Urinary Tract Infections & Vesicoureteral Reflux

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Disclosures

- “In the last 24 months I have had no relevant financial relationships with ineligible companies whose primary business is producing, marketing, selling, re-selling, or distributing healthcare products used by or on patients.”

This Disclosure has been reviewed & mitigated by an AAP-OC CME Committee Member

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Objectives

- Diagnose and treat pediatric UTI appropriately
- Select appropriate imaging after febrile UTI
- Understand the natural history and management of vesicoureteral reflux
- Recognize when to refer to pediatric urology or nephrology

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UTI is common: Age and sex matter

~7%
of infants with fever without a source have a UTI

8.4%
of girls will have a UTI by age 7

1.7%
of boys will have a UTI by age 7

~85–90%
of pediatric UTIs are caused by E. coli

The circumcision discussion: Uncircumcised male infants under 3 months have roughly an 8-fold higher UTI risk (~20%) than circumcised infants with fever (~2–3%) — a key factor in the differential for a febrile young infant boy.

Holzman SA, et al. Retractable foreskin reduces urinary tract infections in infant boys with vesicoureteral reflux. J Pediatr Urol. 2021 Apr;17(2):209.e1-209.

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Higher Risk Patients

- **Female sex (after infancy)**
  Shorter urethra, proximity to perineal flora
- **Uncircumcised male infant**
  Periurethral bacterial colonization
- **Vesicoureteral reflux**
  Retrograde flow reintroduces bacteria to kidney
- **Bowel & bladder dysfunction**
  Constipation, dysfunctional voiding, incomplete emptying
- **Prior UTI / anatomic anomaly**
  Obstruction, duplication, dysfunctional voiding
- **Non-Hispanic white race, age < 12 mos**
  Population-level epidemiologic associations

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Clinical presentation: Age Matters

0–3 months

- Fever (often the only sign)
- Poor feeding
- Vomiting
- Irritability
- Jaundice
- Lethargy
  - Can mimic sepsis

3–24 months

- Most common: fever without an obvious source
- Foul-smelling urine
- New-onset irritability
- Poor growth (FTT)

2+ years (verbal)

- Dysuria
- Frequency
- Urgency
- Suprapubic or flank pain
- New-onset enuresis
- Hematuria

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Diagnosis: Method Matters

✓ **Catheterization**	Preferred in non-toilet-trained (up to 15% contamination)	≥ 10,000 CFU/mL of a uropathogen
✓ **Suprapubic aspiration**	Most specific; used less often in practice (0% contamination)	≥ 10,000 CFU/mL (any growth of a typical uropathogen is significant)
✓ **Clean-catch midstream**	Acceptable once toilet-trained, with proper technique (mid-stream)	≥ 100,000 CFU/mL
✗ **Bag specimen**	High false-positive rate from perineal/skin flora contamination	**NOT acceptable for diagnostic culture or treatment**

AAP position: "the diagnosis of UTI cannot be established reliably by a culture of urine collected in a bag." Bag specimens may be used only for screening urinalysis, never for culture.

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AAP diagnostic criteria: two findings required

Pyuria

- Microscopy needed (>5 wbc/hpf)
  - Absence of pyuria in true UTI is rare
- Positive leukocyte esterase + nitrite = high PPV
  - Both LE and nitrite negative: high NPV
- May see WBC/RBC casts if renal involvement



Culture Growth

- ≥ 10,000* CFU/mL of a single uropathogen (catheterized or SP)
- ≥ 100,000 CFU/mL clean-catch
- Mixed growth or non-pathogens (e.g., Lactobacillus, coagulase-negative Staph, Corynebacterium) suggest contamination

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Pitfalls of Diagnosis

Treating a bag-specimen culture

- Confirm with catheterized/SPA specimen before committing to a diagnosis

Treating asymptomatic bacteriuria

- Growth without pyuria/symptoms in well child usually colonization
- Inappropriate treatment fuels resistance without benefit

Omitting UA to wait on culture

- Culture takes 24–48h
- Pyuria at the bedside helps decide whether to start empiric therapy

”Just a virus" in febrile infants

- A concurrent viral illness does not exclude UTI
- Consider paired testing when fever lacks a clear source

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After a febrile UTI: Start with ultrasound

What it detects

- Hydronephrosis or hydroureter
- Renal size discrepancy, duplication, or scarring
- Bladder wall thickening, ureterocele
- Obstructive uropathy or abscess

Timing: obtain any time after UTI is confirmed. Sooner if no improvement on treatment.

