

# Acute focal bacterial nephritis, pyonephrosis and renal abscess in children

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## Abstract

**Background-Aim** Acute focal bacterial nephritis (AFBN), renal abscess and pyonephrosis are uncommon and not fully addressed forms of urinary tract infection (UTI) which may be underdiagnosed without the appropriate imaging studies. Here, we review the characteristics and outcome of these renal entities in children managed at a single medical centre.

**Patients and Methods** The medical files of all children hospitalized for episodes of AFBN, renal abscess and pyonephrosis during a 10-year period (2003–2012) were reviewed.

**Results** Among the 602 children hospitalized for UTI, 21 presented with AFBN, one with abscess and three with pyonephrosis. All 25 children (13 girls), ranging in age from 0.06 to 13.4 years, were admitted with fever and an impaired clinical condition, and 18 had urological abnormalities. More than one lesion, often of different types, were identified in 11 episodes. Urine cultures from 13 episodes grew non-*Escherichia coli* pathogens and those from two episodes were negative. Antibiotics were administered for 14–60 days, and emergency surgery was required in three cases. During follow-up, 13 patients underwent corrective surgery. Permanent renal lesions were identified in 16 patients.

**Conclusions** AFBN, renal abscess and pyonephrosis should be suspected in children with severe presentation and

urological history. Appropriate imaging is crucial for management planning. Prognosis is often guarded despite appropriate treatment. Based on the results of this study we propose a management algorithm.

**Keywords** Acute focal bacterial nephritis · Pyonephrosis · Renal abscess · Magnetic resonance urography · Non-*E. coli* pathogens

## Introduction

Urinary tract infection (UTI), a common clinical problem in infants and children, usually runs an uncomplicated course but has the potential of severe manifestations and long-term sequelae [1]. The severity of UTI depends on diverse factors, including urinary tract malformations, pathogen–host interactions and promptness of management [2, 3]. Febrile UTI usually takes the form of pyelonephritis. The more serious forms, including acute focal bacterial nephritis (AFBN), renal abscess and pyonephrosis, are uncommon and may be clinically indistinguishable from pyelonephritis, or may mimic abdominal inflammatory processes or even tumours [4–6]. Timely diagnosis is important, as longer antibiotic treatment and occasionally surgery are required [5–7].

Progress in imaging has greatly facilitated the diagnosis of these entities. However, ultrasound (US) has a low sensitivity for renal lesions and, consequently, more sensitive modalities, such as computed tomography (CT) or scintigraphy, are often required for an accurate diagnosis [8–10]. Magnetic resonance urography (MRU) has recently emerged as a technique which enables noninvasive evaluation of many abnormalities of the urinary tract, providing combined structural and functional information; such attributes have led to claims that it is the most powerful diagnostic tool currently available [11].

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These improvements in imaging techniques have resulted in an increasing number of AFBN cases being recognised, suggesting that AFBN is not as unusual as previously considered [12–21]. AFBN is a localised, bacterial, inflammatory renal mass without liquefaction which affects one or more renal lobules; it is regarded as the midpoint between pyelonephritis and renal abscess [8]. Renal abscess is better defined as a focal, walled-off purulent parenchymal cavity, but it remains a diagnostic challenge due to diverse origins of infection and different pathogenetic mechanisms among patients, such as complicating UTI arising from haematogenous spread, or staphylococcal carbuncle in rare cases of proximity to an infected area [5, 10]. Information on pyonephrosis remains more scanty and is based mainly on case reports [6, 22].

As policies for UTI management have recently called for a radical reduction in the use of imaging for clinical purposes [23] and/or the limitation of imaging mainly to US [24], the forms of UTI described above may be underdiagnosed. In this study we report our clinical experience with children with AFBN, renal abscess and pyonephrosis in a referral centre over a 10-year period, focusing on the distinct clinical, laboratory and imaging characteristics. Based on our results, we propose a management algorithm.

## Patients and methods

**Patients** We reviewed the medical records of all children hospitalized with UTI in the Department of Pediatrics, Heraklion University Hospital during the 10-year period (January 2003 to December 2012), looking for severe, complicated forms of infection. Heraklion University Hospital is the referral centre for the island of Crete, with a coverage population of 105,000 children aged <15 years. All medical records of children with AFBN, renal abscess and pyonephrosis were retrieved, and the clinical, laboratory, imaging and follow-up information were recorded. All children had a complete workup with urine and blood culture before treatment was initiated and also underwent US investigation of kidneys and bladder within 3 days of admission. Both investigations are in accordance with our Department's policy for inpatient UTI management, which includes an acute phase US for every child sick enough to require hospitalization for a UTI. The decision for further imaging during hospitalization was based on US findings of focal hyperechogenic or hypoechogenic renal lesions, unilateral or bilateral nephromegaly or inconclusive abnormal findings and/or complicated clinical course, i.e. no improvement after 72 h on antibiotics. MRU was preferred over CT when available to avoid exposure to radiation.

