Spina Bifida – Management of the Neuropathic Bladder

Stuart B. Bauer, MD

President, ICCS

Department of Urology
Children’s Hospital Boston

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What have we learned in the last 30 years?

The only treatment when this picture was taken was urinary diversion

Causes of Neurogenic Bladder Dysfunction in Children

- Myelodysplasia 95%
  - Open spinal cord lesions - 85%
  - Occult spinal dysraphism - 10%
- Sacral Agenesis 3%
- Spinal Cord Injury 1%
- Associated Conditions 1%
  (Imperforate anus, VATER Syndrome)
Myelomeningocele - Back Lesion

Spina Bifida

Diagram showing the development of the neural tube and its components.
Spina Bifida - Types

Spina Bifida Occulta  Meningocele  Myelomeningocele

10-20% of healthy individuals  Least common  Most severe & most common

Spina Bifida - Incidence

• 0.7/1,000 U.S. live births
  ? reduction from 1/1,000 but unknown if underreporting
  Most common permanently disabling birth defect
  Each day 8 babies are born in the US with SB or similar brain/spine defect!

• Variable with ethnic group
  Higher in Caucasi ans & Hispanics
  Highest incidence in immigrants from Ireland
Spina Bifida - Incidence

• The most likely site for meningocele development is:
  Lumbar, Sacral, Thoracic and Cervical
• 5% risk of familial occurrence
• Folic acid (4 mgs/day) reduces but doesn’t eliminate
  the risk of a child being born with MMC

Change in Bladder Appearance Over Time
Upper Motor Neuron Urodynamic Study

Incidences of Urinary Tract Deterioration in Newborns with Myelodysplasia Followed Expectantly

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Deteriorated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synergy</td>
<td>14</td>
<td>2 (14%)</td>
</tr>
<tr>
<td>No Activity</td>
<td>23</td>
<td>7 (30%)</td>
</tr>
<tr>
<td>Dyssynergy</td>
<td>34</td>
<td>18 (53%)</td>
</tr>
<tr>
<td></td>
<td>71</td>
<td>27 (38%)</td>
</tr>
</tbody>
</table>

*excludes 8 with deterioration at birth
Time of Urinary Tract Deterioration in Relation to Age

3 year old girl with myelodysplasia on no specific treatment
Response to Therapy

Incidence of Urinary Tract Deterioration in Newborns with Myelodysplasia Treated Proactively

<table>
<thead>
<tr>
<th>Category</th>
<th>No.</th>
<th>Deteriorated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synergy</td>
<td>39</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>No Activity</td>
<td>53</td>
<td>10 (19%)</td>
</tr>
<tr>
<td>Dyssynergy</td>
<td>30</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td>18 (15%)</td>
</tr>
</tbody>
</table>

* excludes 24 with deterioration at birth
Subsequent Deterioration
Expectant vs Prophylactic Therapy

Current Treatment of Newborns with
Myelodysplasia

- Residual urine after spontaneous voiding
- Allow voiding if able to empty at low pressure
- Credé voiding if no reflux and sphincter is completely denervated (un-reactive to stimuli)
- Begin CIC in presence of reflux, and / or high pressure voiding
- Add anticholinergics if filling / voiding pressures are high
Protocol for the Evaluation of Children with Myelodysplasia

- Residual urine (after a spontaneous void, or if ↑ after a Credé maneuver)
- Urine culture
- Serum creatinine
- Neurologic examination
- Renal ultrasound
- Urodynamic studies
- Voiding cystourethrogram

Current Management Based on Urodynamic Findings

- Observation
  - good compliance
  - low LPP
  - severe denervation in the sphincter
  - minimal PVR
- CIC
  - high LPP or high voiding pressure
  - ↑ PVR
- Anticholinergics
  - poor compliance (pr. ≥ 20 cm H_2O at capacity)
  - DO during filling ➔ wetting between CIC
  - high voiding pressure (pr. ≥ 75 cm H_2O)
Indications for Proactive Treatment in Myelodysplasia

• Clean intermittent catheterization
  High voiding pressures 2° to dyssynergia
  High leak point pressure in patients with fibrosis from sphincter denervation

• Anticholinergic medication
  High detrusor voiding pressure (> 100 cm H₂O)
  Poor compliance - high detrusor filling pressure (> 40 cm H₂O at functional capacity)

Types of Medication for Proactive Treatment in Myelodysplasia

• Oxybutynin
  1 mg / year of age BID - TID
  Proportionately less for those < 1 year