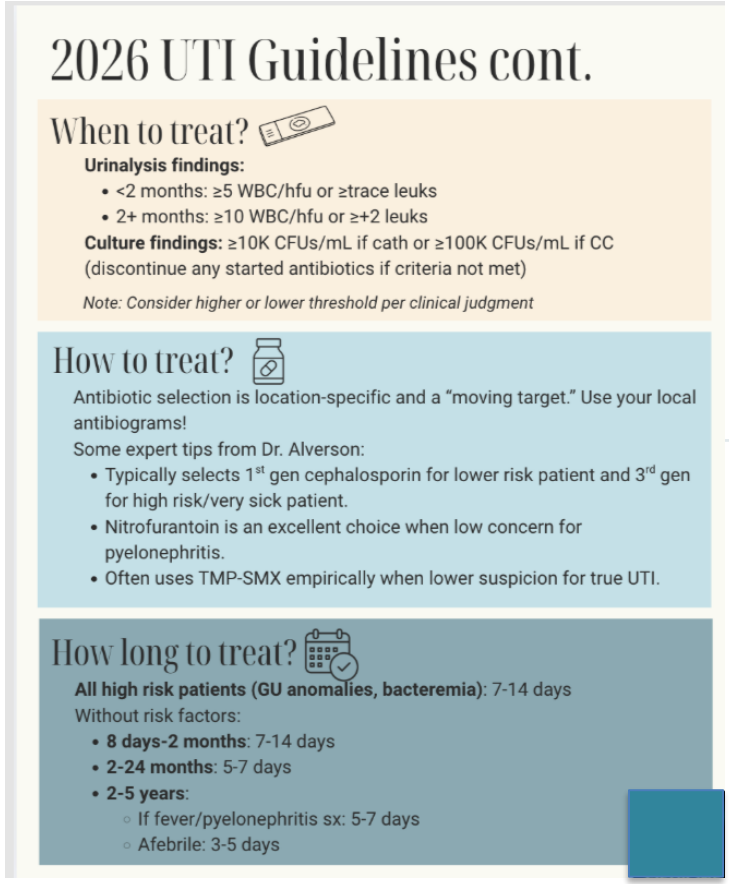
AAP recommendation

- Renal and bladder ultrasound after the first febrile UTI in infants and children 2–24 months of age.
- ** If true febrile UTI – no harm to do after 1st
- RBUS can be normal despite genitourinary anomaly like VUR

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AAP: Updated UTI Guidelines 2026



Key Updates & Recommendations

- Age Range Expanded: 8 days-5 years (previously 2mos-2years)
- Removal of race-based risk factors
- Diagnosis: 3 core domains
  - Symptoms
  - Inflammatory signs (pyuria)
  - Culture: ≥10k CFUs/ml if cath; ≥100k if CC
- Shorter antibiotic course: 7 days or less
- 8-28 days: IV then transition to PO
- Timing of Evaluation: within 72 hours
- Imaging
  - VCUG after 1st febrile UTI (normal RBUS) discouraged
  - Routine antibiotic prophylaxis discouraged for low-risk VUR*
- Highlights bladder-bowel factors/dysfunction as key factors

Who actually needs a VCUG?

Voiding cystourethrogram is the gold standard for detecting and grading VUR

Consider VCUG

- Ultrasound shows: hydronephrosis, scarring, or findings suggesting high-grade VUR or obstruction (hydroureter)
- Recurrence of a febrile UTI
- Clinical circumstances suggestive of high-grade VUR or a complex urinary tract (e.g., family history, atypical organism)

Avoid routine VCUG

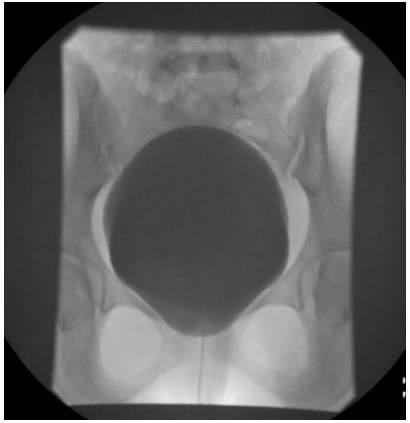
- Routinely after a first febrile UTI with normal ultrasound (AAP 2026)
  - Age of patient* (<1mos)
  - Circumcised
  - Infectious agent other than E. coli
  - Extensive course - ICU
  - Will it change your management?
- "Just to be thorough" without a clinical indication
- As a substitute for careful history and physical (BBD screening) in recurrent UTI

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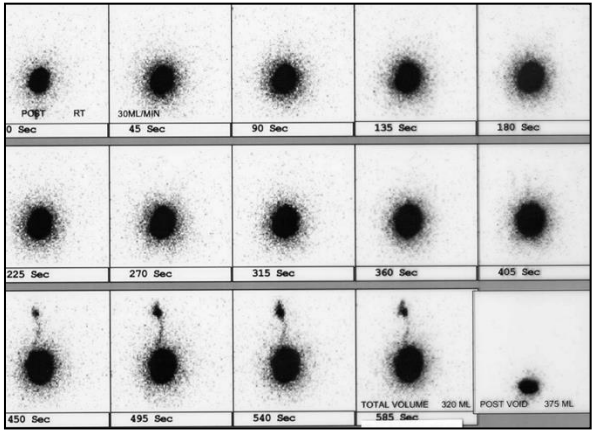
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VCUG

- VCUG = gold standard
  - Shows anatomy + grades reflux
  - Requires catheterization
  - Radiation
- Nuclear cystogram
- Ultrasonic cystography







