Neurogenic Bladder

Innervation of the Bladder
Micturition
from NEJM, January 15, 1998

Sympathetic and Parasympathetic Receptors

Sympathetic Receptors
α1A and β3 receptors
Dissection of external musculature at plane of Bladder Neck in dog

Urodynamics in "NEJM 2004, 350: 786-799"
Neurogenic Bladder Classification

- UMNL or LMNL Neurogenic Bladder
- Spastic or Flaccid Neurogenic Bladder

Lesion in the cord, conus medullaris or cauda equina

Proposed Classification of Neuro-urologic Disorders

- Detrusor hyperreflexia
  A. Coordinated sphincters
  B. Striated sphincter dyssynergia
  C. Smooth muscle sphincter dyssynergia

- Detrusor areflexia
  A. Coordinated sphincters
  B. Nonrelaxing striated sphincter
  C. Denervated striated sphincter
  D. Nonrelaxing smooth muscle sphincter
during the Acute Stage of SCI

- Indwelling catheterization (Foley)
- Monitor I & O
- If not on NPO, acidifying and bacteriostatic agents may be used: Vit C 1000mg qid and methenamine hippurate 1000mg bid
- ICP as soon as medically permitted with no IVF

during Rehab @ Rusk

1. Physical exam: “sacral sparing?”; “anal wink?”
2. Labs: UA and urine C&S, Basic metabolic panel
3. Diagnostic test: renal US, cysto(urethro)gram, IVP or renal scan if clinically indicated
4. Intermittent catheterization/PVRs (bladder scanning)
5. Uropharmacological agent(s), especially for female
6. GU rounds bi-weekly

Urodynamics

[Images of urodynamics tests]
Urodynamics
ASIA D

Male Self Catheterization

Female Self Catheterization
Host Defense Mechanism

- Mechanical wash-out: 99.9%
- Antibacterial activity of the bladder wall
- Antibacterial activity of urine itself related mostly to pH, below 5.0 or above 8.0
- Anatomical barrier: V-U valve
- Physiological advantage: ureteral peristalsis

Pathogenesis of Catheter Associated UTI’s

- Transurethral pathway: migration of bacteria from the skin or the rectum to the urethral mucosa
- Catheter contamination: poor handling
NIDRR Consensus Statement on UTI in SCI
January 27-29, 1992

“For the purpose of this publication, we are defining the following terms” in Consensus Statement on UTI in SCI

- **Urinary tract infection** is bacteriuria with tissue invasion and resultant tissue response with signs and/or symptoms
- **Asymptomatic bacteriuria** represents colonization of the urinary tract with no reference to symptoms or signs

Symptoms and Signs of UTI in SCI

- Onset of urinary incontinence
- Fever
- **Leukocytes of the urine** generated by the mucosal lining (WBC’s >10/hpf)
- Increased spasticity
- Autonomic hyperreflexia
- Cloudy urine with increased odor
- Malaise, lethargy or sense of unease
- Discomfort or pain over the kidney or bladder, or during urination
Consensus statement

A SCI person with asymptomatic bacteriuria need not be treated.

Pyuria with symptomatic UTI accompanied by fever and chills

<table>
<thead>
<tr>
<th>Urinary WBC's</th>
<th>Total # infection</th>
<th>Fever/chills</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>0</td>
<td>263</td>
<td>3</td>
<td>260</td>
<td>1.1% 98.9%</td>
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<tr>
<td>+</td>
<td>130</td>
<td>27</td>
<td>103</td>
<td>20.8% 79.2%</td>
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</tbody>
</table>


Urinalysis
Bacterial Urinary Pathogens

- Enterococcus
- Staph. epidermides
- E. coli
- Enterobacter
- Klebsiella pneumoniae
- Pseudomonas aeruginosa
- Citrobacter
- Acinetobacter
- Proteus mirabilis
- Morganella morganii
- Candida albicans

Treatment of UTI's in SCI while being on CIC program

- With no fever but pyuria
- With low grade fever
- With high fever
IDSA guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults; 2005

"Asymptomatic bacteriuria" is isolation of a specified quantitative count of bacteria in an appropriately collected urine specimen obtained from a person without symptoms or signs referable to urinary infection.