**Definitions** Abnormal urinalysis was defined as positive leucocyte esterase and/or nitrites or a leucocyte count of  $>10$  per high power field. Positive urine cultures were defined as any

bacterial growth in specimens obtained by suprapubic aspiration, isolation of  $\geq 10^4$  colony-forming units (CFU)/ml of a single organism in specimens obtained by transurethral catheterization or the isolation of  $>10^5$  CFU/ml of a single organism in mid-stream specimens. The diagnosis of AFBN, renal abscess and pyonephrosis was based on US and/or CT/MRU findings [7, 16, 18, 19].

**Follow-up** All but two cases involved children with complicated UTI who underwent voiding cystourethrography (VCUG) and dimercaptosuccinic acid (DMSA) scan on average 4 weeks and 6 months, respectively, after the acute episode. Repeat US was performed on demand for each case during hospitalization and in all patients before discharge and at 1 and 3 months thereafter. All children were followed-up in the hospital's paediatric nephrology outpatient clinic.

**Statistics** Children with and without underlying conditions were compared for a number of variables, including age, microbiology, clinical presentation and course and laboratory indexes, using the chi-square test for categorical variables and either the *t* test or the Mann–Whitney test for numerical variables, with 0.05 as the cut-off for statistical significance.

## Results

**Frequency** From a total of 683 episodes of UTI in 602 children, 23 episodes of AFBN (3.4 %) were identified in 21 children; one child presented with 3 distinct episodes (Patient 9; Table 1). Isolated renal abscess was observed in a single child (patient 22) and was of ascending origin, while in 2 children (patients 20 and 21) AFBN progressed to abscess. Pyonephrosis was observed in three children and coexisted with AFBN in an additional three children (patients 1, 3 and 12). Thus, AFBN coexisted with either pyonephrosis or abscess in five of the 21 children (23.8 %) diagnosed with AFBN. No other forms of complicated UTI, such as carbuncles or xanthogranulomatous pyelonephritis, were identified.

**Clinical presentation** The children included in the study ranged in age from 0.06 to 13.4 (median 4.9) years. All presented with an impaired condition and high temperature ( $\geq 39^\circ\text{C}$  in 20/27 episodes) of 1 h to 12 days (average 56 h) duration prior to admission. In 11 episodes, the diagnosis at admission was not UTI, including appendicitis (patients 3, 9a and 17), gastroenteritis (patients 2 and 9c), renal tumour (patients 5 and 20), meningitis (patients 10 and 13) and renal stone (patient 21). A urological history was recalled in 15 children (Table 1), of whom 12 were on antibiotic prophylaxis. With the exception of two (patients 12 and 25) with chronic renal failure, chronic diseases were not reported.

**Table 1** Demographics, history, presentation, and outcome of the 25 children with acute focal bacterial nephritis, renal abscess and pyonephrosis