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DMSA scintigraphy: Best for scarring

Acute (during infection)

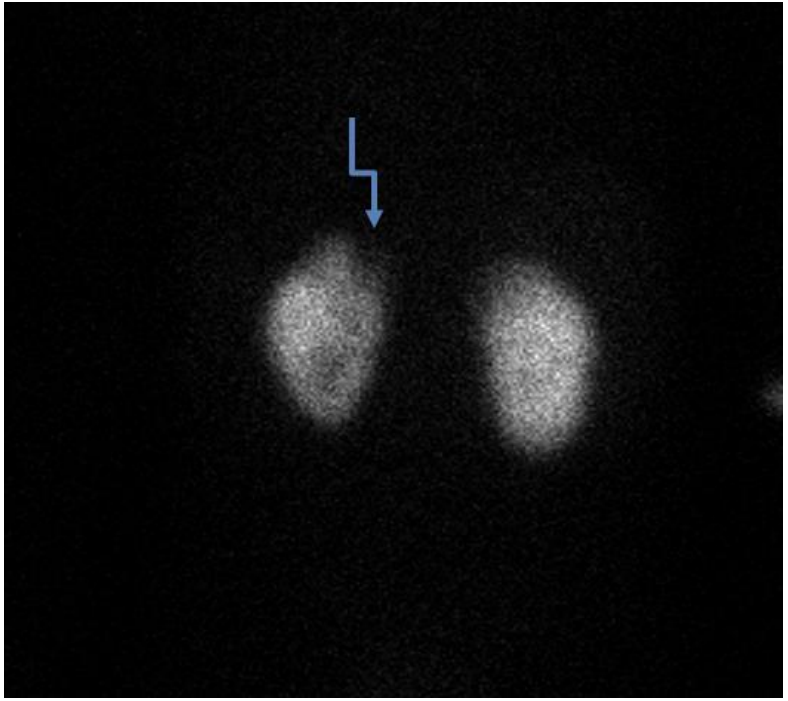
- Detects renal involvement

Delayed phase (~4–6 months later)

- Detects permanent scarring

Routine first UTI

- Generally, NO



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Treatment of Acute UTI/Pyelonephritis

Non-toxic, tolerating PO	Oral/IV therapy equally effective	Cephalosporin (e.g., cefixime, cefdinir) or amoxicillin-clavulanate *Guided by local susceptibilities
Young infant, toxic-appearing, or unable to tolerate PO	Start IV, transition to oral once improving	Ceftriaxone or ceftazidime IV/IM; consider ampicillin + gentamicin under 2 months for enterococcal/atypical coverage
Known resistant organism / complicated anatomy	Broaden and involve specialists early	Culture-directed; consider infectious disease or urology input

***** Know your local antibiogram**

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CHOC CHILDREN'S HOSPITAL – 2022 ANTIBIOGRAM

EMERGENCY DEPARTMENT

Susceptible defined as isolates inhibited by achievable concentration when recommended dosage is used for site of infection. Interpret data with caution when small number of isolates (n<30) are reported

For questions regarding antibiotics, agent selection, dosing, Formulary status, please contact Pharmacy (ext. 9150, 8008 or 7557) for assistance

Gram-Positive Organisms % susceptible	Source	# Isolated	Penicillin	Ampicillin	Oxacillin	Ceftriaxone	Clindamycin	Gentamicin (Synergy)	Erythromycin	Ciprofloxacin	Levofloxacin	Rifampin[3]	TMP-SMX	Tetracycline	Vancomycin	Nitrofurantoin[A]
Breakpoint MIC (mcg/ml)			≤ 0.12[1], ≤ 8[2]	≤ 8[2]	≤ 2[1], ≤ 0.5[3]	*	≤ 0.5[1]	≤ 4[1]	≤ 0.5[1]	≤ 1[1,2]	≤ 1[1], 2[2]	≤ 1[1]	≤ 2/38[1]	≤ 4[1,2]	≤ 2[1], ≤ 4[2,3]	≤ 32[1,2]
Enterococcus faecalis (91% (119) urine)	All	131	100	100				82		96	96				100	99
***Staph aureus*, MRSA** (8% (5) blood/CSF, 47% (28) wound)	All	59					60					97	93	86	100	
***Staph aureus*, MSSA** (16% (22) blood/CSF; 48% (67) wound)	All	139			100		71	93	63	88	91	100	99	97	100	
Strep. Pneumoniae* (46% (11) blood/CSF)	All	24	NM:100 M:67			NM: 10 0 M:83	91		67		100		79	89	100	