Pyuria is evidence of inflammation in the genitourinary tract and is common in subjects with asymptomatic bacteriuria. Pyuria is present with about 32% of young women, 30-70% of pregnant women, 70% of diabetic women, 90% of elderly institutionalized patients. Pyuria also accompanies other inflammatory conditions of the genitourinary tract in patients with negative urine culture results. These may be either infectious (renal TB) or noninfectious (interstitial nephritis).

Pyuria accompanying asymptomatic bacteriuria is not an indication for antimicrobial treatment.

UA of C6 tetraplegic female
c/o increased spasticity and cloudy urine

Leukocyte esterase
urine dipstick test + suggesting WBCs in the urine

False +
in vaginal secretion
Trichomonas infection
**Clostridium difficile**

- Diarrhea
  - Associated with **antibiotic therapy**, i.e. quinolone
  - **Metronidazole** 500 mg bid for 7-14 days
  - For recurrent C. difficile, oral **vancomycin** 125-500 mg q6h for 7-10 days
  - New drug: fidaxomicin (bactericidal, inhibiting RNA synthesis) 200mg bid x10 days
- Infection (contact) precaution

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**Urinary Catheters**

- Latex catheter
- Silicone-coated latex catheter
- 100% silicone catheter

No statistically significant data to support the use of one type of catheter material.


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**Touchless catheter**
Bladder Irrigation: ultimate effect on Infection Rate with neomycin-polymixin irrigant

Non-irrigated group 18%
Irrigated group 16%

Warren et al., NEJM, 299, No 11, 570-573, 1978

Cranberry Juice

300 ml/day
Reduces the frequency of bacteriuria and pyuria in older women

Urinary acidification?
Inhibition of bacterial adherence to the mucosal surface, esp. E. coli

Avorn et al, JAMA, 271, 751-754, 1994
Cloudy Urine 2

Bladder Calculi

Localization of UTI

- Bilat ureteral retrograde catheterization
- Fairley test: Bladder wash-out method
- Antibody-coated bacteria, esp. with IgG
- Leukocyte casts
- CT
Epididymitis

Uro-Pharmacologic Agents

- **Parasympatholytics**: oxybutynin, hyoscyamine, tolterodine, fesoterodine, solifenacin, darifenacin
- **Parasympathomimetic**: bethanechol
- **Sympatholytics**: terazosin, doxazosin, tamsulosin (Flomax), silodosin (Rapaflo)
- **Sympathomimetics**: ephedrine, pseudoephedrine
  - beta-3 adrenoreceptor agonist – Mirabegron (Myrbetriq)
- **Ganglionic blocker**: mecamylamine
- **Antispastic**: baclofen, diazepam
- **Neurotoxin**: botulinum toxin (type A or B)

Urologic Uses of Botulinum Toxin
Cleveland Clinic Journal of Medicine
Vol 82, #7, July 2015
King, Quirozet and Moore
Botox (onabotulinumtoxin A)
Recommended Total Dose

Overactive Bladder: total 100 units
injections across 20 sites into the detrusor

Detrusor Overactivity associated with Neurologic
Condition: total 200 units
injections across 30 sites into the detrusor

Struvite: MgNH4PO4-6H2O
Magnesium Ammonium Phosphate Hexahydrate

Uric Acid Stone
External Sphincter Spasticity

Anal Sphincter Stretch
in "CIBA Symposia"

Post-Void Residuals
Catheterization
Bladder scanning
T4 Para (ASIA A) with persistent fevers

N ENGL J MED 366;13
March 29, 2012
Diamond & Mattoo

Vesico-ureteral Reflux
Isotope Bladder Scanning

Ureteral Orifice on Cystoscopy

Urethro-Vasal Reflux
TURES and TURBN from "CIBA Collections"

Urethra-Decubitus Fistula

Bladder Management at Discharge
Incontinence in female with chronic SCI

Artificial Sphincter and Bladder Augmentation

Mitrofanoff procedure
appendico-vesicostomy
(a catheterizable stoma, usually in the umbilicus)
Cause of Death in SCI

- Respiratory diseases (esp. pneumonia, PE...)
- Infection (septicemia)
- Non-ischemic cardiac diseases

*Renal failure (3.1%) was the most common cause of death in the past.