• Tolterodine
  0.05 mg / kg / day in divided doses Q 12 hours

• Trospium
  0.3 mg / kg / day in divided doses Q 12 hours
Incidence of Reflux in Myelodysplastic Children Followed Expectantly

Newborn     Afterwards
4 (5%)  \rightarrow  18 (23%)

Cumulative Incidence of Reflux in Expectant vs Proactive Treatment

Expectant Tx

Prophylactic Tx

\[ P = < 0.05 \]
The Long-term Effects of Proactive Treatment in Infants with Myelodysplasia

- Hydronephrosis
  - In children at risk 4 (3%)
  - In children not at risk 2 (2%)

Effect of Proactive Treatment

Ultrasound 15 years later on proactive treatment
The Long-term Effects of Proactive Treatment in Infants with Myelodysplasia

Subsequent need for augmentation cystoplasty

<table>
<thead>
<tr>
<th>Condition</th>
<th>Expectant TX no. = 44</th>
<th>Proactive TX no. = 122</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydronephrosis</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Incontinence</td>
<td>6 (18%)</td>
<td>3 (4%)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>
The Long-term Effects of Proactive Treatment in Infants with Myelodysplasia

- Continence in 79 children on treatment
  
  Dry on CIC + medication  58 (73%)
  Augmentation  3 (4%)

Prophylactic versus Expectant Treatment in Children with Myelodysplasia

The need for augmentation cystoplasty is significantly reduced when children are started on prophylactic treatment before they are 1 year (11%) versus 4 years (27%)

*Wu, et al., J Urol., 157: 2295, 1997*
The Long-term Effects of Proactive Treatment in Infants with Myelodysplasia

• Complications from CIC treatment
  Meatitis 0
  Urethral injury 1
  Difficulty with CIC 1
  Side effects from medication 0
  Failure to accept program 0

Conclusions from Proactive Treatment in Children with Myelodysplasia

• It is safe
• It effectively prevents reflux, hydronephrosis and a rise in creatinine
• It reduces the need for augmentation cystoplasty
• It leads to earlier and more universal acceptance of CIC
• It promotes independence at an earlier age
Management of Reflux

- Continuous antibiotics
- Strict CIC schedule
- Anticholinergic meds if hypertonicity +/- detrusor overactivity
- Antireflux surgery if:
  - Recurrent UTI
  - Worsening hydrenephrosis
  - Progressive / new onset scarring on DMSA scan
  - Surgery to increase bladder outlet resistance

Management of Reflux

Anticholinergic meds help to lower detrusor filling pressure and abolish DO, reducing the presence and grade of reflux; resolution rates approach 65%
Management of Incontinence

• Poor bladder dynamics
  Anticholinergic agents
  Botulinum toxin
  Augmentation cystoplasty
• Inadequate bladder outlet resistance
  α sympathomimetics
  Endoscopic injection of bulking agents
  Fascial sling suspension
  Artificial urinary sphincter implantation

Signs of an Occult Spinal Dysraphism
Pathologic Conditions of Occult Spinal Dysraphism

- Lipoma / lipomeningocele
- Split cord syndromes (diastematomyelia)
- Dermal sinus malformation
- Thickened (tight) filum terminale
- Anterior meningocele (Currarino Triad)
  - Pre-sacral mass, sacral agenesis + ano-rectal malformation
- Imperforate anus (30%)

Radiologic Appearance of Tethered Cord
Urologic Presentation by Age

- **Infancy**
  - Usually asymptomatic
  - 90% have a cutaneous manifestation
- **Childhood**
  - Difficulty with toilet training
  - Persistent wetting / urgency after toilet training
  - Recurrent UTI
  - Lower extremity changes
- **Adolescent**
  - Wetting and / or UTI with pubertal growth

Urodynamic Studies in Occult Spinal Dysraphism

- Preoperative assessment determines exact function of the lower urinary tract
  - 20 - 35% normal neuro exam have abnormal UDS
  - 10 - 15% abnormal neuro exam have normal UDS
- Provides functional information not definable on spinal MRI
- If child is observed sequential studies are useful
- Assesses effects of early surgical intervention
  - 60% of young vs 9% of older children improve post-op
  - 68% remain stable but 25% deteriorate over time
Improvement in Function with Untethering Surgery

![Graph showing improvement in function with untethering surgery.](image)

Need for 2° Untethering Related to Age at Initial Surgery

![Graph showing need for secondary untethering related to age at initial surgery.](image)
Tethered Spinal Cord –
Conclusions