Patient/case	Gender, age (years)	Diagnosis	Urological conditions	Outcome
1	Male, 1.1	AFBN + pyonephrosis	VUR (grade V left, grade III right)	Surgical VUR correction
2	Female, 2.6	AFBN	No	Recurrent UTI
3	Male, 2.0	AFBN + pyonephrosis	VUR (V right), solitary kidney	Surgical VUR correction
4	Female, 4.9	AFBN + pyelonephritis	VUR (IV right, III left)	Surgical VUR correction
5	Male, 1.0	AFBN + pyelonephritis	VUR (III left)	VUR management
6	Male, 12.1	AFBN	UTI in infancy	BBD management
7	Female, 12.5	AFBN + pyelonephritis	No	BBD management
8	Female, 6.6	AFBN	VUR (II right)	VUR management
9a	Female, 4.4	AFBN	VUR (III left)	Surgical VUR correction
9b	Female, 4.5	AFBN	VUR (III left)	Surgical VUR correction
9c	Female, 4.8	AFBN + pyelonephritis	VUR (III left)	Surgical VUR correction
10	Male, 0.3	AFBN	Hydronephrosis (VUR IV right)	VUR management
11	Male, 6.1	AFBN	VUR (IV right, IV left), urethral diverticulum, hypospadias	Urethral diverticulotomy/reconstruction
12	Female, 4.2	AFBN + pyonephrosis	VUR (V right); neurogenic bladder	CRF, catheterisation
13	Female, 0.2	AFBN	VUR (V right, III left), duplication	Surgical VUR correction
14	Female, 9.8	AFBN	Renal transplant, bladder augmentation	Catheterisation
15	Female, 13.4	AFBN	Ectopic urethra	Recurrent UTI
16	Female, 0.7	AFBN + pyelonephritis	No	Recurrent UTI
17	Male, 6.4	AFBN	UTI in infancy	BBD management
18	Female, 7.1	AFBN multiple	VUR (IV left, IV right)	Surgical VUR correction
19	Male, 5.2	AFBN	VUR (V left, V right)	Surgical VUR correction
20	Female, 1.0	AFBN + abscess	VUR (III left, III right)	VUR management
21	Male, 6.8	AFBN + abscess	No, diagnosed with hypercalciuria	Hypercalciuria management
22	Male, 0.6	Abscesses	Duplication, upper obstructive megaureter	Acute drainage, later semi-nephrectomy
23	Male, 0.06	Pyonephrosis	Antenatal hydronephrosis, duplication, VUR (II left)	Acute nephrectomy, later surgical VUR correction
24	Female, 0.1	Pyonephrosis	Duplication, megaureter, ectopic orifice	Spontaneous drainage, later semi-nephrectomy
25	Male, 7.2	Pyonephrosis	Valve bladder, hydronephrosis	Acute drainage, later ureter reimplantation, CRF

AFBN, Acute focal bacterial nephritis; BBD, bladder and bowel dysfunction; CRF, chronic renal failure; UTI, urinary tract infection; VUR, vesicoureteral reflux

**Laboratory findings** Laboratory findings on admission included leucocytosis (range 5,200–31,360, median 17,300 white blood cells/mm<sup>3</sup>), elevated erythrocyte sedimentation rate (range 13–140, median 68 mm/h) and C-reactive protein (range 2.21–41.2, median 15.4 mg/dL). A reversible increase of creatinine was observed in 15 episodes, as well as in the two children with chronic renal failure. Abnormal urinalysis was found in 16 episodes, and urine cultures grew *Escherichia coli* in 12 episodes, *Pseudomonas aeruginosa* in eight episodes, *Klebsiella pneumoniae* in three episodes and *Proteus mirabilis* and *P. stuartii* in one episode each; the cultures were sterile in the two recurrent episodes of patient 9. Blood cultures were positive in one child with AFBN (patient 13) and in all three cases of pyonephrosis (patients 23, 24 and 25); all of these grew *P. aeruginosa*, the same isolates as identified in

these patients' urine cultures. Three of the youngest patients (patients 10, 13 and 23) had cerebrospinal fluid pleocytosis (32, 23, and 15 white cells/mm<sup>3</sup>, respectively).

**Diagnosis** Renal US identified the type of lesion in 17/27 episodes, revealed non-specific findings of nephromegaly and/or increased parenchymal echogenicity in seven episodes, was inconclusive in one episode and was falsely negative in two episodes. In 20 and five episodes the diagnosis was confirmed by MRU and CT, respectively, both of which were performed within the first week of admission. The decision for MRU/CT was based on fever persistence while under treatment (14 episodes), suspicion of complicated anatomy (5 episodes) and inconclusive US imaging (6 episodes); US imaging was sufficiently diagnostic in the remaining two episodes.

**Treatment** All children received intravenous antibiotics for 6–52 (median 13) days and completed their course with oral medication for a total of 14–60 (median 21) days. The switch to oral treatment was guided by deferescence, improvement of inflammatory indexes and repeat US findings. Fever subsided after a median time of 48 h (range 12 h to 5 days) from treatment onset. Fever subsided in two children (patients 22 and 25) following surgical drainage on the fifth and third day after hospitalization, respectively, and in one patient (patient 24) after spontaneous drainage from an ectopic orifice on the fourth day after hospitalization. Patient 25 was severely septic and hypotensive and remained in the Intensive Care Unit for 5 days. A male neonate (patient 23) underwent nephrectomy of the affected kidney due to persistent bacteraemia, despite appropriate antibiotic treatment for 1 month. A 4.5-year-old girl (patient 9), with left side grade III vesicoureteral reflux (VUR), was readmitted with new AFBN episodes within 6 months of the initial one, despite complete resolution of the initial lesion and administration of prophylaxis.