Gram-Negative Organisms % susceptible	Source	# Isolated	Ampicillin	Ampicillin-sulbactam	Cefazolin	Ceftriaxone	Cefepime	Ceftolozane-tazobactam	cefoxitin	Piperacillin-tazobactam	Aztreonam	Gentamicin	Tobramycin	Amikacin	Ertapenem	Meropenem	Ciprofloxacin	Levofloxacin	TMP-SMX	Nitrofurantoin[A]
Breakpoint MIC (mcg/ml)			≤ 8[4]	≤ 8/4[4]	≤ 2[5], ≤ 16[5]	≤ 1[4]	≤ 2[4], ≤ 8[7]	≤ 2/4[4], ≤ 4/4[7]	≤ 8[4]	≤ 16/4[4,7]	≤ 4[4], ≤ 8[7]	≤ 4[4,7]	≤ 4[4,7]	≤ 16[4,7]	≤ 0.5[4]	≤ 1[4], ≤ 2[7]	≤ 0.25[4], ≤ 0.5[7]	≤ 0.5[4], ≤ 1[7]	≤ 2/38[4]	≤ 32[4]
***E. coli* - non-ESBL** (96% (878) urine)	All	917	51	59	98	100	100	100	98	98	100	90	90	100	100	100	85	73	68	98
***E. coli* - ESBL** (90% (72) urine)	All	80						98	90	99		60	50	100	100	100	23	20	39	94
Kleb pneumoniae (78% (72) urine; 5% (4) ESBL)	All	92		80	95	95	97	97	97	97	96	97	97	99	100	100	92	91	90	20
Pseudomonas aeruginosa (66% (67) resp; 20% (20) urine)	All	101					85	100		92		77	83	96		95	90	81		
Proteus mirabilis (90% (84) urine)	All	93	87	93	99	99	100		100	100	100	98	97	100	100	100	93	94	86	

Abbreviations: TMP-SMX = trimethoprim-sulfamethoxazole, ESBL = extended Spectrum Beta Lactamase

Enterobacter, Citrobacter, Serratia may develop resistance during prolonged therapy with 3rd-gen cephalosporins during treatment. Testing of repeat isolates may be warranted

Strep pneumoniae breakpoint: non-meningitis (NM) Penicillin ≤2, cefotaxime/ceftriaxone ≤1; meningitis (M) Penicillin ≤0.06, cefotaxime/ceftriaxone ≤0.5

Nitrofurantoin indicated only for uncomplicated UTI (not pyelonephritis). Only urinary isolates reported

[3]Rifampin should NOT be used as monotherapy

[1]Breakpoint for *S.aureus*

[2]Breakpoint for Enterococcus

[3]Breakpoint for *Coag neg Staph*

[4]Breakpoint for Enterobacterales *(eg. E.coli, K.pneumoniae, Citrobacter spp, Enterobacter spp...etc)*

[5]Breakpoint for systemic infection

[6]Breakpoint for uncomplicated UTI due to *E.coli, K.pneumo, P.mirabilis* and can be used to predict results for oral cephalosporins

[7]Breakpoint for *Pseudomonas aeruginosa*

MediCal Rx Preferred F

- Augmentin tab/liquid
- Bactrim tab/liquid
- Cefixime tab/caps/liquid
- Clindamycin caps/liquid
- Doxycycline caps; liquid (PA
- Levofloxacin tab; liquid (PA
- Linezolid tab/liquid
- Nitrofurantoin caps/liquid

Antibiotic Time-Out after 48-hr

- Consider stopping empiric therapy
- De-escalate to narrowest, effective agent with c
- Optimize dose and frequency
- Switch IV to PO when appropriate
- Optimize duration of treatment

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Treatment: Cystitis vs Pyelonephritis

Cystitis (afebrile, lower tract)

- **3-5 days of therapy* (2-5 yo)**
- **5-7 days ages 2-24 mos**
- Shorter courses (as short as 3-5 days) may suffice in older children with straightforward cystitis

Pyelonephritis (febrile, upper)

- **5-7 days of therapy (≥2yo)**
- **>7 days – higher risk, younger (8d-2 mos)**
- Extend for complicated anatomy or slow clinical response

- Adjust treatment to sensitivities
- No nitrofurantoin for pyelonephritis
- Early treatment limits renal scarring

* - 2026 AAP Update

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Prevention of UTIs

- **Treat bowel/bladder dysfunction (BBD)**

"Urotherapy" = teaching kids how to void normally again

EDUCATE
Normal bladder/bowel function

SCHEDULE
Timed voiding
Double voiding

POSITION
Feet on the ground
Legs spread wide

HYDRATE
Clear to light-yellow
Age-based fluid goal

TRACK
Voiding/stooling diary
- 1week stools
- 2 days voiding

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The BBD Prescription

- **VOID** Every 2–3 hours while awake; double void
- **POSITION** Feet supported, legs apart, relaxed
- **HYDRATE** Clear-light yellow urine
- **POOP** Soft stool every day
- **TRACK** Bladder/bowel diary when helpful

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What about D-mannose and cranberry?

