recorded in the charts or inferred by the available data.\(^10\)\(^,\)\(^11\)

The GMFCS determines which of the five levels best corresponds to abilities and limitations in gross motor function, with particular emphasis on sitting (truncal control) and walking: level I denotes patients who walk without limitations, and level V indicates those with severe limitations of head and trunk control who require extensive assisted technology and physical assistance.\(^10\)

The MACS scale is used to assess a patient for coordination in both hands working together; it is not an assessment of each hand taken separately. The five levels are based on a patient’s self-initiated ability to handle objects and need for assistance or adaptation to perform manual activities in daily life. The patients classified at level I handle objects easily and successfully, whereas the patients classified at level V do not handle objects, have a severely limited ability to perform simple actions and require complete assistance.\(^11\)

The Fisher exact test was used to compare the results of the pre- and post-operative GMFCS and MACS’s scores, grouped according to motor adaptive functions (Group A: satisfactory scores – levels I, II or III; Group B: unsatisfactory scores – levels IV or V).

Seizure outcome was assessed using the Engel scale of seizure outcome after epilepsy surgery.\(^12\)

During the postsurgical appointments, each parent was asked which grade of satisfaction he/she would attribute to the surgical intervention (from zero, minimum satisfaction, to 10, maximum satisfaction) regarding the seizure outcome and cognitive/motor functions in his or her child.

3. Results

3.1. Patients and pre-operative data

The age at seizure onset ranged from 18 days to 7 years (mean 3.1/median 3 years). The age at surgery varied between 1.3 and 16 years (mean 9.5/median 5.8), and the epilepsy duration was 0.2–14 years (mean 5.9/median 2). The post-operative follow-up period ranged from 1 to 9 years (mean 4/median 3) and the follow-up was longer than 2 years in two-thirds of the patients (Table 1).

The underlying pathology was Rasmussen encephalitis in nine patients (60%), vascular disorders in five patients (33%) and hemimegalencephaly in one patient (7%). The left hemisphere was involved in ten cases (67%) (Table 1).

Fifteen patients had daily seizures, and nine had epilepsy partialis continua. Fourteen patients were treated with antiepileptic drug (AED) polytherapy, and six had received previous immunomodulatory treatment.

All the patients presented with at least a mild level of hemiparesis, although it was not pronounced in one-half of the patients. Eight patients (53%) had a score of 3 or higher for muscle strength (Table 1). In six patients (40%), fine finger movements were preserved. The GMFCS and MACS scores are shown in Graphics 1 and 2.

3.2. Operative and complications – potential risks

In 14 patients (93%), a hemispherotomy was performed. One patient had undergone a previous surgery, and hence hemispherectomy was indicated. Mild intra- and/or post-operative complications were reported in all the patients, including minor bleeding and fever. Moderate reversible complications were observed as follows: infections (3 patients), ipsilateral vascular ischaemia (1), diabetes insipidus (1), lung atelectasis (1), and trigeminal neuralgia (1).

Table 1

| Clinical data and pre- and post-operative muscle strength in upper and lower limbs. |
|---|---|---|---|---|---|---|---|
| Age at surgery* | Pathology | Follow-up* | Engel Class | MS-UL Pre-HS | MS-UL Post-HS | MS-LL Pre-HS | MS-LL Post-HS |
| 1 | 2.3 | RE | 9 | I | 4 | 5 | 3 | 4 |
| 2 | 1.3 | Vascular | 9 | I | 1 | 2 | 2 | 2 |
| 3 | 5.8 | Vascular | 9 | II | 3 | 4 | 3 | 4 |
| 4 | 10.8 | RE | 4.4 | I | 4 | 4 | 3 | 4 |
| 5 | 3.3 | HME | 1 | II | 2 | 2 | 3 | 4 |
| 6 | 13.6 | Vascular | 4 | III | 2 | 3 | 3 | 3 |
| 7 | 9.4 | RE | 3.6 | I | 4 | 4 | 3 | 4 |
| 8 | 4.9 | RE | 3.6 | I | 4 | 3 | 3 | 4 |
| 9 | 11.3 | Vascular | 3 | III | 3 | 4 | 3 | 3 |
| 10 | 6.3 | Vascular | 3 | I | 4 | 4 | 3 | 4 |
| 11 | 6.2 | RE | 2 | I | 2 | 3 | 3 | 4 |
| 12 | 5.6 | RE | 2 | I | 2 | 3 | 2 | 3 |
| 13 | 3.5 | RE | 2 | II | 2 | 3 | 3 | 4 |
| 14 | 3 | RE | 2 | I | 2 | 4 | 3 | 4 |
| 15 | 16 | RE | 1 | I | 4 | 3 | 2 | 4 |

* In years; MS-UL: muscle strength upper limb; MS-LL: muscle strength lower limb; HS: hemispheric surgery; RE: Rasmussen encephalitis; HME: hemimegalencephaly.
respectively.

