

# Urinary Tract Infections in the Neurogenic Bladder

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# Epidemiology

- Around 166,000 patients with spina bifida (CDC)
  - 1500 children are born with SB each year in the US
  - Most have a neurogenic bladder
- Approximately 200,000 people with SCI in the US
  - 12,000-20,000 new SCI/year
- Multiple Sclerosis, Cerebral Palsy, Parkinson's Disease



# Epidemiology

- Spina bifida:
  - 50% of children with SB will experience their first UTI by 15 months of age (Filler)
  - 44% will have >5 UTI episodes by age 15 years (Filler)
- Spinal Cord Injury
  - 31% are diagnosed with UTI during the first year
  - 21% are hospitalized due to UTI during the first year (Manack)
- The annual incidence of UTI in patients with neurogenic bladder is as high as 20% (Whiteneck)
  - Upper Tract Infection (2.2%)

# Epidemiology: Health Care Burden

- **ED visits (SB)**

- UTI is the number one reason for ED visits (OR 8.7)
- 34% of total ED charges in the SB population are due to UTI.
- SB patients are more likely to be admitted (37.0% vs 9.2%,  $p < 0.001$ )
- Charges per encounter and post admission are higher (Wang).

- **Hospital admission (SB)**

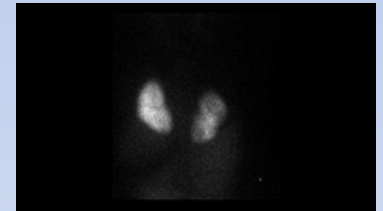
- Number admission for Urinary Tract Infection (UTI)
  - 22.8/1000 admissions for UTI in patients with SB
  - 0.44/1000 admissions for UTI in patients without SB
- Length of stay after admission for UTI
  - 6.9 days with SB
  - ~2 days without SB
- Cost of a hospital stay:
  - \$28,000-\$30,000/ admission for patients with SB (Armor)

# Epidemiology: Patient Burden

- Time away from work/school
  - Patient
  - Parents or Caregivers
    - Gas Money
    - Food Money
    - Care for siblings

# Epidemiology: Impact on Patient Health

- Overall well being = Quality of Life (QOL)
  - » Level of Lesion (Wang)
  - » Status of Urinary Continence (Olesen)
  - » QOL and Recurrent UTI (Unknown)
- Renal Scarring 25%-41% of patients with NGB(Shiroyanagi)(Delair)
  - Renal loss >> End Stage Renal Disease
- Urosepsis
  - Higher incidence in the SCI population
    - » mortality rate of 10-15 %
  - 2<sup>nd</sup> only to pneumonia as the cause of death (Rabadi)



# UTIs in the Neurogenic Bladder

- What We Have Done Well?
  - Introduction of CIC
    - 1972 Lapedes
      - Improved long term kidney function
      - Decreased the number of UTIs
        - » 25% increased risk of UTI for patients performing CIC compared to patients that voluntarily void
  - Imaging
    - Use of Ultrasound
      - Hydronephrosis
      - Stones: Kidney or Bladder
    - Voiding Cystourethrogram (VCUG)
    - DMSA: Pyelonephritis and Renal Scarring

# UTIs in the Neurogenic Bladder

- Urodynamics
  - Bladder function
    - Identification of the Hostile Bladder (High Pressure, DSD)
    - Vesicoureteral Reflux
- Surgery
  - Bladder Augmentation
    - Increases Bladder Capacity and Decreases Pressures
    - Improves Urinary Incontinence
    - Resolve Secondary Vesicoureteral Reflux
      - Decrease Pyelonephritis
  - Ileal Conduit



# UTIs in the Neurogenic Bladder

- Follow-up
  - Multi-Disciplinary Clinics
    - Follow-up Protocols
      - Yearly US
      - Monitoring for recurrent UTIs
- **CDC supported Spina Bifida Registry**



Centers for Disease Control and Prevention

**National Spina Bifida Patient Registry**

<http://www.cdc.gov/ncbddd/spinabifida/nsbprregistry.html>

# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder

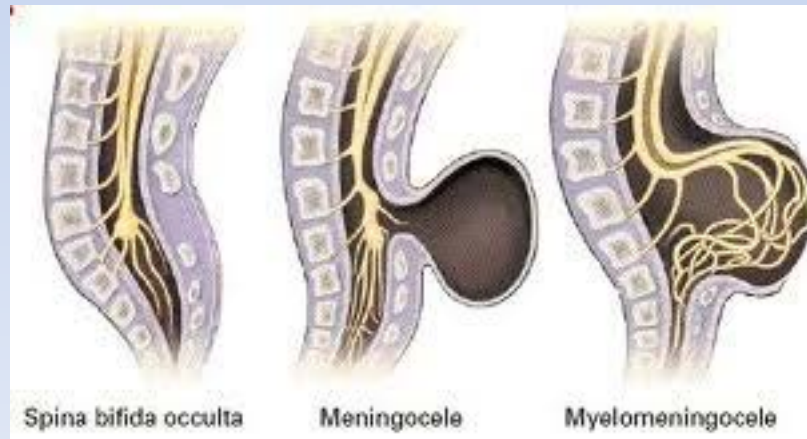
## – Bladder colonization:

- Bacteriuria is common in the neurogenic bladder
  - Patients without symptoms can have abnormal appearing urine
    - » 81% of urine specimens were abnormal
      - 51% bacteriuria and pyuria
      - 26% bacteriuria alone
      - 5% pyuria alone (Schlager)

# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder

## Variations in sensation

- Lesion Level
- Lesion Type
  - Myelomeningocele
  - Meningocele

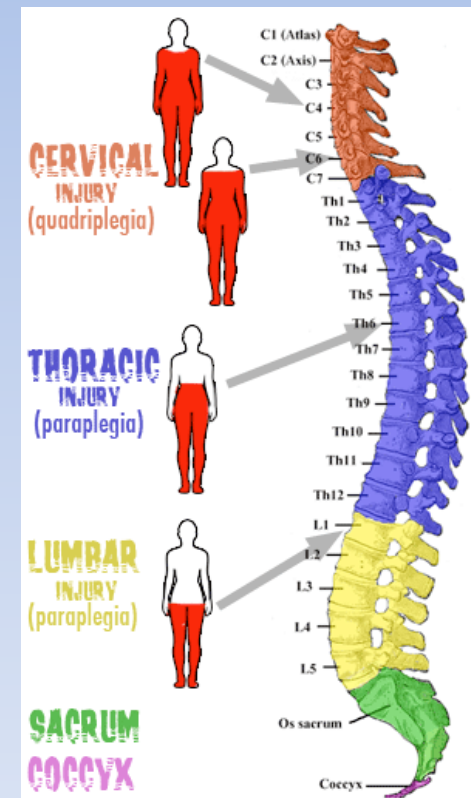


# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder

- Variations in pathology of Neurogenic Bladder
  - MS vs CP vs Spinal Tumor
- Level and Degree of SCI injury



**Variation in Symptoms**



# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder



## – Variations in symptoms

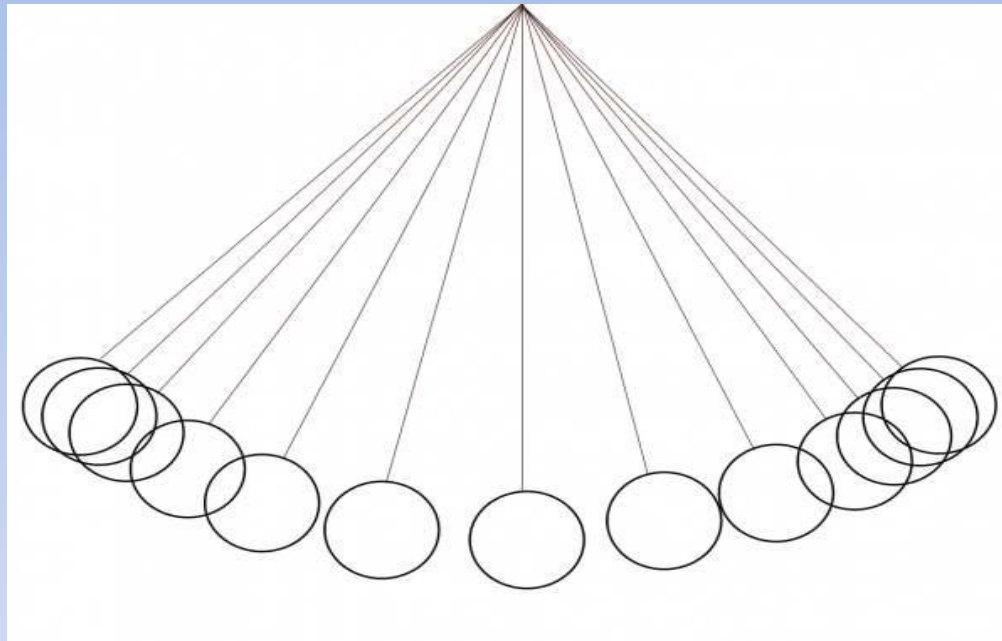
- Abdominal Pain
- Back Pain
- Pain with Catheterization
- Fever +/- symptoms
- Autonomic dysreflexia