Neurogenic Bowel

GI Innervation
Colonic Compliance in SCI patients
Meshkinpour: Arch Phys Med Rehabil vol 64, March 1983

UMNL Bowels

Lack of sensory feedback from the rectum
No voluntary function of the anal sphincter
No voluntary contraction of the abdominal muscles in tetraplegia and high paraplegia
*Normal vagus nerve to the GI tract as far as the splenic flexure of the colon
*Intact hypogastric plexi, pelvic nerves and pudendal nerves with no supraspinal control
Bowel Meds

- Docusate sodium (colace): surface active stool softener
- Oleaginous and Docusate sodium (pericolace): mild stimulant and stool softener
- Magnesium hydroxide (MOM): non-absorbable salt, holding H2O in the intestine to isotonic concentration
- Psyllium hydrophilic mucilaginous (meamuil): highly efficient dietary fiber, non-irritating bulk producer
- Castor oil (synthetic): like other fats in the upper small intestine hydrolyzed to ricinoleic acid, which acts locally to increase intestinal motility
- Bisacodyl (dulcolax): a synthetic compound chemically similar to phenolphthalein, which is a powerful stimulant of the large bowel (direct stimulant of the circular smooth muscle)
- Senna: escharoid quinoline glycosides converted to aglycones (aglycone is the non-carbohydrate portion of a glycoside) in the colon, stimulating Auerbach's plexus to induce peristalsis
- Lactulose (chemically: polyol) absorbed from the GI tract, but acts through osmetry by the colonic microflora to increase osmotic pressure and stool volume content

Enemas/suppositories

- Glycerine supps
- CO2 supps
- Magic bullet (bisacodyl 10 mg in polyethylene-glycol base)
- Enemeez
- Fleet (oil retention enema): phosphate fleet enema not be used in CKD
- SSE
- Tap water enema 250 cc (at 100-105 F)
- 1:2:3 enema (glycerine 30: mineral oil 60: H2O 90)
- High colonic enema
- Rectal tube placement
- Peristeen anal irrigation
- MACE (Malone procedure): Antegrade Colonic Enema

Daily AM Bowel Regimen for UMN Bowel Dysfunction at Rusk

- Docusate sodium 100 mg TID
- Senna (sennosides 8.6 mg/tab) 2 tablets at bedtime for AM routine
- Enemeez at 6AM
- Digital stimulation or dis-impaction, if needed
Issues in LMNL Bowels

- Denervation of the anal sphincter: "I am incontinent"
- Denervation of the distal colon including the rectum: "I don't move bowels"
- Decreased re-absorption of H2O in the distal colon: "oozing"
- Intact abdominal muscles
- Ambulatory
- Cleansing high colonic enema

Acute Abdomen in SCI

"No Pain due to Impaired Sensory Feedback Pathway"

- autonomic dysreflexia
- sudden increase of muscle spasticity
- fever
- MIV
- sepsis
- CBC, amylase, lipase
- IVF
- abdominal flat plate
- KUB
- CT

SMA syndrome

lobster cracker effect

on the 3rd portion of the duodenum between the SMA and the aorta
Cardiovascular issues

- EKG changes: transient asystole, bradycardia, ST-T wave changes
- Blood pressure
- Autonomic hyperreflexia
- Orthostasis
- VTE

Autonomic Nervous System

EKG: non-specific ST-T changes in a young tetraplegic male
Orthostasis

- Apply elastic stockings and abdominal binder for OOB
- Semi-reclining or tilt-in-space wheelchair, especially for tetraplegics
- T.T. training
- Pharmacological agents: ephedrine, pseudoephedrine, fludrocortisone 0.1mg qd, midodrine 10mg tid

Deep Venous Thrombosis

Virchow’s triad

- Venous stasis
- Hypercoagulability
- Intimal damage
Onset of DVT following SCI

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Within 1 week</td>
<td>10%</td>
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<tr>
<td>Within 1 month</td>
<td>80%</td>
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<tr>
<td>Within 3 month</td>
<td>10%</td>
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Watson

