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Imaging in Children with Febrile Urinary Tract Infections

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Abstract

Urinary tract infection (UTI) is most common bacterial infection in childhood, and it may be the first symptom of congenital anomaly of the kidneys and urinary tract (CAKUT) in 30% of children. Prompt diagnosis and treatment are important for the prevention of acute complications as well as renal scarring. In the last 2 decades, a significant amount of research has been done on UTI in children, particularly on renal imaging.The best approach to imaging of a child with febrile urinary tract infection (UTI) is highly debatable. Use of imaging to check for abnormalities or complications therefore needs to be targeted carefully. Renal-bladder ultrasound (RBUS), a micturating cystourethrogram (MCUG) and renal dimercapto-succinic acid (DMSA) scintigraphy are the most commonly used imaging methods.

Because a renal and bladder ultrasound (RBUS) is noninvasive and may evaluate urinary tract anomalies, including obstruction, renal structural anomalies, nephrolithiasis or calcification, or an abdominal mass, should be initially ordered study in children with UTI. RBUS is a less sensitive imaging modality for the diagnosis of VUR, and normal RBUS does not rule out high-grade VUR.

Obtaining a MCUG with first UTI in all male patients, females younger than 3 years, children clinically suspected of having pyelonephritis, and those with US abnormalities has been recommended (”bottom-up” approach).

Due to the risks and cost of the MCUG test, as well as its low yield (<10%) for clinically significant (ie, high-grade) VUR, many have advocated obtaining MCUG selectively.

Another approach to imaging is the so-called “top-down” approach, where DMSA cortical renal scintigraphy is obtained after initially US. It is proposed that 50% of MCUG could be avoided by reserving the study for patients with demonstrated renal injury.

A normal renal scintigraphy allows to safely dismiss the child without programming further investigation(s) as outpatient. On the contrary, in case of true acute pyelonephritis, investigation for VUR can be scheduled without waiting for a relapse.

Keywords: Imaging; Children; Urinary Tract Infection

Introduction

Urinary tract infection (UTI) is most common bacterial infection in childhood, and it may be the first symptom of congenital anomaly of the kidneys and urinary tract (CAKUT) in 30% of children [1]. The incidence of UTI in children in the first year of life in the United States is 2.15% in febrile boys and 2.05% in females. [2]. An estimated 8% of girls and 2% of boys will have at least one episode by seven years of age. Of these children, 12–30% will experience recurrence within one year [3]. Among infants presenting with fever the overall prevalence of UTI was 7.0% [4].

Approximately 85% to 90% of UTIs are caused by Escherichia coli. Other common organisms include Klebsiella, Proteus, Enterococcus, and Enterobacter species. Organisms such as Pseudomonas, group B Streptococcus, and Staphylococcus aureus are usually associated with CAKUT, genitourinary surgery, a foreign body (eg, catheter), or recent antibiotic treatment, whereas infection with urea-splitting organisms (eg, Proteus) is associated with stone formation [5-7].

Prompt diagnosis and treatment are important for the prevention of acute complications as well as renal scarring. A number of risk factors are associated with acquired renal scarring due to acute pyelonephritis (APN). The risk of „scarring“ (permanent renal parenchymal damage) is doubled in those with either an abnormal renal ultrasonographic finding or with both a fever of 39°C or above, a causative organism other than Escherichia coli. (Proteus, Enterococcus, Pseudomonas, Klebsiella Staphilococcus aureus and Staphilococcus epidermis in small children), a high grade of vesico-urethral reflux (VUR), particularly grades 4 and 5, and recurrent UTI [8,9]. Renal scarring is the most significant risk factor for breakthrough UTI in primary VUR patients and could be used to determine those at risk of symptomatic VUR persistence [8]. Scars may occur from primary renal damage in utero, e.g. prior obstruction or developmental factors that precedes the urinary tract infection, but scars may also develop following the infection [10]. In developed countries, kidney damage with long-term complications as a consequence of UTI has become less common than it was in the early 20th century, when pyelonephritis was a frequent cause of hypertension and end-stage renal disease in young women. Currently, these complications are most commonly encountered in infants with congenital renal damage [11,12].

Imaging

Renal-Blader Ultrasonography (RBUS)

Because a renal and bladder ultrasound (RBUS) is noninvasive and may evaluate urinary tract anomalies, including obstruction, renal structural anomalies, nephrolithiasis or calcification, or an abdominal mass, should be initially ordered study in children with UTI [13]. RBUS is a less sensitive imaging modality for the diagnosis of VUR, and normal RBUS does not rule out high-grade VUR. Particular findings on RBUS that may indicate a higher probability of VUR include ureteral dilatation, renal parenchymal changes, and bladder abnormalities. RBUS cannot be used to accurately diagnose patients with APN or renal scarring. [13]. The American Academy of Pediatrics (AAP) guidelines recommend RBUS be performed in all infants (2–24 months) with febrile UTI [14]. Older children with recurrent UTIs may also benefit from an RBUS. The RBUS can be deferred until after resolution of the UTI but should be considered during the acute episode if the illness seems unusually severe or if high fevers persist beyond 48 to 72 hours of treatment [14].