**Further imaging** Voiding cystourethrography was performed on 23 patients and revealed VUR in 14 patients (VUR grades III–V in 12 patients, bilateral in 7 patients; Table 1), with seven being newly diagnosed. Two adolescents were not investigated (patients 6 and 7), but one of these had tested negative for VCUG in infancy. All children had a DMSA scan 6 months after admission; parenchymal defects were identified in 23 of these children, and these defects persisted on the subsequent DMSA scans of 16 of them.

Children with underlying urological conditions ( $n=18$ ) differed from those with normal urinary tracts ( $n=7$ ) in age of presentation (median ages 3.1 and 6.7 years, respectively;  $p=0.04$ ) and microbiology (non-*E.coli* pathogens 0/7 and 11/18, respectively;  $p=0.009$ ). No other differences were identified.

**Outcome** Children were followed-up for 0.9–10 (median 3.5) years. Surgical VUR correction was required for eight children with high-grade VUR and recurrent infection. Corrective surgery was required for an additional two children with duplication and obstructive upper moiety (semi-nephrectomy on affected side): a boy with hypospadias and urethral diverticulum (urethral diverticulotomy and reconstruction) and a boy with acute ureterostomies (sequential ureteral re-implantation). The remaining 13 children with AFBN were medically managed—five for mild VUR, three for unspecified bladder dysfunction, one for hypercalciuria and four for recurrent mild UTI. One of the latter children, who had a renal graft and an augmented bladder, had a favourable course with self-catheterization.

## Discussion

Acute focal bacterial nephritis, renal abscess and pyonephrosis, once considered to be unusual manifestations in children, are being increasingly reported due to improvements in the sensitivity of imaging techniques that enables them to be visualised [17]. The exact frequency of these three clinical entities is not known, and our literature search failed to identify studies that included the whole spectrum of severe UTI. In our paediatric patient population, AFBN, renal abscess and pyonephrosis were identified in nearly 4 % of children hospitalized for UTI, which is in accordance to the rates of AFBN reported from the USA, Germany and Israel [17–19], whereas studies from Taiwan have reported AFBN rates of 8–10 % [21, 25]. Most of the reported episodes occurred in children beyond infancy with a previous urological history. Initial presentation often mimicked other febrile conditions and resulted in diagnostic delays [5, 16, 18, 19, 22].

Multiple lesions and the co-existence of different types of lesions were found in nearly half of our patients. Cheng et al. found that abscess was accompanied by either AFBN or pyelonephritis in all of the paediatric patients included in their study [10] and suggested that this co-existence argues against the concept that AFBN is the midpoint between pyelonephritis and abscess [26]. We rather believe that the renal infectious process takes the form of a continuum from pyelonephritis to abscess of ascending origin and xanthogranulomatous pyelonephritis, with the different forms of the same process possibly associated with urinary tract anatomy, renal vascular bed, bacterial properties or host response to infection. Pyonephrosis is also included in the same inflammatory spectrum in obstructive or dilated collecting systems, as it was noted in both of our patients with obstructive malformations and in those children with dilated VUR and AFBN. These latter cases, representing infected hydronephrosis rather than pure pyonephrosis, can be considered as a stage of the infectious process in the presence of severe dilatation and probably intrarenal reflux, as was the case in two of our patients.

The bacterial spectrum of AFBN and of renal abscess of ascending origin does not differ from that of other forms of UTI [6, 7, 10, 18–20, 23, 27]. In accordance with the findings reported in a study from Germany that included children with acute focal bacterial nephritis [19], we also found that non-*E. coli* pathogens prevailed in our patients, probably due to the inclusion of pyonephrosis cases, which were all due to *P. aeruginosa*, and to high rates of urinary malformations and prophylaxis [3, 28]. In our study, urine cultures were sterile in two AFBN episodes, despite abnormal urinalysis, as has already been reported but not adequately explained in earlier studies [9, 16, 18, 19]. Haematogenous spread of infection could be a potential mechanism in these cases.