Follow-up,

11.3

Handles

Lesion
gross

Patients

Graphic

754

Level

Walking
outdoors
and
in
the
community.
Level
III:
Walks
with
assistance
from
a
device.
Level
IV:
Self
mobility
with
a
limited
selection
of
easily
managed
objects
in
adapted
situations.
Level
V:
Self
mobility
is
severely
limited,
even
with
use
of
assistive
technology.

3.3. Seizure outcome – potential benefits

At the last post-operative follow-up appointment (1–9 years
of
follow-up,
mean
4
years),
67% of
the
patients
were
seizure
free,
and
87%
were
classified
as
Engel
Class
I
or
II.
The
worst
outcome
(Engel
Class
III)
was
observed
in
patients
6
(13.6
years
at
surgery)
and
9
(11.3
years).
Both
of
these
patients
had
an
underlying
vascular
lesion
as,
and
their
epilepsy
duration
was
9.6
and
11
years,
respectively.
Two
patients
were
lost
to
follow-up.
The
other
patients
remained
stable
with
regards
to
seizure
outcome
over
time,
with
the
exception
of
patient
3,
who
went
from
Engel
Class
I
to
II
after
two
years
of
follow-up.

In
the
immediate
post-operative
period,
all
the
patients
continued
taking
the
identical
AED
regimen
used
before
surgery.
The
AEDs
were
gradually
tapered
with
safety
evaluations
concerning
seizure
relapse.
In
nine
patients,
the
level
of
AED
therapy
was
reduced
by
one-half
compared
to
the
pre-operative
levels.
Complete
withdrawal
from
AED
therapy
without
seizure
relapse
was
successful
in
three
patients.

3.4. Motor function outcome – potential risks

The
comparisons
between
the
pre- and
post-operative
measurements
of
muscle
strength
in
the
upper
and
lower
extremities
are
shown
in
Table
1.
The
scores
reflected
a
post-surgical
muscle
strength
worsening
in
40% and
improvement
in
27% of
the
patients
in
the
upper
extremities.
With
respect
to
the
lower
limbs,
in
13% of
the
patients,
the
muscle
strength
decreased;
in
33%,
it
improved;
and
in
53% it
remained
unchanged.

Comparisons
for
the
GMFCS
and
MACS
scores
are
depicted
in
Graphics
1
and
2.
The
post-operative
motor
functional
levels
decreased
in
27% of
the
patients
gross
motor
function.
Only
27%
of
the
patients
had
GMFCS
scores
higher
than
level
III,
indicating
self-mobility
with
limitations
\((p = 0.029)\).
Similar
findings
were
seen
regarding
the
ability
to
handle
objects
in
daily
life
activities.
The
two
patients
who
presented
post-operative
poor
scores
for
the
MACS
(levels
IV
or
V
–
ability
to
handle
a
limited
selection
of
easily
managed
objects
in
adapted
situations)
had
poor
pre-surgical
MACS
scores
before
the
HS
\((p = 0.01)\).

3.5. Parents’ satisfaction with surgery – risks and benefits

All
parents
reported
high
levels
of
satisfaction
with
the
surgical
treatment
(grades
8–10,
mean
9.7)\(a\)
and
80% attributed
grade
10
to
the
procedure.

4. Discussion

4.1. Seizure outcome – potential benefits

The
results
show
good
seizure
outcome
in
our
series,
with
67%
of
the
patients
reaching
Engel
Class
I.
This
finding
is
consistent
with
other
series,
in
which
52–86%
of
patients
became
seizure-free
after
short
and
long-term
follow-up.\(^1,2,4–8,13–18\)
Considering
that
these
patients
presented
with
daily
seizures
or
epilepsia
partialis
continua
before
surgery,
Engel
Class
II,
which
corresponds
to
rare
disabling
seizures,\(^12\)
may
be
considered
good
seizure
outcome.
This
outcome
includes
87%
of
our
series,
corresponding
to
outcomes
in
the
literature
with
reports
of
reduction
in
seizure
frequency
varying
from
58
to
91%.\(^1,2,4–8,13–18\)
In
this
series,
the
stability
of
good
seizure
outcome
during
the
long-term
follow-up
should
be
emphasised.
The
limited
number
of
patients
precluded
any
analysis
of
the
prognostic
factors.
The
worst
seizure
results
were
found
in
two
of
the
three
children
who
were
older
than
10
at
the
time
of
surgery
and
who
had
long-term
epilepsy.
In
the
majority
of
the
pediatric
studies,
age
at
surgery
is
not
considered
to
be
a
d predictor
of
seizure
outcome.\(^4,7,10\)
Kossof
et
al.
(2003)
found
that
the
duration
of
epilepsy
before
surgery
was
shorter
in
the
patients
who
became
seizure
free,
although
this
finding
did
not
reach
statistical
significance.
These
authors
suggest
the
possibility
that
delays
should
be
avoided
in
patients
with
intractable
hemispheric
seizures.\(^6\)

In
addition
to
the
good
seizure
outcome,
we
were
able
to
withdraw
or
reduce
medications
in
the
majority
of
our
patients.
Considering
that
children
with
epilepsy,
especially
those
with
refractory
seizures,
are
at
increased
risk
for
cognitive
impairment,
at
least
in
part
due
to
diagnosis
of
AED
therapy,\(^1,15\)the
possibility
of
reducing
medications
can
be
considered
to
be
a
good
result.
Other
authors
have
previously
reported
this
benefit
from
HS,
with
no
seizure
relapse.\(^1,6,12,16,20\)

4.2. Motor function outcome – potential risks

Regardless
of
the
favourable
seizure
outcome
after
HS
and
considering
both
the
severity
of
the
epilepsies
in
these
patients
and
the
well-known
and
potentially
reversible
surgical
complications,
the exacerbation or initiation of motor deficits might represent a strong reason to postpone surgery, especially in children without such motor deficits.