## – Variations in signs

- Malodorous urine
- Cloudy Urine
- Hematuria



# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder



Low suspicion  
No evaluation  
No treatment

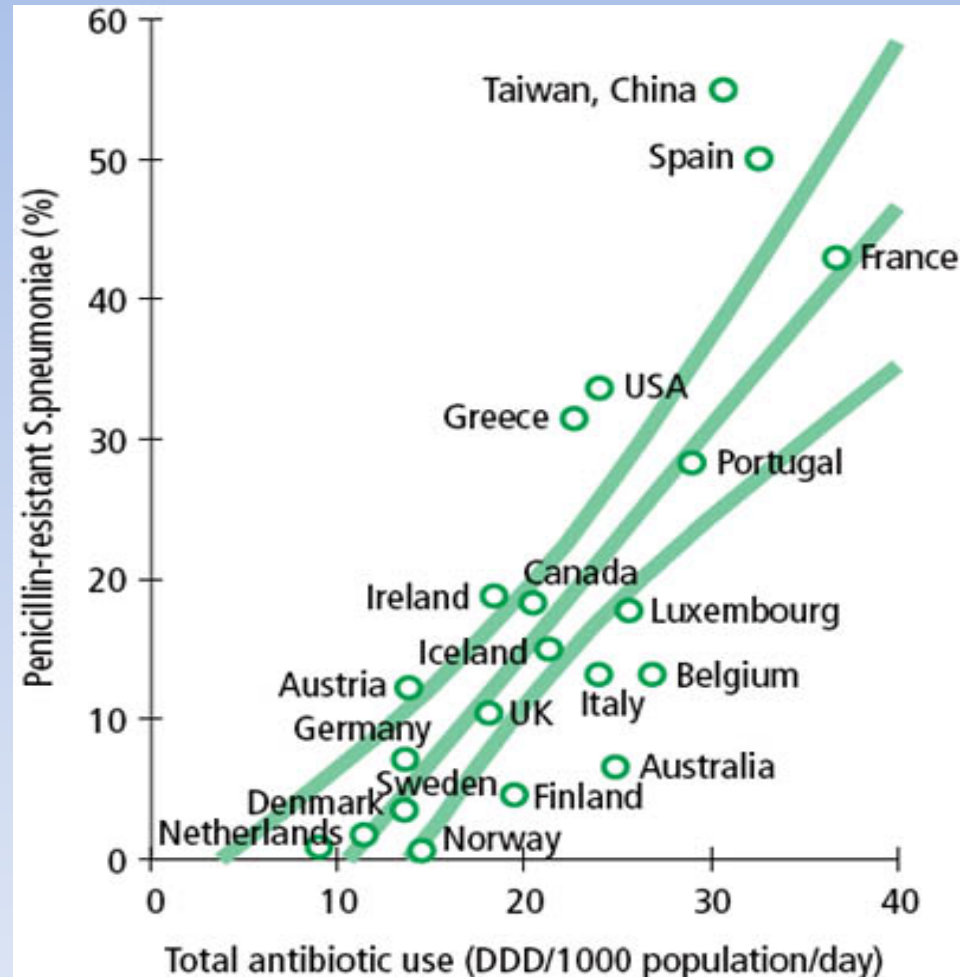
Its ALWAYS a UTI>>>Antibiotic  
Abuse

# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder

Antibiotic overuse



Bacterial resistance



# Bacterial Resistance

- 5131 unique urinary isolates
  - Compared Non-SCI and SCI
- Results:
  - MRSA 27.8% vs 55.4% \*\*
  - Gram-negatives
    - Lower antibiotic susceptibility in SCI
    - Higher frequency of organisms
      - ↑ Beta-lactamases 17.6% vs 5.0% \*\*
      - ↑ Carbapenem-resistant Enterobacteriaceae 2.4% vs 0.5%\*\*
      - ↑ Overall carbapenem resistance 7.6% vs 2.4% \*\*
      - ↑ Isolates resistant to  $\geq 3$  ABX classes 60.7% vs 28.0%\*\*





# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder

## Higher Rate of Resistant Bacteria in the Neurogenic Bladder

36% of patients with SCI have UTI with MDR

- Ampicillin (73%)
- Sulfamethoxazole–Trimethoprim (60%)
- Ciprofloxacin (26%)
- Nitrofurantoin (26%) (Waites)

# Problems with Diagnosis and Treatment of UTIs in the Neurogenic Bladder

- Variations in Organisms
  - UTIs in the normal bladder:
    - E. coli
    - Klebsiella
  - UTIs in the Neurogenic Bladder:
    - Enterococcus
    - Acinetobacter
    - Pseudomonas
    - Multiorganismic infections (Esclarín)

# How to Improve Management of UTIs in the Neurogenic bladder?

- Ultimate Goal >> Prevention of Recurrent UTI
- Immediate Goal >>
  1. Properly Diagnose
    - Colonization vs Infection
  2. Understand Risk Factors for Infection
  3. Eradicate Infection
    - Culture sensitivities
    - Adequate treatment

# Defining Infection of the NGB

What is the Definition of UTI in SB patients

**PEDIATRICS**<sup>®</sup>

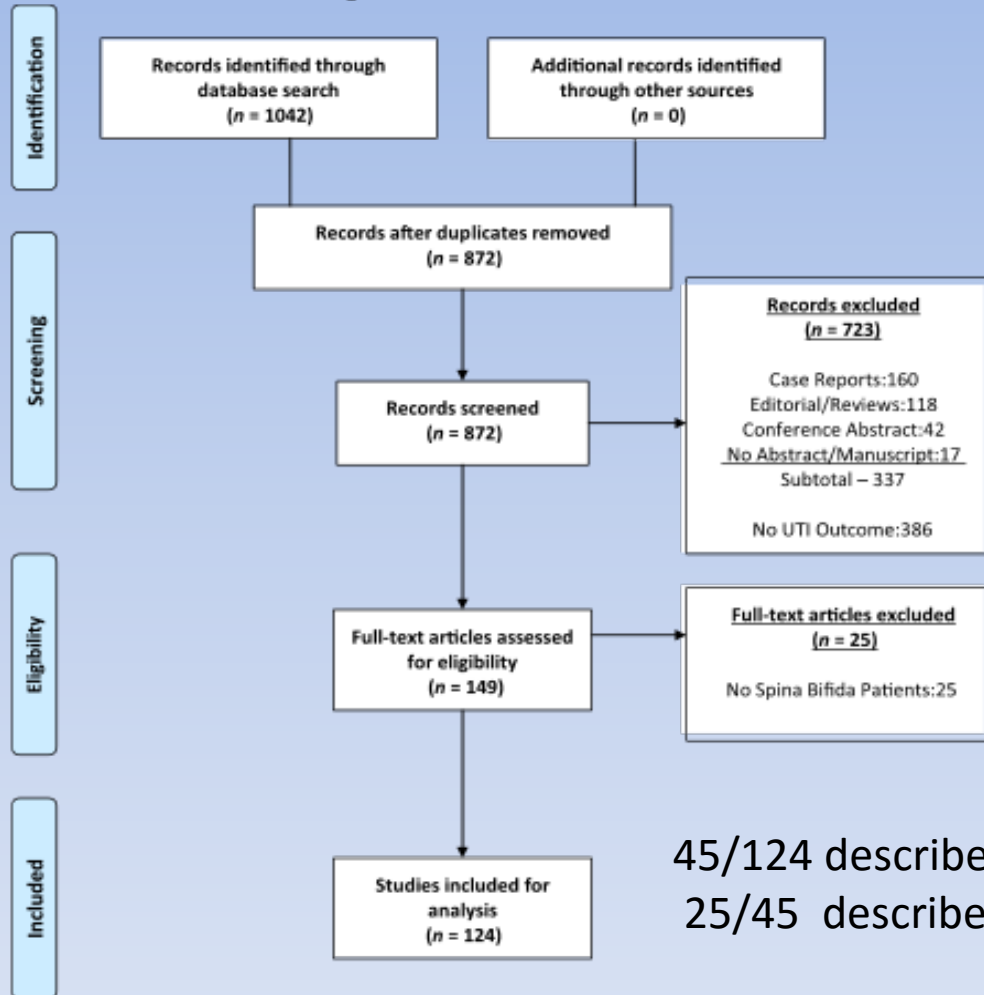
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

