General Movements
General Movement Assessment
a clinical tool to assess neurodevelopmental outcome

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Disclosure

- Dr Berndt Urlesberger
- NIRS - Workshops for Hamamatsu
- NIRS - Workshops for Medtronic

Early, Accurate Diagnosis and Early Intervention in Cerebral Palsy
Advances in Diagnosis and Treatment

- Six systematic reviews and 2 evidence-based clinical guidelines met inclusion criteria. All included articles had high methodological Quality Assessment of Diagnostic Accuracy Studies (QUADAS) ratings. In infants, clinical signs and symptoms of cerebral palsy emerge and evolve before age 2 years; therefore, a combination of standardized tools should be used to predict risk in conjunction with clinical history. Before 3 months corrected age, the most predictive tools for detecting risk are the Developmental Age Assessment Scales (86% sensitivity). The Prochida Qualitative Assessment of General Movements (85% sensitivity) and the Neonatal Neurological Examination (90% sensitivity) after 3 months corrected age, the most

B. Urlesberger, Div. Neonatology, Medical University Graz
What are General Movements?

Without being triggered, the fetal and neonatal nervous system generates a variety of motor patterns, that involve the whole body.

These motor patterns are called General Movements (GMs) (introduced by Prechtl 1990)

GMs are generated by a neuronal network, the central pattern generators (CPGs), which are most likely located in the brainstem.

In order to lend variability to the motor output, supraspinal projections activate, inhibit and, most importantly modulate the CPG activity, as does sensory feedback.

By and large, GMs have the same appearance from the early fetal life until end of the second month after term.

In the first phase they are called “Writhing Movements”

At 6-9 weeks postterm age, the writhing movements gradually disappear, and GMs of a fidgety character gradually emerge.

These “Fidgety Movements” are observable from 3-5 months (postterm)

Fidgety movements are tiny movements of the neck, trunk, and limbs, in all directions and of variable acceleration (Prechtl et al, 1997)
What are General Movements (GMs)?

Reduction of variability!

GMs already start during fetal life

- Startles
- General Movements
- Hiccup
- Isolated Arm Movements
- Isolated Leg Movements
- Breathing Movements
- Micturation
- Side-to-Side Movement of the Head
- Ante- and Retroflexion of the Head
- Jaw Opening
- Hand-Face Contact
- Opening and Closing of Fingers
- Stretch
- Yawn
- Isolated Finger Movements
- Tongue Protrusion
- Sucking and Swallowing
- Rapid Eye Movements
- Blinking

Age in gestational weeks:
14 Wochen PMA 27 Wochen PMA 28 Wochen PMA
Writhing and Fidgety Movements

General Movement Assessment (GMA)

- A Tool to assess the quality of GMs, which can be used in a clinical setting (Prechtl, et al Lancet 1997)
- Pattern recognition (visual Gestalt perception)
General Movement Assessment

**Normal**
- Cerebral palsy
- Early and persisting > GMFCS Level IV, V

**CS**
- Cramped-synchronized general movements
- Lack normal smooth and fluent character
- Movements: rigid and jerky

### Cramped-Synchronized General Movements

- 98% Cerebral palsy
- Unilateral
- Bilateral

### Quality of early movement

<table>
<thead>
<tr>
<th>Type</th>
<th>Normal</th>
<th>Cramped</th>
<th>Synchronized</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRMT</td>
<td>Normal</td>
<td>Cramped</td>
<td>Synchronized</td>
</tr>
<tr>
<td>GMFCS</td>
<td>Normal</td>
<td>Cramped</td>
<td>Synchronized</td>
</tr>
</tbody>
</table>

### Writhing Movements

<table>
<thead>
<tr>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor repertoire</td>
<td>PR</td>
</tr>
<tr>
<td>Cramped-synchronized</td>
<td>CS</td>
</tr>
</tbody>
</table>
General Movement Assessment

**Normal**

Gross movements involving the whole body
Variable movement sequences
Wax and wane in intensity, force, speed
Superimposed rotational movements
Movements fluent and elegant

**PR**

Sequence of successive movement in monotonous manner
Movements do not occur in a complex way as in normal GM

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Poor repertoire (PR) is unspecific

- Seen often in preterm infants
- Especially in first days of life

Table 2
The frequencies of the quality of the general movements

<table>
<thead>
<tr>
<th>Recording days</th>
<th>Abnormal GMs/total recorded GMs (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39/42 (93%)</td>
</tr>
<tr>
<td>2</td>
<td>31/40 (78%)</td>
</tr>
<tr>
<td>3</td>
<td>29/38 (76%)</td>
</tr>
</tbody>
</table>

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Poor repertoire

Trajectories of general movements from birth to term-equivalent age in infants born < 33-week gestation

- Olsen JE et al, Early Hum Dev 2016
- De Vries NKD et al, Early Hum Dev 2010
Trajectory

Preterm infants are at increased risk of adverse neurological outcomes due to their immaturity. Appropriate interventions at an early stage can improve their neurodevelopmental outcome significantly.