- No specific urologic symptom or sign is indicative of a tethered cord
- No combination of neuro-urologic symptoms can predict a spinal cord malformation
- If diagnosed and treated early, un-tethering surgery can improve urologic symptoms in most cases
- Early corrective surgery seems to prevent late 2° re-tethering

Sacral Agenesis
Skin and Radiologic Appearances
Sacral Agenesis

Note:
absence of lower sacral vertebra

Note:
abrupt cut off of conus at T 12

X-ray Faces in Sacral Agenesis

Upper motor neuron lesion with closed ext. sphincter + reflux from dyssynergy

Lower motor neuron lesion with open bladder neck, no reflux + wetting
Urodynamic Findings in Sacral Agenesis

• 1% of insulin-dependent diabetics have a child with sacral agenesis; 16% of affected babies have an insulin-dependent mother

• Types of lower urinary tract function found
  38% have an upper motor neuron lesion (UMN)
  43% have a lower motor neuron lesion (LMN)
  19% have normal lower urinary tract function

• Level of bony defect does not correlate with type of bladder or sphincter function found

• Presence of a B-C reflex has an 80% correlation with type of neuro-urologic function present

• Lesion tend to be stable and rarely progress
α adrenergic receptors

Lower urinary tract
- Bladder neck
- Urethra

Smooth muscle contraction
↑ Outlet resistance

α blocking agents - usefulness

Conclusions:
- Underactive bladder with incomplete emptying
  - Alternative prior to CIC
  - Alternative to biofeedback retraining
  - May facilitate behavioral modification
- Neuropathic bladder with poor compliance
  - ↓ LPP
  - ↑ compliance
  - ↓ hydrenephrosis
  - May ↓ grade of reflux
  - Protects upper urinary tract
- Limitations
  - Need randomized, placebo controlled double-blind studies in uniform populations using standardized testing to evaluate the true effectiveness of this class of drugs
Percutaneous Tibial Nerve Stimulation (PTNS)

34 G needle inserted on the tibial nerve ~ 2 cm cephalad to medial malleolus

Surface electrode on medial side of foot

Portable stimulator provides pulsations between needle & electrode (frequency 20 Hz, 200 microseconds, up to 10 mA)

Correct placement → flexion (or fanning) of great toe

Stimulation performed weekly for 30 min x 12 sessions

Percutaneous Tibial Nerve Stimulation (PTNS)

• Bower, Hoebeke 1st reported responses in children with OAB (2001)
• DeGennaro: 23 (10 OAB; 7 retention; 6 NBD)
  - Results (OAB):
    • 80% ↓ OAB
    • 44% resolution of incontinence
    • 62.5% with ↓ CBC → normalized
  - Results (retention):
    • 72% improvement in symptoms
    • PVR 109 ml (pre-Tx) → ↓ 66% w 0 ml in 50%
    • $PQ_{\text{max}}$ 33.8 → 50.2 cm H$_2$O ($p = 0.09$)
    • $Q_{\text{max}}$ 6.2 → 12.3 ml/sec ($p = 0.05$)
  - Results (NBD):
    • CBC 239 → 289 ml
    • PVR 173 → 154 ml

Lumbo-sacral Nerve Re-routing for Spina Bifida

- Artificial voiding reflex using
  Micro-anastomosis of healthy lumbar motor root to normal sacral motor root
- At follow-up stimulation of sacral dermatome of re-routed nerve → bladder contraction & voiding
- Xiao – 20 pts followed 1 year → 85% able to void w/o CIC
  both OAB and UB pts responded
  bladder capacity doubled
  bladder compliance improved
  residual urine ↓ 100 → 57 ml
  bladder sphincter synergy during voiding


Lumbo-sacral Nerve Re-routing for Spina Bifida

- 9 pts - neurologic levels from L3 to S3
- Follow-up 1 year
  CBC: ↑ 6; no change or ↓ 4
  OAB: ↓ 5 of 7; none developed
  bladder sensation of bladder filling: 1 developed
  voiding: 5 of 7 developed (V Vol avg 133 ml; pvr mean 119 ml; Q max 10 )
  bladder compliance: ↑ 16.1 → 21.8
  2 pts voided to completion on stimulation + off all anticholinergic meds
  1 F permanent foot drop

Future Prospects for Improving Neuropathic Lower Urinary Tract Function

Caution!

Today’s panacea may be tomorrow’s curse