**Variation in Definitions of Urinary Tract Infections in Spina Bifida Patients: A Systematic Review**

Ramiro Jose Madden-Fuentes, Erin Rebekah McNamara, Jessica Catherine Lloyd,  
John Samuel Wiener, Jonathan Charles Routh, Patrick Casey Seed and Sherry  
Sedberry Ross

*Pediatrics* 2013;132;132; originally published online June 24, 2013;  
DOI: 10.1542/peds.2013-0557

# Defining UTI in the NGB



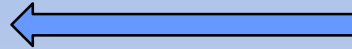
45/124 described UTI parameters  
25/45 described collection method

(Madden-Fuentes)

# Defining UTI in NGB

**TABLE 3** Parameters Defined for UTI Diagnosis

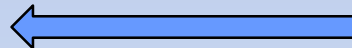
	Publications (n = 45)
<b>Fever</b>	
38°C	4
38.5°C	3
Included but not specified	14
Not included	24
<b>Culture (CFU/mL)</b>	
>10 <sup>4</sup>	8
>10 <sup>5</sup>	19
>10 <sup>4</sup> or >10 <sup>5a</sup>	2
Included but not specified	15
Not Included	1
<b>Symptoms</b>	
Specified	15
Included but not specified	5
Not included	25
<b>Urinalysis</b>	
<b>Leukocyturia</b>	
> 50 WBC/HPF	3
> 10 WBC/HPF	3
> 5 WBC/HPF	2
Leukocyte esterase	2
Bacteriuria	1
Not included	34



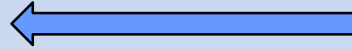
Fever



Culture



Symptoms

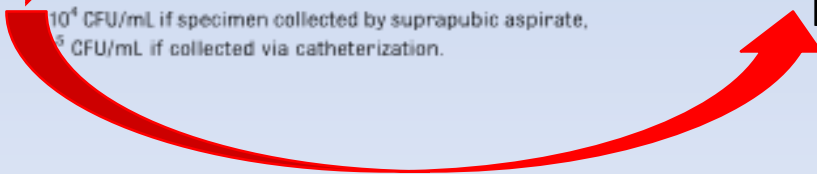


Pyuria



Most exclude it, altogether

(Madden-Fuentes)



<sup>a</sup>10<sup>4</sup> CFU/mL if specimen collected by suprapubic aspirate, <sup>b</sup>10<sup>5</sup> CFU/mL if collected via catheterization.

# Defining UTI in the NGB

Not Validated!!

**TABLE 5** Proposed Definition of UTI in SB Patients

---

≥2 symptoms (fever >38°C, abdominal pain, new back pain, new or worse incontinence, pain with catheterization or urination, or malodorous/cloudy urine) AND

>100 000 CFU/mL of a single organism AND

>10 WBC/HPF on urine microscopy

---

(Madden-Fuentes)

# Defining UTI in the NGB

National Institute on Disability and Rehabilitation Research (NIDRR)

- UTI are comprised of:
  - $\geq 10^2$  (CFU)/mL if CIC
  - $\geq 10^4$  CFU/mL for condom catheter
  - Any value from indwelling or suprapubic catheter
  - leukocytes in the urine
  - discomfort or pain over the kidney or bladder, or during
  - urination
  - onset of urinary incontinence
  - fever
  - increased spasticity
  - autonomic hyperreflexia
  - cloudy urine with increased odor, or
  - malaise, lethargy, or sense of unease.



# Defining UTI in the NGB

## UTI in SCI:

- Body temperature > 38°C
- Abdominal pain
- Reflex perspiration
- Urinary incontinence
- Increased spasticity
- Suprapubic pain
- Flank pain
- Frequent urination
- Dysuria
- Urgency
- Urinary incontinence
- Foul smell in urine
- Cloudy urine
- $10^5$  cfu/ml (Veenboer)



# Defining UTI in the NGB

- Abstract MP26-01 AUA San Diego

## **Inconsistency in the Definition of Urinary Tract Infection in the Spinal Cord Injury Population: A Systematic Review**

- 1425 publications >> 315 met inclusion criteria
- 80% included UTI as a primary outcome
  - 43.9% provided a definition for UTI
    - 11 different definitions
- Conclusion: Definition of UTI in this population is variable, inconsistent and limits the reliability of diagnosis in this population



# Understanding Risk for UTI in the NGB

- **Altered Intrinsic Bladder Mechanisms**
  - **Protective Flora**
  - **Glycosaminoglycan layer (GAG) disruption**
    - Important barrier to bacterial invasion
  - **Defective Apoptosis**
    - Decreased Exfoliation
  - **Poor Immune Response**
  - **Bladder ischemia**
    - High Intravesical pressures
    - Over Distention



# Understanding Risk for UTI in the NGB

- Altered Bladder Mechanics
  - Impaired Washout (**High Post Void Residual**)
  - Disturbed hydrokinetics
  - Vesicoureteral Reflux
- Catheterization
  - Introduction of bacteria into the bladder
  - Catheterization may damage GAG layer
  - No mechanical cleansing without urinary passage seen with normal voiding
  - Biofilm formation with indwelling catheters

# Risk Factors: Alterations in Protective Flora

## Variations in the Microbiome of the Neurogenic Bladder: Is there a role?



**Our Self Portrait: the Human Microbiome**

Oil on canvas

Artist Joana Ricou

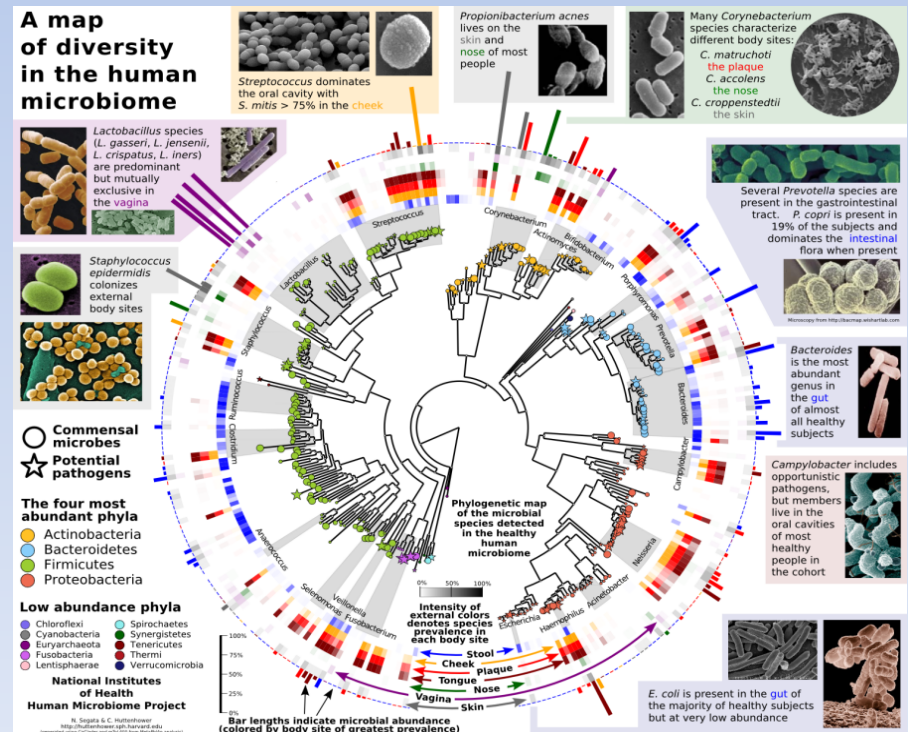


# The Microbiome

“The ecological community of commensal, symbiotic, and pathogenic microorganisms that literally share our body space”

The body contains 10 times more microbial cells than human cells (approximately 10 trillion microbial cells).