- Neither replaces evaluation/treatment of recurrent UTI
- D-Mannose
  - Limited pediatric evidence
- Cranberry products
  - Possible modest benefit
  - Evidence variable






GAVIN PUBLISHERS
OPEN ACCESS
Archives of Pediatrics
Case Report
Brownlee EM, et al. Arch Pediatr 5: 180.
DOI: 10.29011/2575-825X.100180
D-Mannose Reduces the Risk of UTI in Complex Paediatric Urology Patients
Ewan M Brownlee[1], Christopher Blore[2], Ruth Wragg[3], M Patel[3], Liam McCarthy[3]*

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Vesicoureteral Reflux

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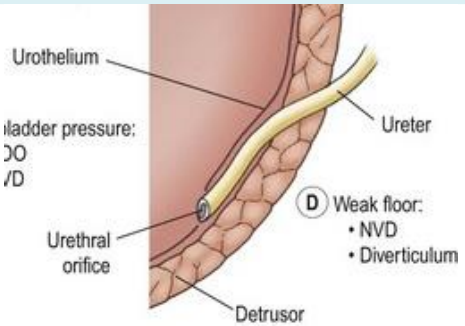
The Basics of Vesicoureteral Reflux

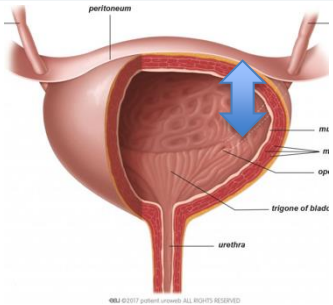
Primary VUR

- Incompetent ureterovesical junction
- Congenitally short or abnormally positioned ureteral tunnel through the detrusor muscle
- Tunnel length is inversely related to reflux severity
  - Shorter tunnel = less competent mechanism
- **Genetics:** strong familial clustering
  - 27% siblings, 37% offspring

Secondary VUR

- High bladder pressure
- Most commonly from:
  - BBD
  - PUV
  - Neurogenic bladder
- Treat the cause
  - Reflux surgery alone will not fix.

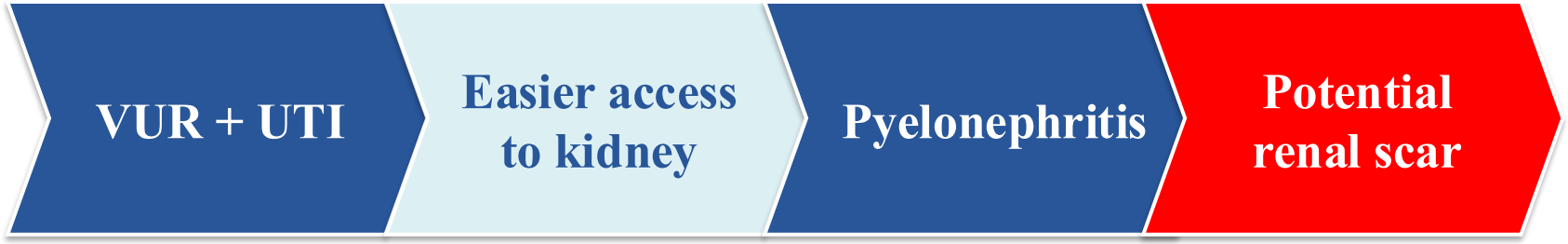




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Clinical Implications of VUR

