The Neurogenic Bladder
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Outline
• Anatomy and Bladder Physiology
• Bladder Dysfunction in SCI
• Patient Assessment and Work-up
• Bladder Management and Treatment
• Complications of the Neurogenic Bladder

UROLOGY
• Anatomy
• Upper urinary tract
  – Kidneys
  – Ureters
• Lower urinary tract
  – Bladder
  – Urethra

Lower Urinary Tract
Bladder
  Detrusor: multi-layered smooth muscle, thickest at the base and bladder neck
  Urethra: 3-4 cm in women, ~20 cm in men

Urethral sphincters:
  Internal: primary continence mechanism (increased muscle tone during filling)
  External: striated muscle under voluntary control

Kidney
Ureter
Bladder
Urethra
Sphincters
Muscular bladder wall
Ureters
Bladder
Sphincter muscles
Urethra
Bladder filling

- During filling:
  - minimal rise in bladder pressure due to viscoelastic properties of bladder wall (allow for compliance)
  - Increase in urethral sphincter EMG activity

Bladder emptying

- During emptying:
  - Urethral sphincter EMG activity stops
  - drop in urethral sphincter pressure
  - Detrusor contraction (strong enough and long enough)
  - urethral sphincter should remain open throughout voiding
  - should be no/minimal PVR

Bladder volumes

- First sensation of bladder filling: 100-200ml
- Sensation of bladder fullness: 300-400ml
- Urgency: 400-500ml
Neuroanatomy of Voiding

- Innervation of the bladder and urethra is complex
- Involvement of both
  - Somatic Nervous system
  - Autonomic Nervous system

Neuroanatomy of Voiding

- Cerebral cortex and cerebellum
  - inhibitory action on voiding reflex
- Pontine micturition center
  - generation of the normal voiding reflex
  - coordination of detrusor and sphincters
- Spinal cord: ascending and descending tracts
  - augmentation of reflex
- Peripheral innervation
  - Bladder: S2-4 (pelvic n.), T10-L2 (hypogastric n.)
  - Bladder neck: T10-12
  - External sphincter: S2-4 (pudendal n.)

Parasympathetic Efferents

- Parasympathetic cholinergic innervation stimulates detrusor contraction and bladder outlet relaxation
- pelvic nerves (S2-4)
Sympathetic Efferents

- Sympathetic innervation facilitates urine storage.
- Detrusor relaxation and bladder outlet contraction.
- (T10-L2) hypogastric plexus.

Somatic Efferents

- Somatic innervation via pudendal nerve (S2-S4) provides volitional control to striated muscle of external urethral sphincter.

Lower Urinary Tract Receptor Types

- Detrusor cholinergic (Ach) receptors ➔ parasympathetic control ➔ bladder contraction
- Detrusor Beta-adrenergic (NE) receptors ➔ sympathetic control ➔ bladder relaxation, facilitates storage and filling
- Bladder neck/proximal urethra alpha-adrenergic (NE) receptors ➔ sympathetic control ➔ facilitates storage and filling

Bladder Dysfunction in SCI

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Spinal lesion above sacral cord
- Detrusor Hyperreflexia
- Urge Incontinence
- Hypocontractility
- Sphincter Dysynergia
- Diminished sensation
- Incomplete emptying

Spinal lesion at sacral cord
- Areflexia
- External urethral sphincter laxity
- Diminished sensation
- Large residuals
- Stress incontinence

Bladder behavior after SCI

<table>
<thead>
<tr>
<th></th>
<th>&quot;Hyper-reflexic&quot; blader</th>
<th>&quot;Flaccid&quot; bladder</th>
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<tbody>
<tr>
<td>Uninhibited detrusor contraction with bladder filling</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Location of SCI</td>
<td>Above level of sacral cord</td>
<td>At or below level of conus medullaris</td>
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<td>Neurologic exam</td>
<td>Intact BC reflex normal anal sphincter tone</td>
<td>Absent BC reflex Absent anal sphincter tone</td>
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<td>Risks</td>
<td>High detrusor pressure, detrusor-sphincter dysynergia (DSD), vesico-ureteral reflux, hydronephrosis, upper tract deterioration</td>
<td>Low risk for high detrusor pressure Low risk for DSD, lower but present risk for upper tract deterioration</td>
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Detrusor sphincter dyssynergia (DSD)
- Failure of urinary sphincter relaxation during bladder contraction
- Occurs in individuals with suprasacral lesions
- Can cause high intravesical pressure
**Clinic Evaluation**

- **History**
  - medications that impact voiding function
  - muscle relaxants, anti-depressants, anti-cholinergics, etc
- **GU neurology evaluation**
  - assess for sensation, bulbocavernosal reflex, and anal tone
- **Urinalysis/culture**
- **Post void residual urine**

**Assessment of SCI**

- **Annually:**
  - Urinalysis ➔ if indicated: culture and sensitivity
  - Serum Cr
  - Screening of upper tracts with Renal U/S
    - hydronephrosis, stones, parenchymal abnormality
  - Further diagnostic imaging (CT scan, renal scan) only when clinically indicated
Urodynamic

- Can answer specific question such as:
- Is detrusor overactivity the cause of incontinence?
- Is bladder outlet obstruction contributing to urinary retention?
- Is there evidence of detrusor sphincter dysynergia?
- Is bladder compliance impaired?