These organisms are important inhabitants that play a role in health and disease





# Microbiome and Disease

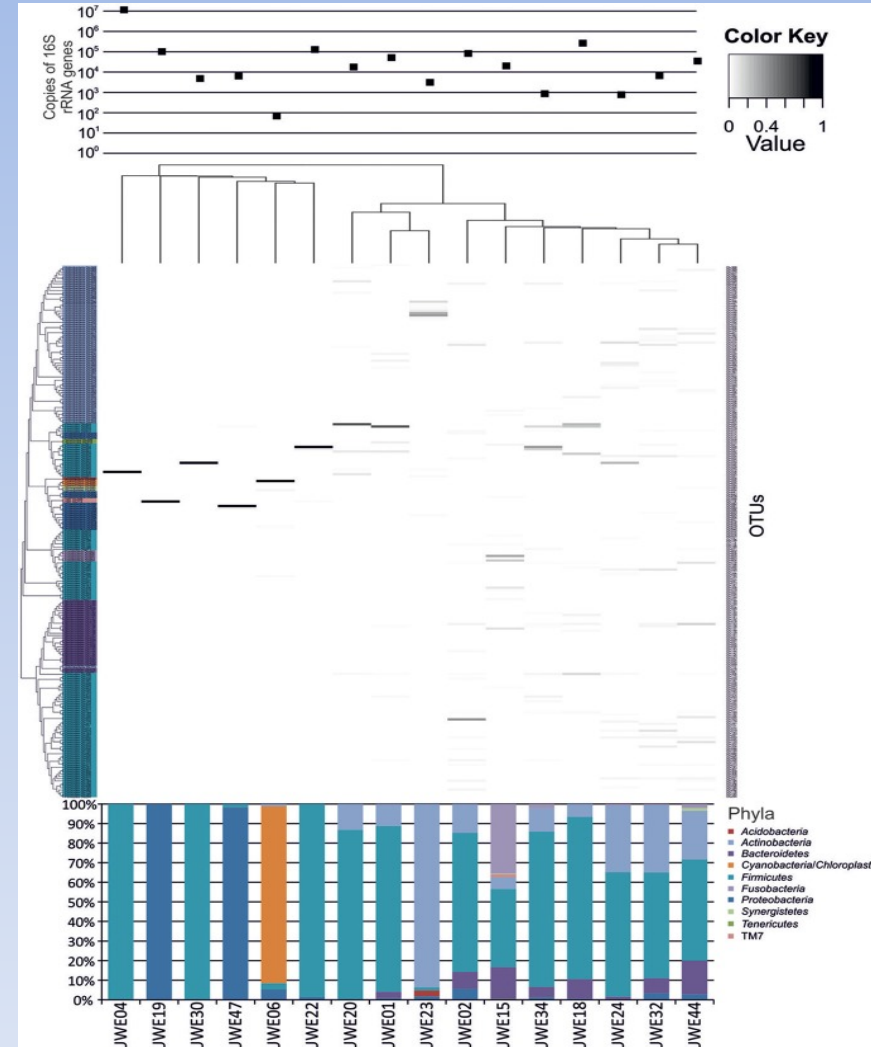
- Necrotizing enterocolitis does not result from growth of a single causative pathogen but rather from a generalized disturbance of normal colonization patterns in the developing gut (Carlisle)
- Males with infectious urethritis are colonized with different bacterial species relative to those men without urethritis (Nelson)
- Antibiotics exposure is a risk factor for vaginal candidiasis due to alterations in the normal vaginal flora (Dan)
- Antibiotics significantly alter the salivary bacterial community in children treated with antibiotics for acute otitis media (Lazarevic)
- Antibiotics exposure predispose to Clostridium Difficile due to alterations in normal gut flora (Dulny)
- Patients with Prostate Cancer and BPH have significant variations in the Microbiome of the EPS (Yu)
- **MOST IMPORTANT:** Fecal transplant restores normal gut flora
  - 92% resolution of symptoms and recurrent CD infection (Gough)



# Urinary Microbiome:

## Proof of Concept

1. A community of urine organisms
2. The organisms vary by age
3. The organisms vary by sex



(Lewis)





# Urinary Microbiome: Hilt et al. J Clin Microbiol.

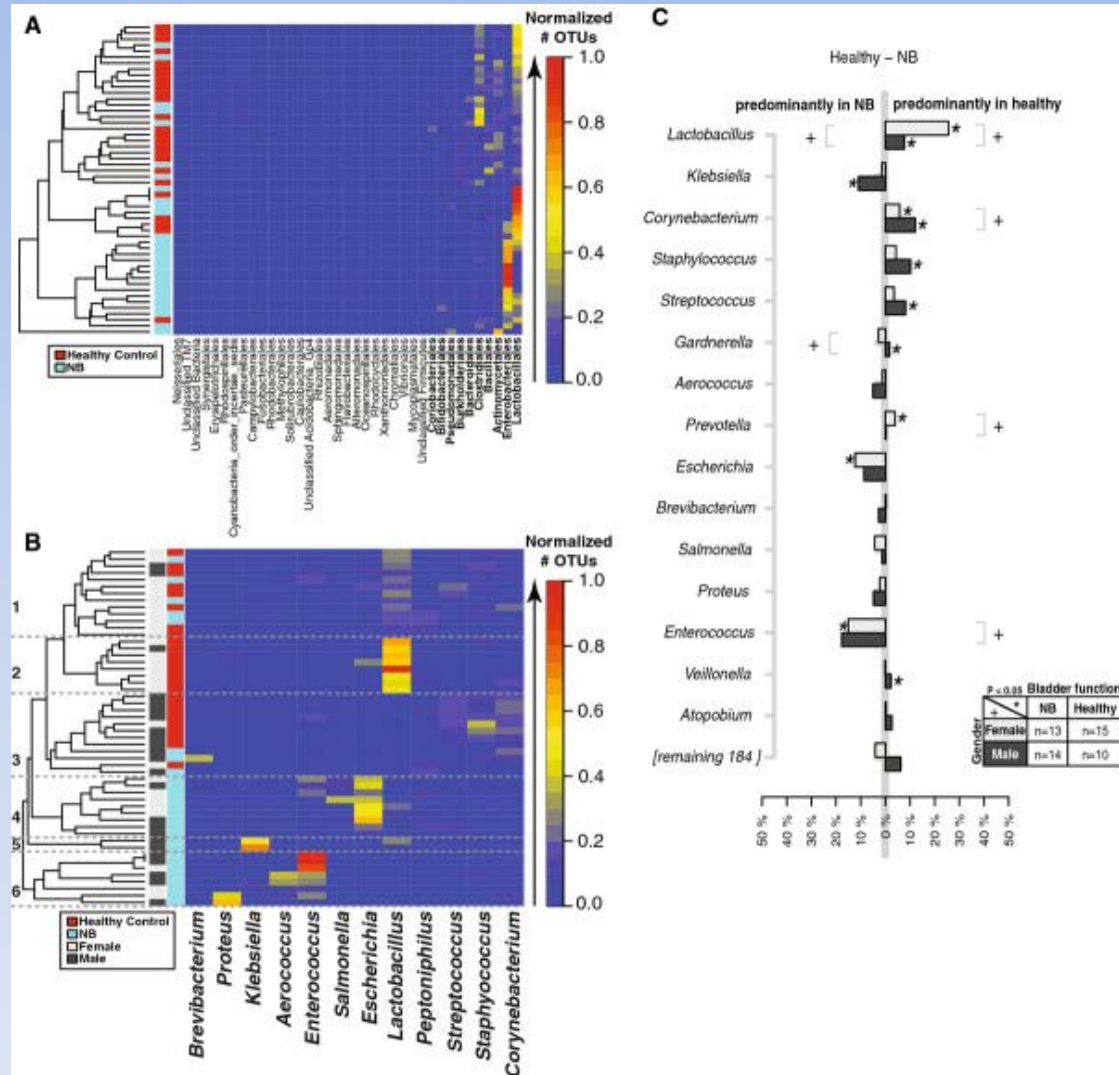
- 80% of urine grew bacteria with EQUC
- 35 different genera and 85 different species
  - Lactobacillus (15%)
  - Corynebacterium (14.2)
  - Streptococcus (11.9%)
  - Actinomyces (6.9%)
  - Staphylococcus (6.9%)