- **~30% of children evaluated after UTI have VUR**
- **VUR ≠ UTI**

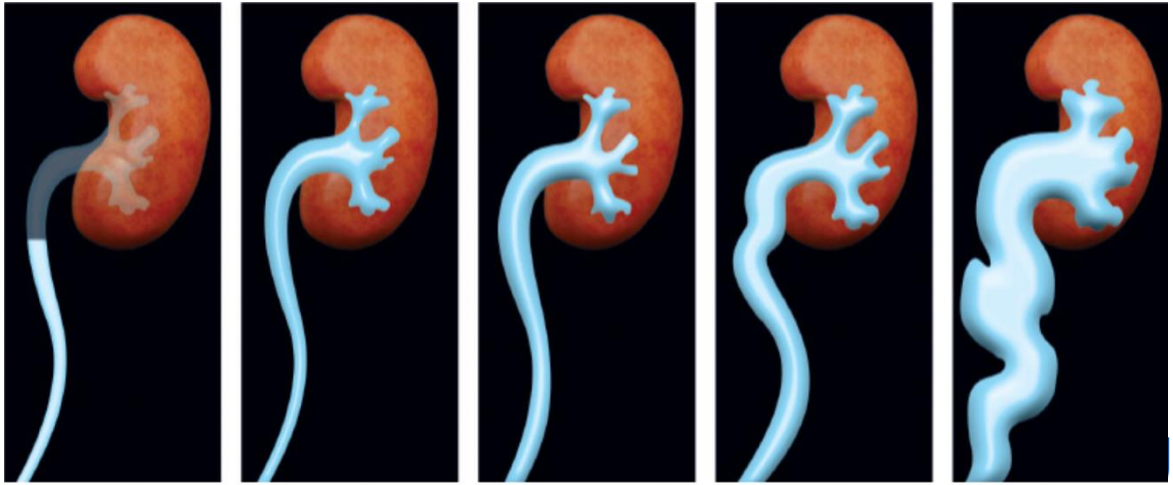


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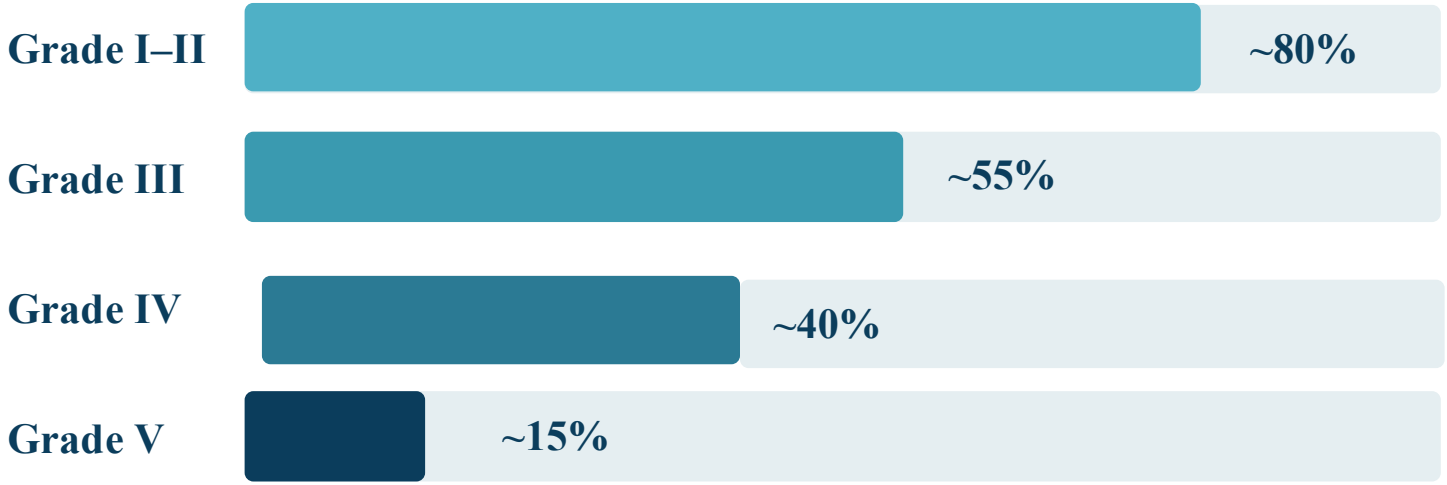
Reflux Grading

Grade I	Grade II	Grade III	Grade IV	Grade V
Non-dilating, low-grade	Non-dilating, \low-grade	Intermediate	Dilating, high-grade	Dilated, high-grade



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Most VUR resolves spontaneously…



Prediction of Resolution:

- Lower grade, unilateral reflux, younger age at diagnosis, normal bladder function
- Less likely: Bilateral high-grade reflux, untreated BBD

Duckett 1983, Arant 1992, Edwards et al 1977
Duckett 1983; McLorie et al 1990
Weiss 1992b, International Reflux Study in Children; Skoog et al 1987

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The Management Dilemma

- Wait for reflux to resolve
  - Most reflux resolves spontaneously
- Prevent infection while we wait
  - Febrile UTIs can scar kidneys
- Does prophylaxis actually work?
  - 1st line treatment (keep urine sterile)
- Whom do we treat while we wait?



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The real target: preventing renal scarring

2.8%	~26%	~29%
One febrile UTI	Second febrile UTI	≥3 febrile UTIs

Repeated febrile UTIs, not reflux itself, concern for acquired renal injury

Complications from renal scarring:

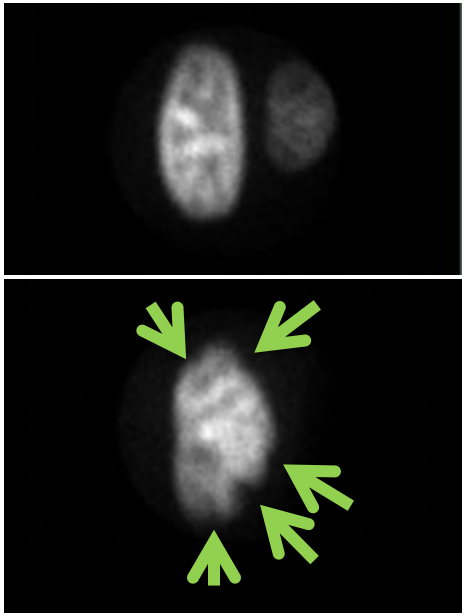
Hypertension
Proteinuria/CKD
Pregnancy complications

