Assessing the Infant and Child with Spinal Muscular Atrophy

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Why Assessment Matters

- New drug therapies for SMA
- Regular, standardized assessments now crucial for reimbursement
  - Must demonstrate motor improvements for continued coverage
- Important for PT community to be competent in assessing these children using appropriate standardized assessments

Course Objectives

- Provide an introduction to spinal muscular atrophy including genetics and clinical presentations of types 1, 2, and 3.
- Discuss recent changes in the treatment of SMA and how this effects physical therapy evaluation and treatment
- Review key outcome measures for this patient population including the CHOP INTEND and Hammersmith Motor Scale Expanded

Introduction to SMA

- Autosomal recessive inheritance
- Survival Motor Neuron gene → SMN protein
- SMN1 vs SMN2
The Result:

Loss of alpha motor neurons in ventral horn, progressive paralysis, premature death

Types of SMA

• Type 0 - antenatal onset, most severe

• Type 1 - infantile onset, never sit independently
Types of SMA

• Type II- childhood onset (7-18mo), sit independently, typically don’t stand/walk independently
Types of SMA

- **Type III** - onset after 18 months, can stand and walk independently
- **Type IV** - adult onset, able to walk during adult years

Therapeutic Strategies

2 main strategies:

1. **Address genetic defect**
   - Stimulate SMN2
   - Replace SMN1

2. **Protect motor neurons and skeletal muscle**

Addressing the Genetic Deficit

Increase amount of SMN protein produced by upregulating SMN2 gene

- Inhibit histones so that DNA is “undressed” longer to increase transcription or mRNA and make more protein
- Increase expression and inclusion of exon 7 of the SMN2

Protecting the Nerves and Muscles

Increase survival and performance of remaining motor neurons:

- Protect motor neurons from stress and toxicity
- Promote axonal sprouting

- Non-specific treatment: will not modify cause of disease, may alter phenotype
- Combination treatment with genetic modifiers?
Spinraza (Nusinersen)

- Antisense oligonucleotide
- Increases production of full-length SMN protein by increasing exon 7 inclusion in SMN2 mRNA
- Administered intrathecally: delivers concentrations in CSF which is distributed to CNS and peripheral tissues

Spinraza study details

- Multicenter, double-blind, randomized, sham-procedure controlled study in 121 symptomatic patients
- Subjects ≤7mo, dx with SMA with sx onset prior to 6mo, 98% with 2 copies of SMN2
- Additional open-label uncontrolled trials included patients who had or were likely to develop Type 1, 2, or 3

Spinraza study details

"In a controlled trial, significantly more patients with infantile-onset SMA treated with SPINRAZA achieved motor milestone improvements, including head control, rolling, or sitting, compared with sham-control patients, at the time of the planned interim analysis"^6

Spinraza study details

"Motor milestone responder" at day 183
40% of subjects on Spinraza
0% of subjects in sham-control
P<0.0001
Change in CHOP-INTEND at Day 183

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Spinraza (n=52)</th>
<th>Sham-control (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOP improvement from baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 4 points</td>
<td>33 (63%)</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>CHOP worsening from baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 4 points</td>
<td>2 (4%)</td>
<td>12 (40%)</td>
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</tbody>
</table>

What this means for you

1. Natural history is changing
2. Affects on treatment and long term planning for these patients
3. Regular, standardized assessment crucial for insurance coverage

Insurance requirements

• Vary based on insurance company
• All require baseline PT assessment and regular re-assessment
• Hammersmith extended, CHOP-INTEND, RULM
• Medicaid requires both CHOP-INTEND and HFMSE for initial dosing
Standardized assessment for SMA type I

- Birth and developmental history
- CHOP-INTEND
- ROM assessment

Standardized Assessment for SMA type II

- Birth and developmental history
- Hammersmith Functional Motor Scale Expanded
- Revised Upper Limb Module
- ROM assessment
- Add 6MWT if pt begins independent ambulation, TUG

Standardized Assessment for SMA type III

- Medical history
- HFMSE
- RULM
- TUG
- 6MWT
- ROM
- MMT

CHOP-INTEND

15 item assessment developed to test infants with SMA Type I who present with very limited motor skills

Shown to be a reliable measure of motor skills in patients with SMA1 and other infantile onset NM disorders
CHOP-INTEND: General Principles