Urine contains communities of living bacteria that make up a  
urine microbiome

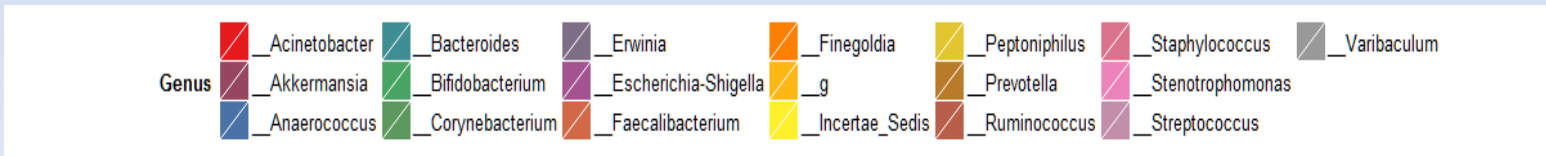
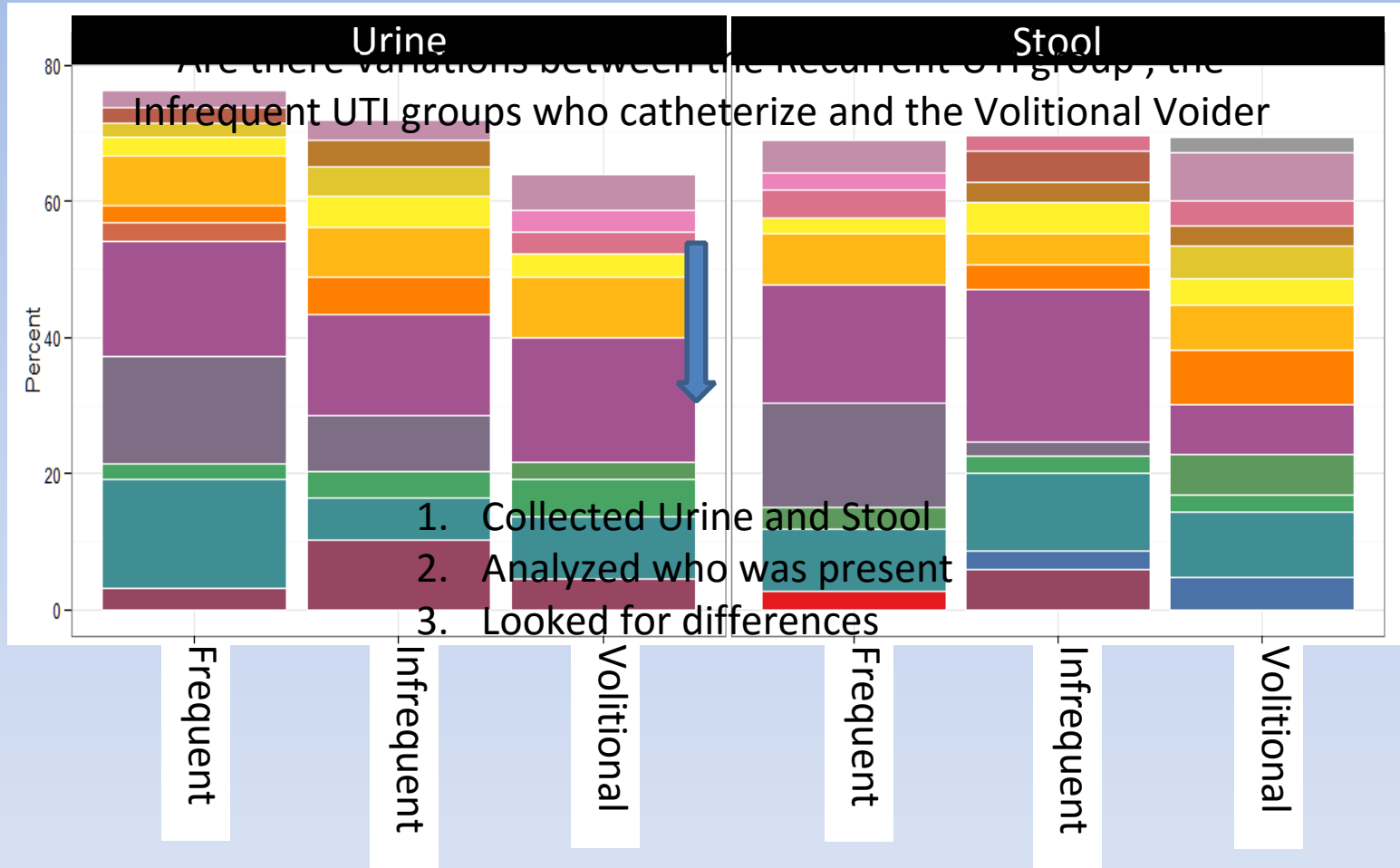
# Microbiome of the Neurogenic Bladder

## Varies (Fouts)

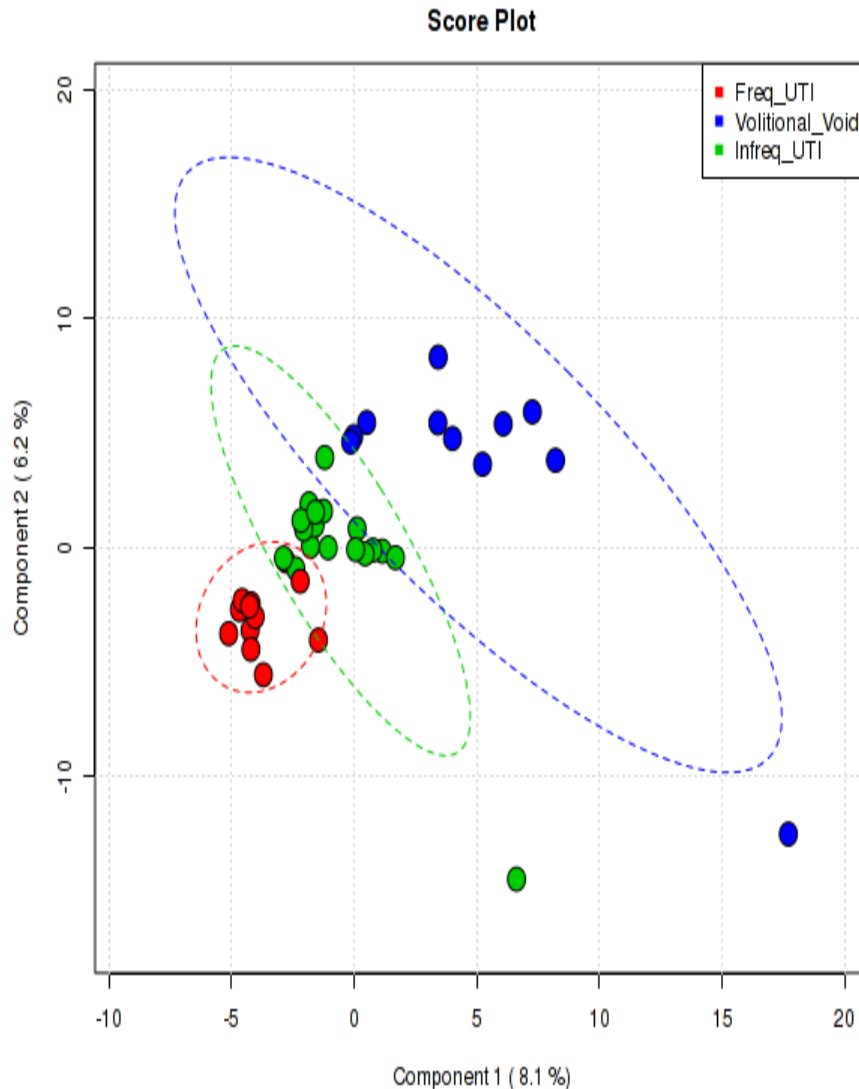
- Gender
- Duration of NB
- Bladder Management
  - Void vs CIC



# Microbiome of the Neurogenic Bladder



# Microbiome of the Neurogenic Bladder



Name	Comp 1	Comp 2
<i>Propionibacterium</i>	<b>2.84</b>	<b>2.35</b>
Christensenellaceae	<b>2.67</b>	<b>2.16</b>
Enhydrobacter	<b>2.51</b>	<b>2.03</b>
Bacillus	<b>2.47</b>	<b>2.02</b>
Lactobacillus	<b>2.31</b>	<b>2.18</b>
Massilla	<b>2.13</b>	<b>2.03</b>
Variovorax	<b>2.13</b>	<b>1.92</b>
Marmoricola	<b>2.11</b>	<b>1.86</b>
Acidovorax	<b>2.11</b>	<b>1.97</b>

# Microbiome of the Neurogenic Bladder

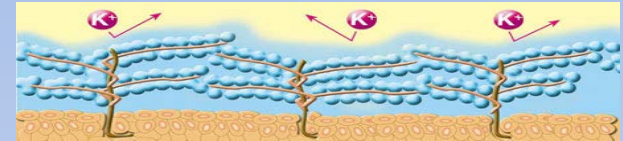
What do we not know?