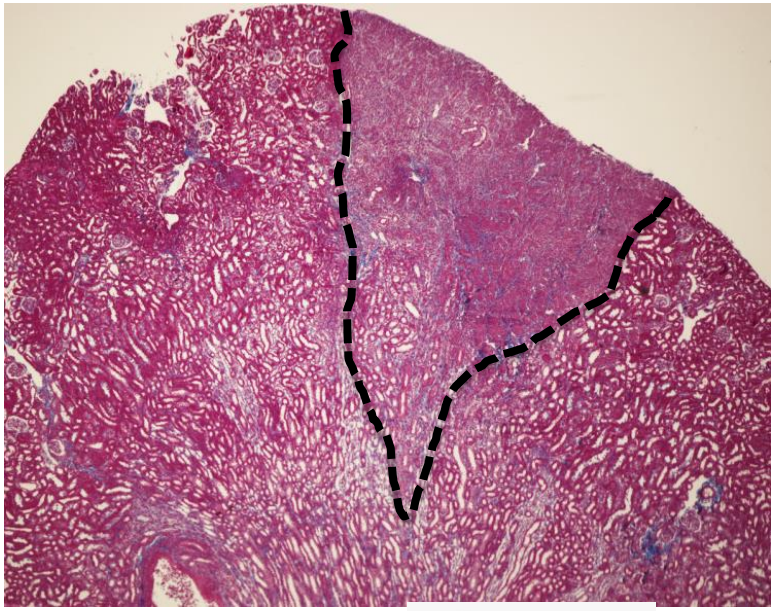
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What does renal scarring look like?

- Fibrous tissue replacing normal tissue destroyed by injury or disease





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Top-down vs Bottom-up: Two strategies

Bottom-up (traditional)

- **Finds reflux = more VCUGs**
- Ultrasound + VCUG in every child after febrile UTI
- Radiation, catheter

Top-down (selective)

- **Finds renal involvement = fewer VCUGs, more DMSAs**
- VCUG only if abnormal or recurrent febrile UTI
- Possible delay in identifying VUR
- Radiation (5-10x), no catheter

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Does prophylaxis work?

- Does it prevent recurrent febrile UTI?
- Does it prevent renal scarring?
- Does everyone benefit equally?
- 3 trials changed our thinking

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RIVUR: Does prophylaxis prevent recurrence?

Randomized, double-blind, placebo-controlled trial — 607 children, ages 2–71 months, with grade I–IV VUR after a first or second UTI; TMP-SMX (Bactrim) prophylaxis vs. placebo for 2 years, 19 U.S. centers

34/278 (12.2%)	**67/293 (22.9%)**	**~ 50%**	**No sig. diff.**
Recurrences on bactrim prophylaxis	Recurrences on placebo	Relative reduction in recurrent febrile UTI	In renal scarring between groups at 2 years

Bottom Line:

- ~ 50% relative reduction in recurrent UTI
- No significant reduction in renal scarring*
- More resistant breakthrough infections

Hoberman A, et al. NEJM 2014;370:2367–2376 (RIVUR Study Group)

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Swedish Reflux Trial (2010): A 3-arm comparison

Children ages 1 to <2 years with dilating (grade III–IV) VUR after a febrile UTI, randomized to: (1) antibiotic prophylaxis, (2) endoscopic injection (Dx/HA), or (3) surveillance only

GIRLS

- Both active treatments (prophy and endoscopic injection) significantly reduced recurrent febrile UTI compared with surveillance.
- Surveillance-arm girls also developed new renal damage more often on follow-up DMSA.
- **Dilating reflux benefited**

BOYS

- Recurrence rates were low across all three arms, with no significant benefit shown for active treatment over surveillance
- Boys in this age group resolved reflux and avoided recurrence at high rates regardless of assigned treatment.
- **Boys had low recurrence regardless**

Brandström P, et al. J Urol 2010;184:274–279 and companion papers (Swedish Reflux Trial Group)

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LANDMARK TRIAL 3 OF 3

PREDICT (2023)High-grade VUR: does prophylaxis matter more?

292 Infants 1 to 5 months of age with grade III-V VUR randomized to CAP vs not

POPULATION			
High-Risk VUR	**21.2% on CAP vs 35.6% placebo** UTI	Antibiotic resistance more common in CAP, more Pseudomonas species	**No sig. diff.** In renal scarring, GFR between groups at 2 years

Bottom Line:

- **Risk-stratified treatment**

Morello W, Baskin, et al. PREDICT Study Group. Antibiotic Prophylaxis in Infants with Grade III, IV, or V Vesicoureteral Reflux. N Engl J Med. 2023 Sep 14;389(11):

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High-grade VUR: does prophylaxis matter more?

Population → prophylaxis vs no prophylaxis → recurrent UTI result → renal scarring result → adverse/resistance tradeoff → bottom line.

RIVUR	Swedish	PREDICT
Prophylaxis works overall	Benefit differs by risk/sex	Higher-risk patients may derive greater benefit

Bottom Line: **Risk-stratified treatment**

Duployez C, Loïez C, Le Guern R. Antibiotic Prophylaxis for Grade III, IV, or V Vesicoureteral Reflux in Infants. N Engl J Med. 2024 Feb 8;390(6):577. doi: 10.1056/NEJMc2311879. PMID: 38324499.