- Items scored with spontaneous or active movement
- Administer test items in order as much as possible
- When in doubt, score down
- Test on firm, padded mat in diaper or onesie only
- Give rest breaks as needed to calm the infant if upset
- Score both sides and select maximum score for best score

Behavioral State

Brazelton behavioral states:
State 1 - deep sleep
State 2 - light sleep
State 3 - drowsy of semi-dozing
State 4 - alert, with bright look
State 5 - eyes open, considerable motor activity
State 6 - crying

Item 1: Spontaneous movement (upper extremity)
Can be observed in any position throughout the test

- Score 4 - Antigravity shoulder movement (elbow off surface)
- Score 3 - Active antigravity movement (hand and forearm off surface)
- Score 2 - Active wrist movement
- Score 1 - Isolated finger movement
- Score 0 - No movement of limbs

Item 2: Spontaneous movement (lower extremity)
Can be observed in any position throughout the test

- Score 4 - Antigravity hip movement (feet and knees off surface)
- Score 3 - Active antigravity hip adduction/internal rotation (knees off surface, assess passive range)
- Score 2 - Active gravity eliminated knee/hip movement (extension and flexion in abduction and external rotation)
- Score 1 - Isolated ankle movement
- Score 0 - No movement of limbs
### Item 3: Hand grip
Start position: supine with arm and forearm on surface in pronation with wrist extended

Place pinkie or similar sized toy/pen in infant’s hand until grip response is secure, then slowly lift arm and hand

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Maintains grip with shoulder off bed</td>
</tr>
<tr>
<td>3</td>
<td>Maintains grip with elbow just off bed, shoulder on surface</td>
</tr>
<tr>
<td>2</td>
<td>Maintains grip with forearm off surface, elbow supported</td>
</tr>
<tr>
<td>1</td>
<td>Maintains grip only with no traction</td>
</tr>
<tr>
<td>0</td>
<td>No grip or rattle/pen slips out</td>
</tr>
</tbody>
</table>

### Item 4: Head in midline
Start position: supine head in midline

Visual stimulation in midline, if maintained >5 sec turn head to 90° to right and encourage return to midline, repeat to left

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Rotates from 90° back fully to midline</td>
</tr>
<tr>
<td>3</td>
<td>Actively turns head part way from 90° toward midline</td>
</tr>
<tr>
<td>2</td>
<td>Maintains head within 15° of midline for 5 or more sec</td>
</tr>
<tr>
<td>1</td>
<td>Maintains head within 15° of midline for &lt;5 sec</td>
</tr>
<tr>
<td>0</td>
<td>Head falls to side and no attempt to regain midline is noted</td>
</tr>
</tbody>
</table>

### Item 5: Hip adductors
Start position: hook lying, feet hip width apart, remove diaper if needed

Position legs in neutral with thighs parallel and release, observe response of legs

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<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Maintains knee off surface of bed &gt;5 sec or lifts feet off surface</td>
</tr>
<tr>
<td>2</td>
<td>Keeps knee off surface of bed 1-5 sec</td>
</tr>
<tr>
<td>0</td>
<td>No attempt to maintain knees off surface</td>
</tr>
</tbody>
</table>

### Item 6: Rolling elicited from legs
Start position: supine arms at sides

Hold infants lower thigh, flex hip and knee and adduct across midline to stimulate rolling

<table>
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<th>Score</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>When traction is applied at end of maneuver, rolls to prone with lateral head righting</td>
</tr>
<tr>
<td>3</td>
<td>Rolls through side lying into prone without lateral head righting (clears weight bearing arm completely)</td>
</tr>
<tr>
<td>2</td>
<td>Pelvis, trunk and arm lift from support surface, head turns and rolls onto side (arm comes through to front of body)</td>
</tr>
<tr>
<td>0</td>
<td>No attempt to maintain knees off surface</td>
</tr>
</tbody>
</table>
Item 7: Rolling elicited from arms
Start position: supine arms at side

Hold infant at elbow and move across midline toward opposite shoulder to elicit rolling

Score 4 - Rolls onto side with lateral head righting
Score 3 - Rolls into prone without lateral head righting (clears weight bearing arm completely to finish roll)
Score 2 - Rolls onto side (leg comes through and adducts bringing pelvis vertical)
Score 1 - Head turns to side and shoulder and trunk lift form surface
Score 0 - Head turns to side; body remains limp or shoulder lifts passively without active participation

Item 8: Shoulder flexion and elbow flexion and horizontal abduction
Start position: side lying with upper arm supported on body in 30° of elbow flexion and shoulder extension