Bladder management Goals

- maintain low intravesical pressure
- complete emptying
- minimize/eliminate incontinence
- Don’t make bladder emptying dependent on others
**Intermittent catheterization (IC)**

- Individual should have:
  - Adequate hand function
  - Ability to empty bladder q4-6h
  - Adequate storage of urine between caths
  - Sufficient motivation/cognition to keep volumes less than 500 ml per cath

**Indwelling catheters**

- Urethral or suprapubic
- Used if intermittent catheterization is not possible or refused
- Well tolerated but higher risk of infection and urethral complications (false passage, urethral erosion, periurethral abscess, etc)

**Indwelling catheters**

- Changed monthly
- Must be well secured which avoids traction and kinking of catheter

**Condom catheters**

- Must have:
  - Reflex voiding at safe intravesical pressures with low residual volumes or
  - Intervention to decrease outlet resistance (sphincterotomy)
### Bladder Management Algorithm

| Does bladder consistently empty to < 300 cc with spontaneous voids? |
|--------------------------|--------------------------|
| **NO**                   | **YES**                  |
| Good hand, cognitive function? |
| **NO**                   | **YES**                  |
| Spontaneous voiding       |
| **Continent and able to self-take?** |
| **YES**                   | **NO**                   |

#### Detrusor overactivity “spastic bladder” Treatments

- **Anticholinergic medications** (oxybutynin, tolterodine, solafenacin, etc) inhibit detrusor contractions and increase bladder storage
- **Bladder onabotulinum toxin A injection**

### Onabotulinum toxin injection

- FDA approved for symptoms due to neurogenic overactivity
- Blocks release of Ach from presynaptic nerve terminals, resulting in detrusor paralysis
- Duration of efficacy: 6-12 mos
- **Minimal side effects:** UTI and bleeding

### Bladder Chemodenervation

- Treats detrusor overactivity
- Improves bladder compliance and increases bladder capacity
- Research underway to examine potential improvements in autonomic dysreflexia symptoms and patient-reported UTI frequency
Bladder Chemodenervation

Common urologic complications in spinal cord injury

Urinary tract infections (UTI):
- 50-80% in first year post-injury
- 20% annual incidence after acute period

UTI

- 3 criteria should be met for an individual to be considered as having a UTI:
  1. Significant bacteriuria
  2. Pyuria
  3. Signs and symptoms of UTI:
     fever, chills, cloudy or malodorous urine, malaise, incontinence, increase spasticity, autonomic dysreflexia

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### UTI: Diagnosis
- Urine culture and sensitivity obtained prior to starting therapy
- If there are known/suspected renal stones or recurrent/persistent UTIs, imaging is recommended

### UTI: Treatment
- Mild/moderately ill individuals are started empirically with oral antibiotics
- Antibiotics tailored to culture sensitivity
- Review of prior urine cultures may guide in selection of empiric antibiotics
- Treatment should last 7-10 days
- Asymptomatic bacteriuria SHOULD NOT be treated

### Stone Formation Risk Factors in SCI
- Immobility ➔ increased bone turnover and calcium delivery to kidneys
- Urinary stasis due to impaired emptying
- Foreign bodies (catheters) serve as stone nidus
- Recurrent infections

### Renal Stones
- Generally all stones treated in patients with SCI
- Increasing stone burden, renal insufficiency, and/or recurrent infection necessitate treatment
- Multiple surgical options for stone treatment
Hydronephrosis

- vesico-ureteral reflux
- obstructing stones
- obstructing tumors
- ureteral stricture, scarring, or external compression

Hydronephrosis Treatment

- Decrease bladder pressures (increase CIC frequency or place indwelling foley catheter)
- Treat obstructing stone, tumor, or stricture
- If persists, urodynamics may be next step to further define cause

Autonomic Dysreflexia

- Occurs in injuries at level T6 and above
- Due to impairment of sympathetic efferents
- Bladder (distension, infection, etc) often nidus of AD symptoms
- Ensure bladder decompression during episode