1. How these organisms play a role in the initiation of infection.
2. How antibiotics effect organisms in the neurogenic bladder.
3. How these organisms can prevent infection



## Risk Factors for UTI in the Neurogenic Bladder: Intrinsic Bladder Mechanisms

- **Glycoaminoglycans** play an important role in the pathogenesis of UTIs in children<sub>(Ceoiz)</sub>...no studies of the role in Neurogenic Bladder



[http://produkte.pohl-boskamp.de/en/products/Gepan\\_instill\\_therapy/77074/](http://produkte.pohl-boskamp.de/en/products/Gepan_instill_therapy/77074/)

- **Urothelial cell apoptosis, exfoliation** and impairment of barrier function urothelial cells may contribute to recurrent UTI<sub>(Chuang)</sub>

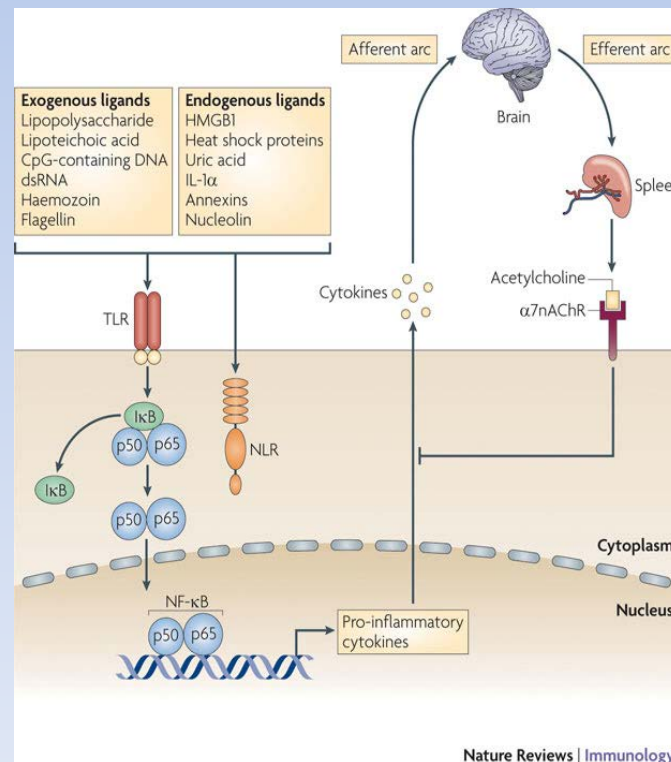
– 2 studies have shown disruption in the neurogenic bladders ability to exfoliate <sub>(Vaidvanathan, Schlager)</sub>

- **Immune Variations**

- Significant differences in secretory IgA between the normal and neurogenic bladder <sub>(Vaidvanathan)</sub>
- Impaired nonspecific Natural Killer cell and B and T cell immunity in patients with SCI <sub>(Iversen, Campagnolo)</sub>

# Risk Factors for UTI in the Neurogenic Bladder: Intrinsic Bladder Mechanisms

Inflammatory reflex: neural circuit that regulates immune response to injury and invasion



## Risk Factors for UTI in the Neurogenic Bladder: Altered Bladder Mechanics

Merritt et al 1981 : In SCI patients, post void residual increased the rate of UTI 4-5 fold.

Dromerick et al 2003: Elevated post void residual was an independent risk factor for UTI.

Naito et al 2004 : Detrusor over activity, Poor bladder compliance and presence of VUR were significantly associated with recurrent UTI and were found to be significant factors for the incidence of febrile UTI

Esclarin de Ruz et al 2000: Hyperreflexic bladder with detrusor sphincter dyssynergia (DSD) was associated with higher incidence of UTI in spinal cord injured patients

Chaudhry et al (submitted for publication 2015): Only predictive factors were young age and level of lesion.



# Treatment of UTI in the NGB

Proper Treatment starts with Proper Evaluation



Symptoms (abdominal or back pain, pain with catheterization, fever, nausea/vomiting, pressure, )



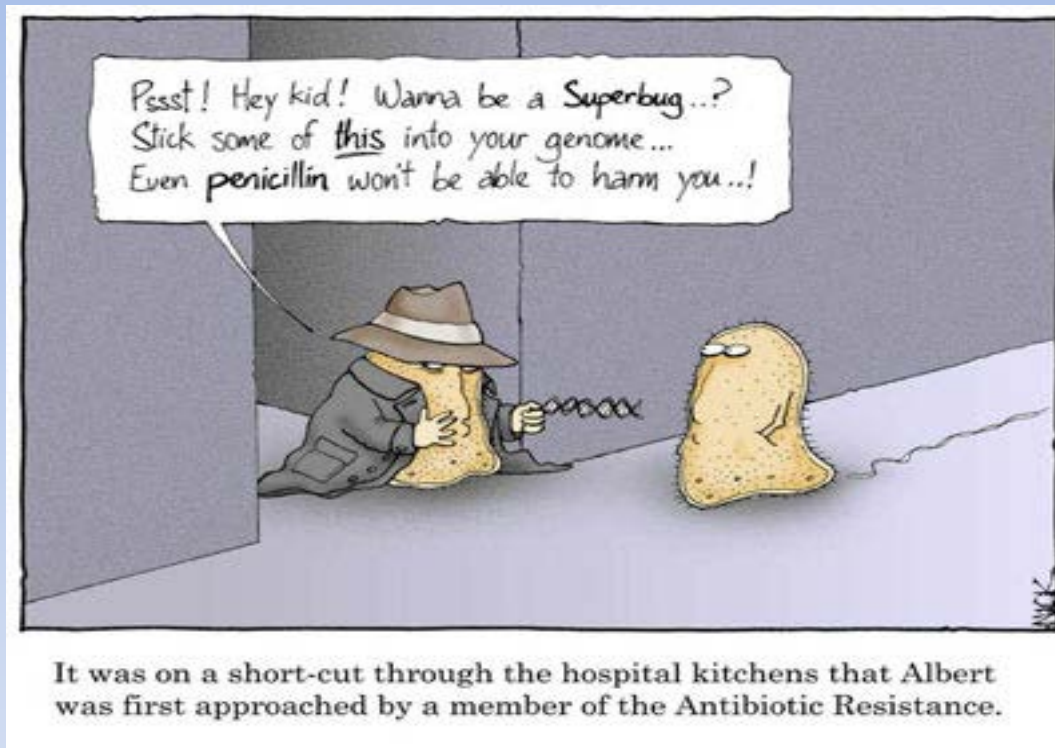
Signs (malodorous urine, cloudy urine, gross hematuria)



Urine analysis  Urine Culture



# Treatment of UTI in the NGB

Identify the Organism and Determine Sensitivities



Follow-up for clinical improvement

# UTI Prevention Today

- Colonization of the Neurogenic Bladder
  - Bladder colonization with E. coli HU2117 safely reduces the risk of symptomatic UTI in patients with spinal cord injury. (Darouicher)
  - E. coli 83972-coated urinary catheters are a viable means of achieving bladder colonization with this potentially protective strain in persons practicing ICP.(Prasad)
- Catheter Type
  - Gel reservoir and Hydrophilic catheters vs Sterile Non-coated Catheters
    - significantly less likely to report one or more UTIs compared P=0.04 (Bermingham)
  - Hydrophilic vs Sterile Non-coated Catheters
    - mean monthly UTI P=0.84
    - total UTIs at 1 year P=0.60  No difference
  - Clean versus Sterile Non-coated Catheters
    - One or more UTIs P=0.86.  No difference



# UTI Prevention Today

- Cranberry Capsules: (RCT)

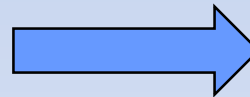
- 20 (F/M: 13/7)
- mean age of  $7.25 \pm 3.49$  (4-18) years.
  - Median UTI rate was 0.5/year during placebo
  - Median UTI rate 0/year cranberry capsule
    - Decrease in infection rate was significant with cranberry capsule usage ( $P = 0.012$ ).
    - Decrease in the percentage of the pyuria was also recorded as significant ( $P = 0.000$ ).
    - No adverse events or side effects
    - Conclusion: Cranberry capsules may help (Matlu)

- D-Mannose

- May be beneficial for predominately E.Coli and Pseudomonas Infections

- Antibiotics

- Oral antibiotics prophylaxis
  - Only helpful in the presence of VUR
- Bladder irrigations
  - Safe but efficacy is limited by resistance
- **Increases bacterial resistance**



We Don't have Much!