Prompt reaching for toy at arm’s length at shoulder level

Score 4 - Clears hand from surface while reaching (antigravity horizontal abduction)
Score 3 - Able to flex shoulder to 45° (gravity eliminated shoulder flexion)
Score 2 - Flexes elbow after arm comes off body
Score 1 - Able to get arm off body
Score 0 - No attempt (arm remains on trunk)

Item 9: Shoulder flexion & elbow flexion
Start position: sitting slightly reclined on parent’s lap straddled over leg

Present toy at midline at shoulder level

Score 4 - Abducts or flexes shoulder to 60°
Score 3 - Abducts or flexes shoulder to 30°
Score 2 - Any shoulder flexion or abduction
Score 1 - Flexes elbow only
Score 0 - No attempt to lift arm

Item 10: Knee extension
Start position: sitting on parent’s lap in straddle position on one leg

Tickle plantar surface of foot or gently pinch toe

Score 4 - Knee extension >45°
Score 2 - Knee extension 15-45°
Score 1 - Any visible knee extension
Score 0 - No visible knee extension
**Item 11: Hip flexion & foot dorsiflexion**

Start position: support infant’s back against parent’s chest with support across infant’s abdomen, let legs dangle unsupported

Stroke plantar surface of foot

Score 4- hip flexion or knee flexion >30°
Score 3- any hip or knee flexion is noted
Score 2- only dorsiflexion is observed
Score 0- no active hip, knee, or ankle motion noted

**Item 12: Head control**

Start position: ring sitting facing examiner, whose hands support shoulders on anterior and posterior surfaces with fingers supporting head

Position with head erect, if unable allow head to fall forward and support chin with thumbs to keep chin off chest

Score 4- attains upright head position at least once from flexion and moves head freely with control
Score 3- maintains head upright >15 seconds
Score 2- maintains head in midline >5 sec with head tipped in up to 30° forward flexion or extension
Score 1- actively lifts or rotates head twice within 15 sec
Score 0- no response, head hangs

**Item 13: Elbow flexion**

Start position: supine

Initiate pull to sit with arms extended at 45° angle until shoulders lifted off surface

Score 4- active elbow flexion
Score 2- visible biceps contraction without elbow flexion
Score 0- no visible biceps contraction

**Item 14: Neck flexion**

Start position: supine

Provide traction response as described in Item 13

Score 4- lifts head off bed
Score 2- visible muscle contraction of SCM
Score 0- no visible contraction
Item 15: Head/neck extension (Landau)

Start position: ventral suspension, held in one hand over upper abdomen/lower rib cage

Stroke paraspinal muscles bilaterally along spine from neck to sacrum

Score 4: head extended to or above horizontal plane
Score 2: head extended partially, but not to horizontal plane
Score 0: no active head extension is noted

Manual of Procedures for CHOP INTEND can be found here:


Item 16: Spinal incurvation (Galant)

Start position: prone over examiner’s hand supported at the upper abdomen or lower thorax

Stroke right then left thoracolumbar paraspinal muscles with thumbnail from sacrum to mid-thoracic level

Score 4: twists pelvis toward stimulus off axis
Score 2: visible paraspinal muscle contraction
Score 0: no response

Hammersmith Functional Motor Scale Expanded

33 item motor assessment

Shown to be a valid, time-efficient outcome measure for SMA types II and III
Hammersmith Functional Motor Scale: Expanded

• Need to be able to achieve start position to score item

• Administer test items in order as much as possible, attempt all items, allow 3 trials of each

• When in doubt, score down

• Test on large, firm, padded mat

• Give rest breaks as needed

• Do not instruct on movement strategies

Item 1: Plinth/chair sitting

Seated over edge of plinth feet unsupported or on plinth/floor with feet support, back unsupported

“How can you sit on the plinth/chair without using your hands for support for a count of 3?”

Score 2: Able to sit using no hand support for count of ≥ 3
Score 1: Needs one hand support to maintain balance for count of 3
Score 0: Needs 2 hand support to maintain balance or unable to sit

Item 2: Long Sitting

Sitting on floor/plinth with legs in max extension and kneecaps pointing to the ceiling, back unsupported

“How can you sit on the floor/plinth without using your hands for support and with your legs straight for a count of 3? Don’t leg your legs roll out.”

