Intraoperative Neurophysiology in Pediatric Supratentorial Surgery: 59 cases

A. Korn, H. Benvenisti, M. Jubran, Y. Bitan-Talmor, P. Ekstein, S. Constantini, J. Roth

Departments of Pediatric Neurosurgery, Anesthesiology
Intraoperative neurophysiological monitoring service
Dana Children’s Hospital, Tel-Aviv Medical Center, Israel
Intraoperative neurophysiology (ION): Mapping Vs. Monitoring

Mapping
Cortical: Defining phase reversal region
Direct cortical stimulation (motor, linguistic)
Monopolar / bipolar (Penfield) probes

Subcortical stimulation
Probes
CUSA

Goal - define functional regions, as well as proximity to motor tracts (CST)
Intraoperative neurophysiology (ION)

Monitoring

MEP – trans-cranial, trans-cortical

SEP

Goal – assess neural pathway integrity
Implications of ION

Adults

Widely applied in resection of intraaxial tumors, epilepsy foci, and brainstem related pathologies.
Focus on preserving neurological function during the approach and maximizing resection.

Children

Widely used for lesions in and around the brainstem.
No literature relating supratentorial surgery.
Intraoperative mapping and monitoring of the corticospinal tracts with neurophysiological assessment and 3-dimensional ultrasonography-based navigation

Clinical article

*Erez Nossek, M.D.,1 Akiva Korn, M.Med.Sc.,1 Tal Shahar, M.D.,1 Andrew A. Kanner, M.D.,1,2 Hillary Yaffe, B.S., M.M.S.,2 Daniel Marcovicci, B.S.,2 Carmit Ben-Harosh, R.N., M.A.,1 Haim Ben Ami, M.Sc.,3 Maya Weinstein, M.A.,3,4 Irit Shapira-Lichter, Ph.D.3 Shlomi Constantini, M.D., M.Sc.,1,2 Talma Hendler, M.D., Ph.D.,1,5 and Zvi Ram, M.D.1,2

Linear relationship:
Current in MA Vs. Distance in mm
What is unique about children?

Pathology

Tumors

Low grade

Hemispheric, thalamic, ventricular

Epilepsy

Defining motor regions and pathways during epilepsy resections and other surgeries

Immaturity of motor and sensory conducting pathways (de-synchronization, myelination)

Awake craniotomy limited in children
Questions:

Can ION be applied (mapping / monitoring) in children undergoing supratentorial surgery, and what factors influence evokability

How do mapping and monitoring affect surgical decisions

What is the correlation between monitoring changes and lesion factors, EOR, and neurological outcome
Methods

Retrospective

All children undergoing ION (focusing on motor system) for any supratentorial surgery

Collected data included pathology, location, EOR, neurological status (pre and postop), technical data regarding the ION, and impact ION had on surgery
Definitions

**Evokability**: ability to elicit a motor response following an electrical stimulation (AKA monitorability)

**Lesion location**
- Superficial (cortical / immediate subcortical)
- Deep – involving / distorting CST
- Superficial + deep (both)
- Ventricular
Results

Age 3-207 m (95±58)

Lesion location
- Deep (e.g. thalamic) – 18%
- Superficial – 54%
- Deep + superficial – 22%
- Ventricular – 5%

Pathology
- Tumors 41
- Epilepsy 18
- Lesional 10
- Non lesional 3
- Vascular 4
- Abscess 1
Evokability and age

Age of evokable group was higher..
100±58m vs non evokable group 54±43m
Bipolar Vs. monopolar stimulation

Most pts had both monopolar and bipolar stimulation attempt, but most bipolar stimulations did not elicit a motor response

Monopolar stimulation was achieved at a significantly lower age (min age 3m in mono, and 93m in bipolar)

In infants (<24m) – 6/8 monopolar stimulations were successful, Vs. 0 in bipolar

The current needed for monopolar stimulation increase in younger ages
Evokability did not correlate with:

Lesion grade (high / low)

Lesion location (superficial / deep / superficial+ deep)
Evokability and preop. motor status

Strength 1-3/5 $\rightarrow$ 60% success rate of evokability
Strength 4/5 $\rightarrow$ 88%
Strength 5/5 $\rightarrow$ 90%