Identification and management of risk factors are crucial. This includes monitoring of vital signs, early feeding, and preventing hypoxia and hyperbilirubinemia.

Serious medical conditions such as Inborn Errors of Metabolism, Dyskinetic CP, and Autism Spectrum Disorder can significantly impact neurodevelopment.

Prechtl et al., Lancet 1997
Nakajima et al., Early Hum Dev 2005

NORMAL NEURODEVELOPMENTAL OUTCOME

Mediterranean University of Graz, University of Innsbruck, www.medunigraz.at
NORMAL

A

B

N

O

R

M

A

L

neurodevelopmental outcome

Einspieler et al, Front Psychol 2016
Bruggink et al, Pediatrics 2010
Kodric et al, Eur J Ped Neurol 2011
Beccaria et al, EHD 2012
Spittle et al, 2013

Cerebral palsy
GMFCS Levels I-III
Ferrari et al, Arch Pediatr Adolesc Med 2002
Bruggink et al, Dev Med Child Neurol 2009
Yang et al, Early Hum Dev 2012
Fidgety Movements (FM) 9-16 weeks pt

Circular movements of small amplitude
Moderate speed
Variable acceleration of neck, trunk, limbs
In all directions

FM absent
Never observed from 6-20 weeks pt of age
Amplitude, speed, and jerkiness are moderately or greatly exaggerated

No Fidgety Movements
↓
CP
95 %

Fidgety Movements (FM) 9-16 weeks pt

FM +
Normal neurodevelopmental outcome
96 %

Optimal timepoint: 12-16 weeks postterm
1 Evaluation: 10-12 weeks postterm
2 Evaluations: 10-12 weeks and 14-16 weeks postterm

FM: best time for evaluation?
**GMs Trajectory**

![Graph showing GMs Trajectory](image)

**Predictive Value**

| Table 6. Age Period-Related Likelihood Ratios (LRs) and Accuracy for General Movement (GM) Observation, Grouped Semmavala Criteria, and Neurological Examination (N=85) Shown in Serial Parity |

<table>
<thead>
<tr>
<th>Age Period</th>
<th>General Movement</th>
<th>Neurological Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm</td>
<td>Writhing</td>
<td>Fidgety</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

**Interobserver Reliability**

- **Experts**
  - Review 16 Studies (98 Observers)
  - Kasedin et al., Early Hum Dev 2005
  - Mutlu et al., Neonatology 2008
  - 3 Observers
  - 4 Observers (Fidgety Movements)
  - Parnell et al., Early Hum Dev 2009

- **Trainees**
  - 700 Observers, 3-4 Days Training
  - Valentin et al., Early Hum Dev 2005

- **Intra-individual Consistency** (N=85)
  - Kappa = 0.76-0.83
  - Mutlu et al., Neonatology 2008

Kappa = 0.81-0.92

Kappa = 0.75-0.91

Kappa = 0.85-0.94
N\textsuperscript{=} 738 videotapes from 233 children
M : F = 154:79
Median GA 34 weeks (range 26-42)
Detailed General Movement Assessment

<table>
<thead>
<tr>
<th>GMOS</th>
<th>Normal GM (n=169)</th>
<th>PR GM (n=441)</th>
<th>CS GM (n=160)</th>
<th>Chaotic GM (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>42</td>
<td>39</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>P90</td>
<td>42</td>
<td>39</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>P75</td>
<td>41</td>
<td>29</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Median</td>
<td>39</td>
<td>25</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>P25</td>
<td>37</td>
<td>22</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>P10</td>
<td>35</td>
<td>19</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Minimum</td>
<td>30</td>
<td>13</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>p-values</td>
<td>p=0.01*</td>
<td>p=0.01*</td>
<td>p=0.09*</td>
<td>p=0.01*</td>
</tr>
</tbody>
</table>


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Detailed Assessment for the FM age
Motor Optimality Score

- Max. points: 28
- Min. points: 5
- Normal values: 25-28 points
Motor Optimality Score (MOS)

Motor Optimality Score (MOS) and neurodevelopmental prognosis:

- MOS 3-6: severe CP, GMFCS IV-V
- MOS 7-10: Moderate CP, GMFCS III
- MOS 10-20: Complex Minor Neurological Dysfunction (MND)

Bruggink et al, J Pediatr 2008
Yang et al, Early Hum Dev 2012

Automated Computer Based Assessment

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GMAppe: 1-App for 1-World
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Thank you for your attention!