Incidence of DVT in SCI prior to introduction of LMWH

<table>
<thead>
<tr>
<th>%</th>
<th>Center</th>
<th>Diagnostic Tools</th>
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<tbody>
<tr>
<td>72%</td>
<td>RIC 1979</td>
<td>Fibrinogen scanning,</td>
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<tr>
<td></td>
<td></td>
<td>Venography</td>
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<tr>
<td>81%</td>
<td>RIC 1979</td>
<td>Doppler, IPG</td>
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<tr>
<td></td>
<td></td>
<td>Fibrinogen scanning</td>
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<tr>
<td>61%</td>
<td>VA, West Roxbury 1976</td>
<td>IPG, Venography</td>
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<tr>
<td>100%</td>
<td>VA West Roxbury 1976</td>
<td>Fibrinogen scanning</td>
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<tr>
<td>16%</td>
<td>VA Palo Alto 1979</td>
<td>IPG, Venography</td>
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<tr>
<td>19%</td>
<td>NYU 1985</td>
<td>Daily LE Inspection, SGP, Doppler</td>
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</table>

*13.7% as per SCI Databank
Abnormal SGP

Venous Doppler check-list

Color Venous Doppler
Abnormal venogram

Prophylactic Measures

- Ace wrap
- TEDS
- SCD boots
- E. stim
- Mobility
  - SQ heparin 5,000 U q8h
  - Mini-heparin+dehydroergotamine
  - Adjusted SQ heparinization
  - Low dose coumadin
  - Dextran-70
  - Low molecular weight heparin (LMWH)
  - Fondaparinux, esp for +HIT

Pulmonary Embolism
Adjusted SQ heparinization

Dosage-Adjusted Schedule for Adjusted Subcutaneous Heparin according to APTT 6 hours after injection

<table>
<thead>
<tr>
<th>APTT (sec)</th>
<th>Adjustment to heparin dose</th>
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<tbody>
<tr>
<td>27.5</td>
<td>+ 1000</td>
</tr>
<tr>
<td>28-31</td>
<td>+ 500</td>
</tr>
<tr>
<td>31.5-36</td>
<td>0</td>
</tr>
<tr>
<td>36.5-39</td>
<td>- 500</td>
</tr>
<tr>
<td>39.5</td>
<td>- 1000</td>
</tr>
</tbody>
</table>

Initial dose: 3500 IU q6h

Leyvraz et al. (Switzerland) N Engl J Med, 309, 984-986, 1983

Low molecular-Weight Heparin

Enoxaparin

DVT prophylaxis: 30 mg SC q12h
40 mg SC qd
DVT treatment: 1 mg/kg SC q12h

Dalteparin

DVT prophylaxis: 5,000 IU SC qd
DVT treatment: 200 IU/kg SC qd or 100 IU/kg SC q12h
Heparin

- Derived from L-arginine
- Not interfere with heparin-induced antibodies
- Direct thrombin inhibitor
- Check aPTT
- For HIT

Argatroban

- Derived from L-arginine
- Not interfere with heparin-induced antibodies
- Direct thrombin inhibitor
- Check aPTT
- For HIT

Foundaparinux

- Synthetic selective Fa Xa inhibitor by binding to antithrombin III
- Excretion: urine
- Half-life: 17-21 hours
- For DVT pp: 2.5 mg SC qd
- For DVT/PE Tx: 7.5 mg SC qd (50 – 100 kg BW)
- d/c if plt<100K
- For +HIT antibody
Therapeutic Coumadinization

- Coumadin: inhibiting Vit K-dependent coagulation factor synthesis - II, VII, IX, X, and protein C and S

Noble oral agents

- Dabigatran (Pradaxa)
  - Direct thrombin inhibitor
  - idarucizumab for dabigatran reversal: NEJM August 6, 2015

- Apixaban (Eliquis)
  - Highly specific Fa Xa inhibitor (oral)

- Rivaroxaban (Xarelto)
  - Fa Xa inhibitor

Hematoma
Abscess

Heterotopic Ossification

Hip Fracture