Thus, patients with a better preoperative neurological status were more likely to have a motor response following cortical stimulation.
Monitoring stability

Stability not affected by
- Age
- Grade of lesion (low / high)

was affected by
- Extent of resection (EOR)
- Lesion location
EOR & monitoring stability

- The more aggressive we were, monitoring became more unstable
EOR & monitoring stability

Stimulation threshold for stopping resection was changed over time (reduced from 10mA to 2-3mA)
Subcortical stimulation and neurological outcome

Rate of immediate postop neurological deterioration when eliciting a positive SC stimulation

At lower SC thresholds, the risk for immediate postop decline is higher

ISPN, Kobe, Oct 2016
Tumor location and ION

Deep tumors were associated with more instability
ION and immediate postop motor status

Permanent attenuation in monitoring is associated with a higher immediate postop neurological motor decline

<table>
<thead>
<tr>
<th></th>
<th>sens</th>
<th>spec</th>
<th>PPV</th>
<th>NPV</th>
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<tbody>
<tr>
<td>Preserved Function</td>
<td>42%</td>
<td>92%</td>
<td>80%</td>
<td>67%</td>
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<td>Deterioration</td>
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Effect of ION on surgery

<table>
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<tr>
<th></th>
<th>Deep</th>
<th>Superficial +</th>
<th>Superficial</th>
<th>Ventricular</th>
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<tr>
<td>Low subcortical threshold</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Altered corticectomy</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>11</td>
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<tr>
<td>MEP Alarm</td>
<td>11</td>
<td>13</td>
<td>32</td>
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- Effect on surgery is hard to define
- A monitoring change will elicit a surgical response
- But also a stable monitoring provides confidence to advance with a certain maneuver
- Effect on resection and oncological outcome is hard to estimate
Immediate and long-term motor status

Of 19 patient with immediate postop motor decline
13 improved
  5 intact
  5 to preop status
  3 improved but not to preop status
1 remained permanently deteriorated
5 unknown status

The impact of ION stability on long-term motor outcome is being analyzed
Conclusions

ION is a valid technique in pediatric supratentorial surgery

In infants, despite immaturity of motor pathways and difficulty in technique, ION serves as a complement to other surgical considerations

Monopolar stimulation is more successful in eliciting motor responses in young children
Future studies focusing on specific locations (i.e. thalamic tumors) and pathologies could possibly better evaluate the added value and role of ION in pediatric supratentorial surgery.

ION has a role in selected children with lesions in proximity to the motor pathways.
ありがとうございます
Arigatou gozaimasu
Evokability and stimulation technique

**Bipolar stimulation (Penfield technique)**

<table>
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<th>Count</th>
<th>Average of age at surgery (m)</th>
<th>StdDev of age at surgery (m)</th>
<th>Min of age at surgery (m)</th>
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<tr>
<td>with response</td>
<td>10</td>
<td><strong>154.2</strong></td>
<td>38.2</td>
<td><strong>93</strong></td>
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<tr>
<td>without response</td>
<td>30</td>
<td>71.5</td>
<td>56.0</td>
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<tr>
<td>Total</td>
<td>40</td>
<td><strong>92.2</strong></td>
<td>63.1</td>
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**Monopolar fast train technique**

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<th>StdDev of age at surgery (m)</th>
<th>Min of age at surgery (m)</th>
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<tr>
<td>Yes - with response</td>
<td>44</td>
<td><strong>101.3</strong></td>
<td>58.5</td>
<td><strong>3</strong></td>
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<td>Yes - without response</td>
<td>8</td>
<td>54.1</td>
<td>43.1</td>
<td>7</td>
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<tr>
<td>Total</td>
<td>52</td>
<td><strong>94.1</strong></td>
<td>58.6</td>
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25% Evokability

85% Evokability
Stimulation intensity and age

\[ y = -0.0145x + 9.3389 \]

\[ R^2 = 0.0543 \]

\[ y = -0.0538x + 18.49 \]

\[ R^2 = 0.3181 \]
EOR & monitoring stability

Indications for STR as opposed to GTR were multifactorial and not 100% associated with ION

- Proximity to language centers
- Learning curve (implementing ION)
- Heterogeneous lesion locations and pathology

Stimulation threshold for stopping resection was changed over time (reduced from 10mA to 2-3mA)

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