



- a. Radionuclide cystography or contrast-enhanced voiding urosonography may be alternative to MCU in initial assessment of girls or follow up studies (see Remarks)
- b. Definition of atypical UTI: poor response to antibiotics within 48 hours, poor urine stream, sepsis, raised creatinine, non E-coli UTI
- c. Definition of recurrent UTI: two or more acute pyelonephritis / upper urinary tract infection, OR one acute pyelonephritis / upper urinary tract infection plus one or more cystitis / lower urinary tract infection, OR three or more cystitis / lower urinary tract infection
- d. In atypical / recurrent UTI, NICE guideline 2016 reserves MCU in child < 6months or child between 6 months to 3 years with the following:
 - Dilatation on US
 - Poor urine flow
 - Non E-coli infection
 - Family history of VUR

REMARKS

Imaging protocol of febrile urinary tract infection (UTI) in children

UTI is a frequent indication for imaging evaluation of paediatric urinary tract. The goal of all imaging has been to improve outcome and prevent end-stage renal failure due to scarring from late diagnosis and inadequate treatment.¹

Imaging approach of UTI in children younger than 2 months may need to be more aggressive, as there is limited research on this age group and neonates with UTI have a high incidence of renal anomalies and are more likely to be complicated with sepsis.²

US of kidneys and bladder is usually appropriate² and it is recommended in National Institute for Health and Care Excellence (NICE) guideline.³ Micturating cystourethrography (MCU) may be appropriate and can be considered in boys and in presence of sonographic abnormality. Radionuclide cystography may be appropriate and can be considered in girls.² Contrast-enhanced Voiding Urosonography (ceVUS) is a valid and radiation-free alternative examination for MCU and radionuclide cystography.^{1,4}

American Academy of Pediatrics (AAP) 2011 guidelines recommends US for all children between ages of 2 months and 2 years after first episode of UTI.^{3,5} AAP 2011 recommends that MCU is indicated if US reveals hydronephrosis, scarring or other findings that would suggest high grade vesicoureteric reflux (VUR) or obstructive uropathy or in other atypical and complex clinical circumstances. It should also be performed for recurrent UTI.⁵ NICE 2007 recommends that MCU should be considered if several clinical and imaging features are present. Guideline from Italian group recommends MCU for patients with abnormal US findings, risk factors or recurrent UTI.⁶

Risk factors are derived from NICE 2016, American College of Radiology (ACR) Appropriateness Guideline and Italian Guideline^{2,3,6}:

- First degree relative with VUR
- Septicemia
- Urinary retention
- Poor urine stream
- Raised creatinine
- No or poor response to antibiotics treatment within 48 hours
- Bacteria other than E. Coli

NICE 2016 defined Recurrent UTI as follows:³

- 2 or more episodes of UTI with acute pyelonephritis / upper urinary tract infection, or
- 1 episode of UTI with acute pyelonephritis / upper urinary tract infection plus one or more episode of UTI with cystitis / lower urinary tract infection, or
- 3 or more episodes of UTI with cystitis / lower urinary tract infection

Renal cortical scintigraphy (with dimercaptosuccinic acid [DMSA]) in six months is recommended in patient with high risk factors, recurrent UTI, abnormal US or VUR shown to evaluate for renal parenchymal defects and relative renal function.^{3,6}

1 MCU

The main role of MCU is to detect VUR. Patient with high grade VUR (grade 3-5) are more likely to have recurrent UTI and scarring.² It can also detect obstructive anomalies, such as posterior urethral valves or ectopic ureterocele.

2 US

US can detect urinary tract anomalies such as hydronephrosis, duplex renal system, hydroureter and ureterocele. Sensitivity of US for detecting VUR and renal scarring is low.²

3 Nuclear medicine

3.1 Renal cortical scintigraphy

Renal cortical scintigraphy with DMSA has greater sensitivity for detection of acute pyelonephritis and renal scarring than does either US or MCU. The findings on nuclear scans rarely affect acute clinical management. Hence, it is not recommended as part of routine evaluation of infants with their first febrile UTI.⁵ It is recommended 6 months after the febrile UTI to obtain a morphological and functional evaluation of the renal parenchyma.⁶

3.2 Radionuclide cystography (RNC)

Direct RNC is comparable in sensitivity to MCU in detecting VUR. RNC has a lower absorbed radiation dose than MCU but it does not have the spatial resolution needed to identify anatomical abnormalities of urethra, bladder and ureters. Initial evaluation of VUR in girls and follow-up studies may be done by RNC.²

4 Contrast-enhanced voiding urosonography (ceVUS)

ceVUS is an ultrasound-based reflux examination, involving intravesical instillation of ultrasound contrast and continuous alternative sonographic examination of the kidneys, bladder and urethra. It has been applied in Europe for two decades. The procedure is similar to MCU except the replacement with ultrasound contrast and sonographic examination.⁴ ceVUS has been considered as a safe, reliable, radiation-free and valid alternative to MCU or RNC, and has a higher reflux detection rate than MCU due to stability of ultrasound contrast microbubbles, advances in ultrasound technology, and longer examination time.^{1,7} The currently used stabilized ultrasound contrast agent has been approved in paediatric use by the U.S. Food and Drug Administration in 2016, though the intravesical application in ceVUS is still off-label.⁸

ceVUS can be considered as an alternative to MCU in the following conditions:

4.1 First examination for vesicoureteric reflux in girls

4.2 Follow up examination for vesicoureteric reflux in boys and girls after conservative or surgical treatment

4.3 Screening high-risk patients for vesicoureteric reflux

Application of ceVUS in male urethral assessment is feasible and accurate,⁸⁻⁹ and expanded use of ceVUS in first examination in boys will be further validated.

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