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AUA guideline: Risk-stratified approach

Scenario	Preferred approach
Infant + febrile UTI + any grade VUR	Continuous antibiotic prophylaxis
Infant + high-grade VUR + NO UTI	CAP recommended
Infant + low grade + NO UTI	CAP optional; surveillance reasonable
Child > 1 yr, + BBD	Treat BBD; CAP recommended until BBD resolves
Child > 1 yr, + NO BBD,+ NO recurrent febrile UTI	CAP or surveillance — both acceptable
Breakthrough febrile UTI on CAP, or strong parental preference	Consider surgical correction (endoscopic or open reimplantation)

AUA Guideline: Management and Screening of Primary VUR in Children (2010, amended 2017, incorporating RIVUR)

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AUA guideline: Risk-stratified approach

Scenario	Preferred approach
Infant + febrile UTI + any grade	Continuous antibiotic
High-grade VUR	Continuous antibiotic
BBD + VUR	Treat BBD, CAP until BBD resolved

Breakthrough febrile UTI → reassess / consider intervention

AUA Guideline: Management and Screening of Primary VUR in Children (2010, amended 2017, incorporating RIVUR)

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Bowel & bladder dysfunction: Always Screen

Constipation → dysfunctional voiding → UTI → persistent VUR

Screen for it

- Stool frequency, size, and any withholding behaviors
- Voiding frequency, urgency, holding maneuvers (e.g., Vincent's curtsy)
- Daytime incontinence or straining to void
- Consider a validated symptom score

Treat it

- Aggressive constipation management (osmotic laxatives, timed toileting)
- Scheduled voiding, double voiding, adequate fluid intake
- Pelvic floor / biofeedback therapy for refractory dysfunctional voiding
- Why? - treating BBD improves spontaneous VUR resolution and surgical success rates

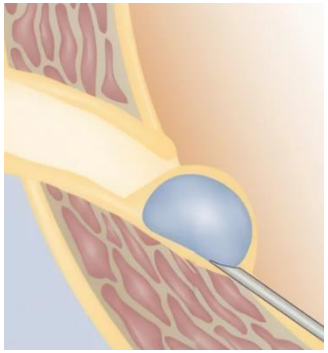
MOST MODIFIABLE RISK FACTOR

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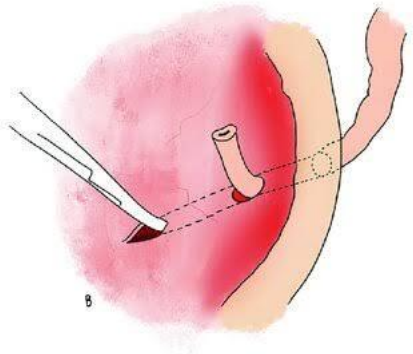
When conservative management isn't enough

- Endoscopic injection
  - Outpatient
  - Less invasive
  - Variable success by grade
- Ureteral reimplant
  - Highest definitive success
  - Open/robotic approaches









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WHEN TO REFER

Red flags for pediatric urology or nephrology referral

High-grade VUR (IV–V)	Urology
Abnormal renal ultrasound (hydronephrosis, scarring, duplication, obstruction)	Urology
Breakthrough febrile UTI while on antibiotic prophylaxis	Urology
Recurrent febrile UTI despite treated BBD	Urology
Known or suspected renal scarring on DMSA	Nephrology
Hypertension, proteinuria, or declining renal function	Nephrology
Atypical organism (Pseudomonas without catheter) or complicated anatomy	Urology
Male infant with recurrent febrile UTI (higher suspicion for anatomic anomaly)	Urology

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WHEN TO REFER

UROLOGY

- Abnormal/complex anatomy
- High-grade VUR*
- Recurrent/breakthrough febrile UTI
- Persistent issues despite BBD treatment
- Atypical organisms

NEPHROLOGY

- Renal scarring
- Hypertension
- Proteinuria
- Declining renal function

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AAP 2026 Updated UTI Guidelines

- New: **8 days – 5 years** (previously 2-24mos)
- Fever without a source: evaluate with **72 hours**
- Antibiotic duration: **≤ 7 days preferred** (previously 7-14days)
- **Oral antibiotics recommended;** hospitalization not required for most
- **Parenteral antibiotics initially age 8-28 days**; early transition to oral
- Urine collection dx: Same collection, **Pyuria + Culture**
- **RBUS after 1st febrile UTI** (Same)
- **VCUG** indications: **abnormal RBUS; 2nd febrile UTI**
- Continuous antibiotic prophylaxis: against routine use for low-risk VUR
- **Bowel-bladder dysfunction** – Major emphasis to treat

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KEY TAKEAWAYS

1. **Confirm the diagnosis:** pyuria + culture (MICRO UA!); no bag
2. **Start with RBUS:** use VCUG for recurrence or abnormal findings
3. **VUR often resolves:** grade, age, and bladder function predict outcomes
4. **Reduce febrile recurrence:** consider prophylaxis for higher-risk children and treat BBD
5. **Refer when needed:** high-grade reflux, breakthrough infection, or renal injury

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AUA Guidelines - 2017

AAP 2026 Guidelines

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Questions?



When in doubt,
call pediatric urology

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