Score 2: Able to sit with legs straight without hand support for count of 3
Score 1: Able to sit with legs straight propping with 1 hand support for count of 3
Score 0: Able to long sit using 2 hands or unable to sit with straight legs

Item 3: One hand to head in sitting

Sitting on floor/plinth or over edge of chair/plinth, back unsupported

“How can you get one hand to your head (above your ear) without bending your neck?”

Score 2: Able to bring one hand to head, head and trunk stable
Score 1: Can only bring hand to head by flexing head
Score 0: Unable to bring hand to head even using head and trunk movement
Item 4: Two hand to head in sitting

Sitting on floor/plinth or over edge of chair/plinth, back unsupported

“Can you lift both hands up at the same time, to your head, without bending your neck?”

Score 2: Able to place both hands on head arms free from side, head and trunk stable
Score 1: Able to place hands on head but only using compensation
Score 0: Unable to place both hands on head

Item 5: Supine to side lying

Supine arms by side or in mid-position

“Can you roll onto your side in both directions?”

Score 2: Able to ½ roll from supine both ways
Score 1: Can ½ roll only one way R/L
Score 0: Unable to half roll either way

Item 6 & 7: Rolls prone to supine over R & L

Prone arms in mid position or by side

“Can you roll from your tummy to your back in both direction? Try not to use your hands.”

Score 2: Turns to supine with free arms to the right and left
Score 1: Turns to supine using arms to push/pull
Score 0: Unable to turn to supine

Item 8 & 9: Rolls supine to prone over R & L

Supine arms in mid position or by side

“Can you roll from your back to your tummy in both direction? Try not to use your hands.”

Score 2: Turns to prone with free arms to the right and left
Score 1: Turns to prone using arms to push/pull
Score 0: Unable to turn to prone
Item 10: Sitting to lying
Sitting on plinth/floor

“Can you lie down in a controlled way from sitting?”

Score 2- Able to lie down in a controlled fashion through side lying or using clothes
Score 1- Able to lie down by flopping forward and rolling sideways
Score 0- Unable or falls over

Item 11: Props on forearms
Prone- arms by side (pelvis in contact with mat)

“Can you prop yourself on your forearms and hold for a count of 3?”

Score 2- Able to achieve prop on forearms with head up for a count of 3
Score 1- Holds position for a count of 3 when placed
Score 0- Unable

Item 12: Lifts head from prone
Prone arms by side, forehead resting on floor

“Can you lift your head up keeping your arms by your side for a count of 3?”

Score 2- Able to lift head up in prone arms by side for a count of 3
Score 1- Lifts head with arms in a forward position for a count of 3
Score 0- Unable

Item 13: Prop on extended arms
Prone arms by side (pelvis in contact with floor)

“Can you prop yourself up with straight arms for a count of 3?”

Score 2- Able to prop on extended arms, head up for a count of 3
Score 1- Can prop on extended arms if placed for a count of 3
Score 0- Unable
**Item 14: Lying to sitting**

Supine arms by side

“Can you get from lying to sitting without rolling to your tummy?”

Score 2 - Able by using side lying
Score 1 - Turns into prone or towards floor
Score 0 - Unable

**Item 15: Four-point kneeling**

Prone arms in mid position or by side

“Can you get onto your hands and knees with your head up and hold for a count of 3?”

Score 2 - Achieves four-point kneeling, head up for a count of 3
Score 1 - Holds position when placed for a count of 3
Score 0 - Unable

**Item 16: Crawling**

From four-point kneeling

“Can you crawl forwards?”

Score 2 - Able to crawl forward, moves all four points twice or more
Score 1 - Moves all four points only once
Score 0 - Unable

**Item 17: Lifts head from supine**

Supine with arms folded across chest

“Can you lift your head to look at your toes keeping your arms folded for a count of 3?”

Score 2 - head must be lifted in midline, chin moves toward chest, held for count of 3
Score 1 - Head lifted through side flexion or protraction (no flexion), held for count of 3
Score 0 - Unable
Item 18: Supported standing

Standing, supported as necessary, on a firm surface

“Can you stand using one hand for support for a count of 3?”

Score 2- Can stand with one hand support for a count of 3
Score 1- Able to stand with minimal trunk support (not hip) for a count of 3
Score 0- Can stand with hand support but needs hip/knee support in addition for a count of 3 or unable

Item 19: Stand unsupported

Standing, supported as necessary, on a firm surface

“Can you stand without holding onto anything for a count of 3?”