# Urinary Tract Infections in NGB

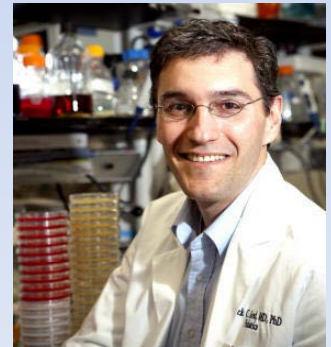
## Definitive Prevention

Step 1: Understand UTIs in the Neurogenic Bladder

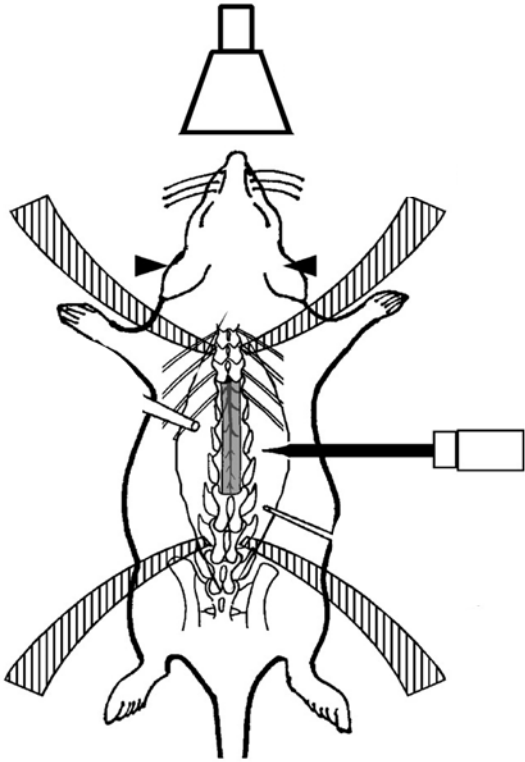
Infection and  
Immunity

**Enhanced Susceptibility to Urinary Tract Infection in the Spinal Cord-Injured Host with Neurogenic Bladder**

Zarine R. Balsara, Sherry S. Ross, Paul C. Dolber, John S. Wiener, Yuping Tang and Patrick C. Seed  
*Infect. Immun.* 2013, 81(8):3018. DOI: 10.1128/IAI.00255-13.  
Published Ahead of Print 10 June 2013.



# Neurogenic Bladder/UTI Model



**Rat models of NB mimic human lower urinary tract dysfunction**

- Increased bladder capacity
- High voiding pressures
- **High residual volumes**

- 2 weeks an antibiotic treatment>> Stop
- Transurethrally infected with uropathogenic E. coli

# Urinary Tract Infections NB/UTI Rat

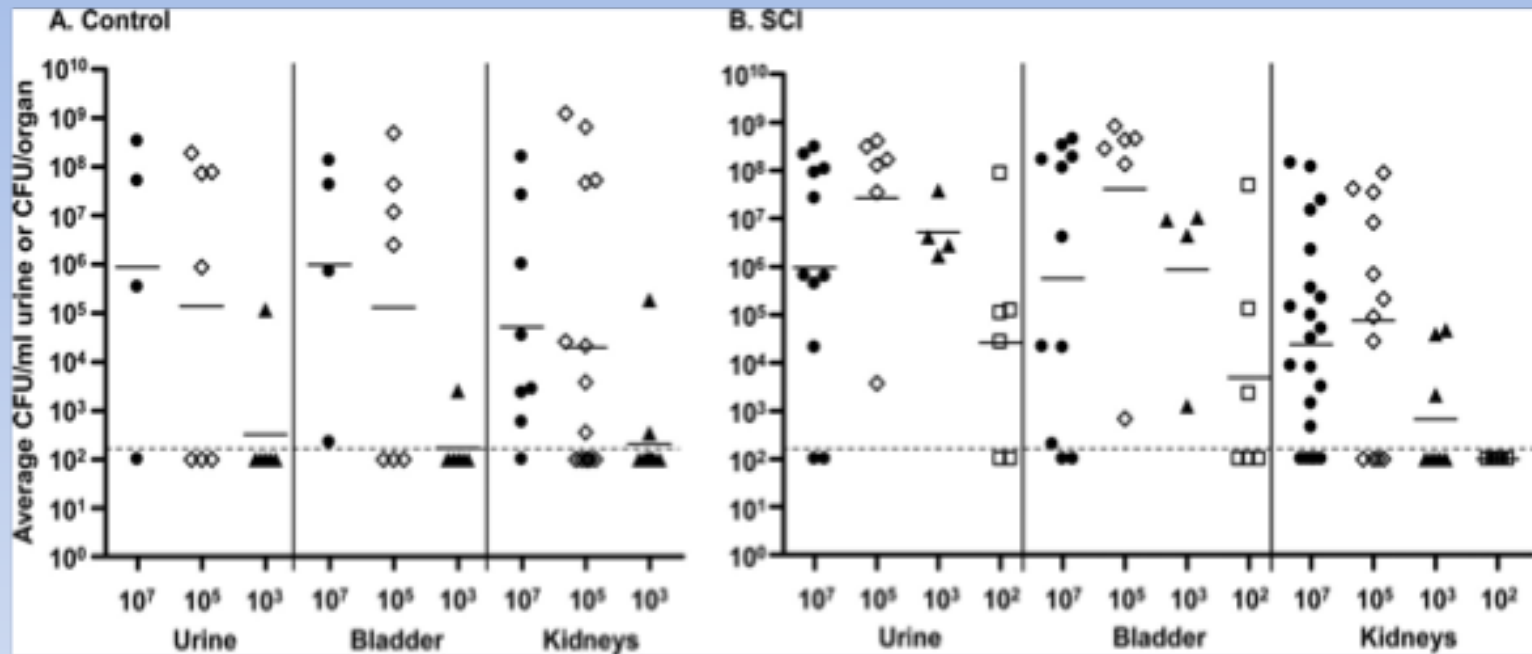
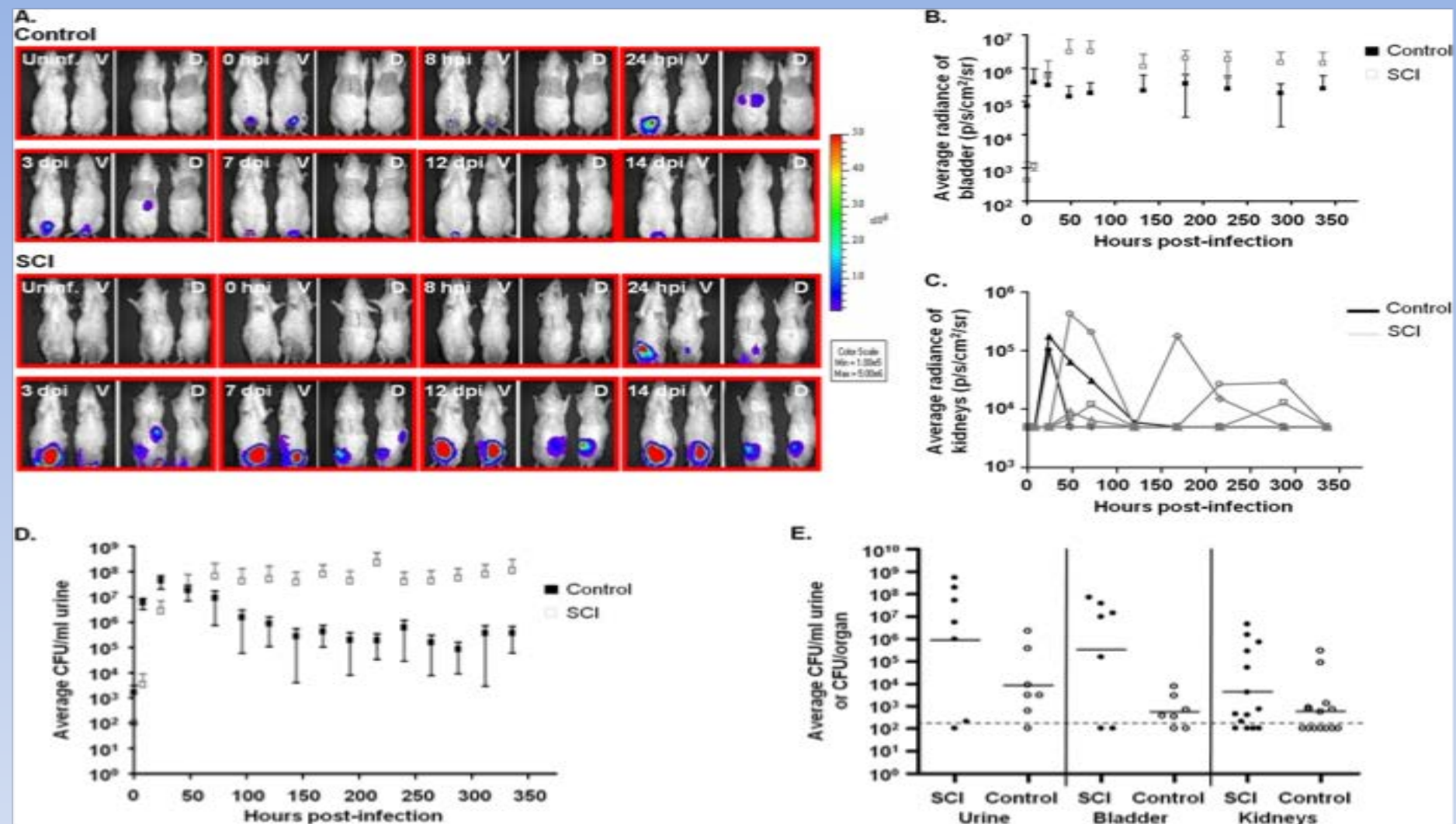