Regarding the choice for imaging, after initial RBUS, no uniform opinions have been relayed on the order of MCUG or DMSA renal scintigraphy. Two approaches are recommended for the diagnosis of VUR: the bottom-up method (MCUG and, if positive, a DMSA scan) or the top-down method (DMSA scan and, if positive, MCUG) [15].

Micturating Cystourethrography (MCUG)

The assumption that recurrent UTIs in patients with VUR lead to renal scarring and consecutive chronic kidney disease had been the indication for accurate diagnosis and specific treatment of VUR. Obtaining a micturating cystourethrogram (MCUG) with

first UTI in all male patients, females younger than 3 years, children clinically suspected of having pyelonephritis, and those with US abnormalities has been recommended ("bottom-up" approach). Infants < 2 months of age admitted for first UTI are at risk for grade 3-5 VUR and thus should undergo a voiding cistourethrography if their RBUS is abnormal or if they have Pseudomonas UTI. Avoiding MCUG can be considered in afebrile infants and infants with BNP< 53%, or NLR>1.65 [16]. Because of the risks and cost of the MCUG test and radiation burden (from 0.5 – 3.2 mSv depending on technique), as well as its low yield for clinically significant (ie, high-grade) VUR, obtaining MCUGs should be selectively. Part of the reason for this is that less than one-third of children with their first UTI have VUR, and of these, fewer than 10% have grade 4 to 5 VUR [17,19]. Positive MCUG increases the probability of renal damage by about 15%, while the negative MCUG reduces the probability of renal damage by only 9% [20]. A MCUG should be considered after first UTI in children with abnormal RBUS, family history of VUR or CAKUT, atypical causative pathogen, complex clinical course, or known renal scarring [20-24]. The interobserver variability in VUR grading must be kept in mind while making clinical decisions [25].

Renal Cortical Scintigraphy with Technetium 99m-Dimercaptosuccinic Acid (DMSA)

Another approach to imaging is the so-called "top-down" approach, where cortical renal scintigraphy with technetium 99m-dimercaptosuccinic acid (DMSA) is obtained after initially US. This approach focuses on identification of renal scarring, the long-term adverse effect that we are hoping to avoid, regardless of whether reflux is present or not. The incidence of abnormal findings was significantly higher in children with UTI and VUR than in those with UTI without VUR [26]. Damage to the kidney tissue, which was previously attributed to UTIs or reflux nephropathy, can to be congenital in nature. DMSA scan is the current gold standard for assessment of renal parenchymal injury in a child with a history of febrile UTI. It is more sensitive for renal scarring than RBUS, which misses a substantial proportion of such cases [27-29]. DMSA cannot differentiate acquired scarring from ante-natal dysplasia

A normal cortical renal scintigraphy allows to safely dismiss the child without programming further investigation(s) as outpatient. On the contrary, in case of true acute pyelonephritis, investigation for VUR can be scheduled without waiting for a relapse. Findings of renal scarring may influence surgical decision-making in patients with surgically correctable conditions (eg, VUR). Cortical defects on DMSA scan performed during or shortly after APN may be due to preexisting lesions (either acquired or congenital) or to the acute inflammatory reaction associated with APN. A delayed DMSA scan at 4 to 6 months allows the acute inflammatory reaction to subside, at which point any persistent cortical defects can be assumed to represent permanent renal scarring, although in the absence of baseline (pre-APN) scans, it may still be difficult to differentiate acquired from congenital lesions. DMSA could play an important role in selecting children with UTI/VUR who would benefit from close monitoring and/or early intervention [30].

Discussion

Urinary tract infection (UTI) is most common bacterial infection in childhood. Prompt diagnosis and treatment are important for the prevention of acute complications as well as renal scarring. In the last 2 decades, a significant amount of research has been done on UTI in children, particularly on renal imaging. Aim of imaging is to identify risk factors and abnormalities that can be modified, to decrease likelihood of recurrent UTI and to reduce risk of complications, renal scarring on the first place. Use of imaging to check for abnormalities or complications needs to be targeted carefully. Lack of consensus in imaging evaluation depends mainly on the following reasons: the poor correlation between the severity of UTI and the presence or absence of VUR, the debated role of VUR in the appearance of renal scars, the trend of VUR to spontaneously resolve, the psychological stress and radiation of imaging, and the unclear yield of the tests in improving the long term health of patients [30]. An aggressive protocol has a high sensitivity for detecting abnormalities, which in some cases could be of questionable benefit to the infants, and it is burdened with high financial and radiation costs. There was still a lack of sufficient data to formulate coherent, unequivocal guidelines on UTI management in children, with imaging tests remaining the main area controversy [31].

Conclusion

The need for imaging in children with febrile UTI is discussed in search of a balance between reducing hospitalization, cost and radiation burden without risk of missing any renal deterioration. RBUS is indicated in all patients less than two years of age, or present with atypical or recurrent UTI. Regarding the choice for imaging, after initial RBUS, no uniform opinions have been relayed on the order of MCUG or DMSA renal scintigraphy. Two approaches are recommended for the diagnosis of VUR: the bottom-up method (MCUG and, if positive, a DMSA scan) or the top-down method (DMSA scan and, if positive, MCUG). In patients with recurrent infection DMSA scintigraphy should be performed 4-6 months after UTI. Despite all concerns and different approaches and interests, an agreement was reached about reducing the number of imaging in children with UTI.

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