4.2.1. Muscle strength
With respect to motor function, at pre-surgical baseline, all of our patients presented with a degree of hemiparesis, which was mild or moderate in half of them. In nine patients (60%), the hemiparesis was disproportionate, more prominent in the upper limbs, and more severe distally, with impairment of fine finger movement. Other authors have observed this disproportionality among the upper and lower limbs in patients evaluated for HS and have noted the difference between proximal and distal impairment, which is more severe in the hands.9,10,21–23

The motor function outcome after HS varied between patients and among the upper and lower limbs. The results were worse in the measurements of upper extremity muscle strength, in which the scores reflected a further post-surgical loss of power in 40% of the patients. The scores for the lower limbs remained unchanged in 53% and worsened in 13% of the patients. A degree of muscle strength improvement was observed in 27% (upper limbs) to 33% (lower limbs) of the children. These findings are in accordance with the literature: post–HS motor strength can improve, remain unchanged or worsen, and worsening is observed more frequently in the upper limbs.2,4,9,14,15,17,21–23 Several features are identified as predictors for improvement or deterioration in motor functioning, including the age at surgery,16,22 post-surgical seizure remission,4,7,8 the level of pre-operative cognitive development,4,16 or previous paresis and/or aetiology.8,9,22,23 Our sample was too small for statistical analysis aimed at identification of prognostic factors.

4.2.2. Adaptive motor functions
Impairment is defined as a problem in structure leading to significant deviation or loss,24 reflecting the consequences of a disease at the organ level.9 Limitations in activities reflect dysfunction in performance and motor activity, and restrictions refer to difficulties encountered in social participation.9,24

Hemispheric epilepsy in children represent a functional and/or structural impairment, and seizures can potentially lead to limitations and restrictions. Despite the motor injury that is a consequence of HS, the post-operative motor functional levels showed that the majority of our patients (60%) were unchanged with respect to gross motor function, while 27% improved. The two patients who worsened in post–HS GMFCS had Rasmussen encephalitis. They presented with relatively preserved pre-operative motor strength (level 4), but a higher potential for deterioration caused by the progressive evolution of the disease without surgical treatment.

Equivalent results were obtained for the ability to handle objects in daily life activities. Although more patients showed a decrease in this evaluation, which was expected as a consequence of the HS, 60% of the children were at level II according to the MACS, indicating that they were capable of handling most objects, with somewhat reduced quality and/or speed of achievement.11

The two children who did not reach satisfactory scores in the MACS did not reach them in the GMFCS either because of severe deficits before surgery.

Our data confirms and expands previous studies. Qualitative functional analysis9,12,15,17 or the use of international functional motor scales, including the GMFCS9,16 and the 74 Fugl-Meyer Assessment of Motor Recovery scale,25 showed similar data. Kossoff et al. (2003) observed that, except for those with major perioperative complications, all the patients (93/105) were walking independently without the use of assist devices, and the majority of these patients had learned to use one hand as a helper. Several have adapted to their disability condition so well that they were able to play the piano, golf, and ping-pong, and were able to dance.9 The motor impairments, limitations in motor activities and aspects of social participation exist before HS and remain unchanged in the majority of cases, with the pre-operative functionality maintained or improved. These results, including seizure control in particular, indicate overall improvement in epilepsy management.

In the past, the effectiveness of epilepsy surgery was measured predominantly in terms of seizure reduction. In addition to seizure reduction, developmental and cognitive function,16,20 including motor abilities9,16,23 and language function10,25 tend to be evaluated with increasing frequency as additional outcome measures, in particular due to their influence on the quality of life. The level of satisfaction of the parents with the surgical procedure supports this hypothesis in our series.

Our data follow the tendency of paediatric epilepsy treatment in general, in which an assessment of daily activities and participation in social life is more comprehensive and more reflective of a patient’s needs than an assessment of the impairments themselves.9,24 According to this concept, the target of HS is an overall good outcome, including seizure frequency, developmental measures and quality of life.

5. Conclusion

The favourable motor functional outcome is relevant because the assessment of pre-surgical motor function continues to play a role in the surgical decision making process. Considering that the seizure outcome is good and that complications are manageable, HS, which was once regarded as a radical intervention and the last treatment resource, may become routinely indicated for refractory lesonal hemispheric epilepsy in children and adolescents.

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