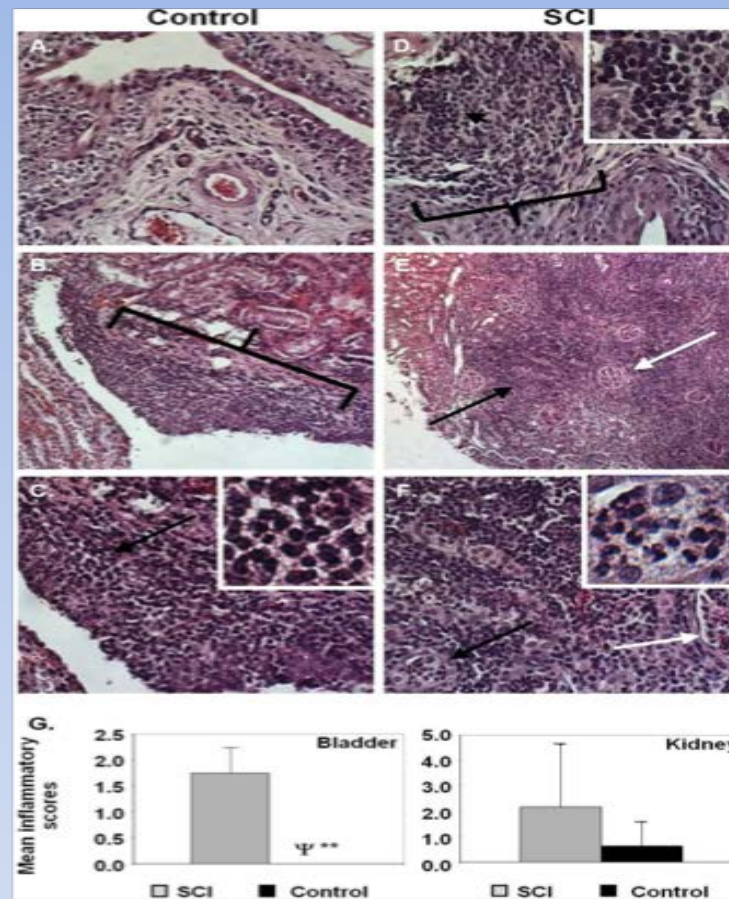
FIG 2 SCI rats are more susceptible to acute *E. coli* UTI than control rats. To determine the median infectious dose ( $ID_{50}$ ) of experimental *E. coli* UTI in SCI versus spinally intact control rats, animals were transurethally inoculated with  $10^2$  to  $10^7$  CFU of the prototypic *E. coli* cystitis strain, UTI89 ( $x$  axis). Urine, bladders, and kidneys were harvested at 24 hpi and plated to enumerate CFU of UTI89 ( $y$  axis). The  $ID_{50}$  for control rats is  $\sim 10^5$  CFU (A), while the  $ID_{50}$  for SCI rats is  $\sim 10^2$  CFU (B). At the lowest inoculum compared ( $10^3$  CFU), there was a statistically significant difference between the numbers of control animals and SCI animals that established infections within their urine and bladders ( $P = 0.048$ , Fisher's exact test). Individual symbols represent individual animals, solid black lines represent the geometric mean for each group, and the dashed black line represents the level of detection for the assay.



**FIG 3** SCI rats maintain high levels of UTI89 infection in urine and bladders for at least 14 days postinfection. (A) Control and SCI rats were transurethraly inoculated with a bioluminescent strain of UTI89 carrying the complete *lux* operon (*luxCDABE*) from *Photobacterium luminescens*. The inoculum used for each group was  $\sim 1.5$  logs above their respective  $ID_{50}$  values (control,  $3.5 \times 10^6$  CFU; SCI,  $3.5 \times 10^3$  CFU). *In vivo* imaging with the IVIS Spectrum imaging system (Xenogen) was performed to determine the temporospatial course of UTI89 infection. Animals were imaged in both the ventral (V) and dorsal (D) positions to maximize detection in the bladders and kidneys, respectively. Representative images are shown in panel A. Uninf., uninfected. Regions of interest were identified over the bladders and kidneys of each animal for each time point, and the average radiance of emitted photons (in photons/s/cm<sup>2</sup>/sr) from bladders (B) or kidneys (C) of control ( $n = 4$ ) versus SCI ( $n = 3$ ) animals is plotted. Because of the high levels of background interference detected over the kidneys, the threshold level of detection for kidneys was set at  $5 \times 10^3$  p/s/cm<sup>2</sup>/sr. The average CFU in urine collected from control ( $n = 7$ ) and SCI animals ( $n = 7$ ) over 2 weeks postinfection is shown in panel D. Squares in panels B and D represent the arithmetic mean values for all animals in each group, and error bars represent standard deviations from the means. Symbols in panel C represent values for individual animals. Closed symbols with black lines represent control animals, whereas open symbols with gray lines represent SCI animals. Panel E shows the numbers of CFU present in the urine, bladders, and kidneys of control and SCI animals at 14 dpi. Individual symbols represent individual animals, solid black lines represent the geometric mean for each group, and the dashed black line represents the level of detection for the assay.



# Urinary Tract Infections NB/UTI Rat



**FIG 5** Significant differences in the inflammatory response to UTI89 are seen in the bladders of control versus SCI rats in late infection. (A to F) Two weeks after infection with UTI89, bladders and kidneys from SCI and control rats were fixed, embedded, sectioned, and stained with hematoxylin and eosin. Inflammation completely resolves in bladders of control animals (A) (magnification,  $\times 40$ ), while mild inflammation is confined to the renal pelvis of these animals after 2 weeks of infection (magnification,  $\times 40$  [B] or  $\times 100$  [C]; renal pelvis is designated with a bracket; the black arrow and inset highlight neutrophils and mononuclear cells). In contrast, bladders of SCI animals (D) (magnification,  $\times 40$ ) display chronic inflammatory infiltrates resembling lymphoid aggregates (designated with a bracket; the black arrowhead and inset highlight mononuclear cells) and kidneys (magnification,  $\times 40$  [E] or  $\times 100$  [F]) exhibit focal collections of acute inflammation that extend out to the cortex (black arrows and inset highlight neutrophils; white arrows designate glomeruli within the renal cortex). (G) Histologic grading of inflammation was performed by a pathologist who was blinded to the identities of samples. Error bars represent standard deviations from the mean. The symbol “ $\Psi$ ” represents a mean inflammatory score of 0. “\*\*” indicates a statistically significant difference between groups, with a *P* value of 0.029.

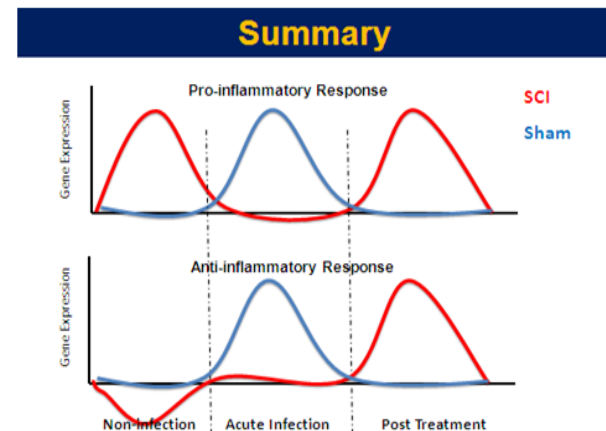
# Urinary Tract Infections NB/UTI Rat

## Inflammatory Response to *Escherichia coli* Urinary Tract Infection in the Neurogenic Bladder of the Spinal Cord-Injured Host

Compared to sham rats, SCI rats have:

- Altered inflammatory pathway activation in absence of infection
  - Suggests that disruption of neural network to bladder may alter inflammatory profile at baseline
- Attenuated pro-inflammatory response to *E. coli* infection as compared to sham bladders
  - May lead to impaired clearance of bacteria and increased susceptibility to recurrent UTI
- SCI animals have delayed anti-inflammatory response after antibiotic treatment

Inflammatory Response to *Escherichia coli* Urinary Tract Infection in the Neurogenic Bladder of the Spinal Cord-Injured Host



Overall, there appears to be dysregulation of the inflammatory response in the neurogenic bladder

# Conclusion:

## 1. Immediate Goal

- a. Properly diagnose UTIs
- b. Treat infections appropriately and effectively
  - o To decrease morbidity (hospitalization, renal scarring)

## 2. Intermediate Goal

- a. Understand the NGB and risk of UTI
- b. Identify who is at Risk for Recurrence
- c. Understand Long term Sequela (?increased risk of Bladder Cancer)

## 3. Ultimate Goal

- a. Prevention of UTIs in patients with NGB

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