Score 2- Can stand independently for more than a count of 3
Score 1- Stands independently for a count of 3
Score 0- Stands only momentarily (<3) or unable

Item 20: Stepping

Standing on firm surface

“Can you walk without using any help or aids? Show me.”

Score 2- Able to take more than 4 steps unaided
Score 1- Able to take 2-4 steps unaided
Score 0- Unable

Item 21 & 22: Right and left hip flexion in supine

Supine with hips and knees in maximal available extension

“Can you bring your knee to your chest?”

Score 2- Full hip and knee flexion achieved
Score 1- Initiates hip and knee flexion (>10% available ROM
Score 0- Unable
**Item 23: High kneeling to right half kneel**

High kneeling

“Can you bring your left leg up so that your foot is flat on the ground without using your arms and hold for a count of 10?”

- Score 2: Arms used for transition, maintains arms free for half kneel count of 10
- Score 1: Maintains half kneel with one arm support
- Score 0: Unable

**Item 24: High kneeling to left half kneel**

High kneeling

“Can you bring your right leg up so that your foot is flat on the ground without using your arms and hold for a count of 10?”

- Score 2: Arms used for transition, maintains arms free for half kneel count of 10
- Score 1: Maintains half kneel with one arm support
- Score 0: Unable

**Item 25: High kneeling to standing, leading with left leg**

High kneeling, arms free

“Can you stand up from this position starting with your left leg without using your hands?”

- Score 2: Able with arms free
- Score 1: Able to shift weight off both knees (with or without arm support)
- Score 0: Unable

**Item 26: High kneeling to standing, leading with right leg**

High kneeling, arms free

“Can you stand up from this position starting with your right leg without using your hands?”

- Score 2: Able with arms free
- Score 1: Able to shift weight off both knees (with or without arm support)
- Score 0: Unable
**Item 27: Stand to sitting on floor**
Standing on a level floor or mat, must be able to maintain independent standing without arm support to attempt item

“Can you sit on the floor in a controlled way? Try not to use your arms.”

Score 2- Able to sit down with arms free and no collapse
Score 1- Sits on floor but uses arms or crashes
Score 0- Unable

**Item 28: Squat**
Standing on a level floor or mat

“Can you squat? Pretend you are going to sit on a very low seat.”

Score 2- Squats with arms free
Score 1- Initiates squat (>10%), uses arm support
Score 0- Unable to initiate

**Item 29: Jumps 12 in forward**
Standing on a level floor in front of 2 parallel lines taped 12” apart on the floor

“Can you jump as far as you can, with both feet, from this line all the way to the other line?”

Score 2- Jumps at least 12”, both feet simultaneously
Score 1- Jumps between 2-11”, both feet simultaneously
Score 0- Unable to initiate jump with both feet simultaneously

**Item 30: Ascends 4 stairs with railing**
Standing at the base of the stairs

“Can you walk up the steps? You can use one railing.”

Score 2- Ascends 4 stairs with railing, alternating feet
Score 1- Ascends 2-4 stairs, one rail, any pattern
Score 0- Unable to ascend 2 stairs using one rail
Item 31: Descends 4 stairs with railing

Standing at the top of the stairs

“Can you walk down the steps? You can use one railing.”

Score 2: Descends 4 stairs with railing, alternating feet
Score 1: Descends 2-4 stairs, one rail, any pattern
Score 0: Unable to descend 2 stairs using one rail

Item 32: Ascends 4 stairs without arm support

Standing at the base of the stairs

“Can you walk up the steps? This time try not to use the railing.”

Score 2: Ascends 4 stairs, arms free, alternating feet
Score 1: Ascends 2-4 stairs, arms free, any pattern
Score 0: Unable to ascend 2 stairs arms free

Item 33: Descends 4 stairs without arm support

Standing at the top of the stairs

“Can you walk down the steps? This time try not to use the railing.”

Score 2: Descends 4 stairs, arms free, alternating feet
Score 1: Descends 2-4 stairs, arms free, any pattern
Score 0: Unable to descend 2 stairs arms free

Manual of Operating Procedures for Hammersmith Functional Motor Scale Expanded can be found here:

Revised Upper Limb Module for SMA

Developed by the ULM Physiotherapy Working Group to assess motor performance in the upper limbs for individuals with SMA

- Used with ambulant and non-ambulant patients children through adults
- Specific equipment required
- Measures strength proximally to distally

Manual of Operating Procedures for RULM can be found here:


References