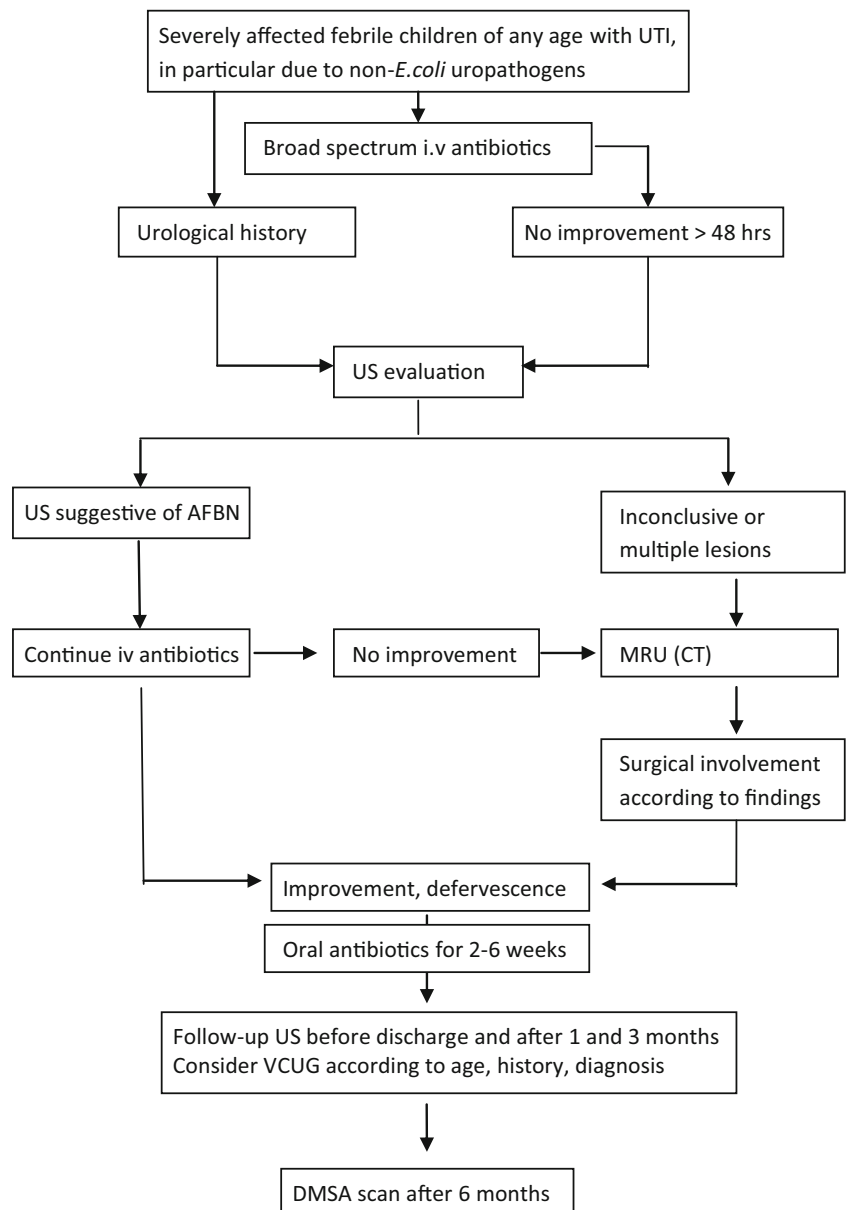
Acute phase renal US can provide diagnostic help, but less extensive lesions may be missed [8]. In our paediatric

patient population, 17 cases had suggestive US presentation, including all of the pyonephrosis cases, and seven additional cases had non-specific findings. CT is considered to be the most sensitive and specific diagnostic method for imaging parenchymal and suppurative renal lesions [4, 5, 10, 18]. To our knowledge, MRU is not yet routinely used for the diagnosis of AFBN, abscess and pyonephrosis in medical institutions but in our experience it provides accurate information on the type of renal lesions and underlying urological abnormalities that can guide early or late surgery decisions.

The administration of intravenous antimicrobials until 2–3 days of defervescence and a total treatment duration of at least 2 weeks are generally recommended in AFBN [4, 7, 16–18]. Our experience with AFBN suggests at least 1 week

of intravenous treatment and a total antibiotic course of 3 weeks. Abscesses often require drainage, but medical management alone might be sufficient, as was the case for two of our patients [5, 10]. Antibiotic treatment for 4 weeks is required in any case [5, 10]. Nephrectomy is exceptional as a treatment for pyonephrosis; however drainage is unavoidable in most cases [22]. All of our children with pyonephrosis and the one patient with renal/perirenal abscess required corrective surgery after the acute phase. High rates of renal scarring despite antibiotic treatment have been reported in children with AFBN, and this was also the case in 16/25 of our patients, in whom persistent parenchymal defects corresponding with the acute site of infection were identified [21]. Because most of our patients had pre-existing urological abnormalities, the possibility of congenital lesions cannot be

**Fig. 1** Management algorithm for children with complicated urinary tract infection (UTI). AFBN Acute focal bacterial nephritis, CT computed tomography, DMSA dimercaptosuccinic acid, i.v. intravenous, MRU magnetic resonance urography, US ultrasonography, VCUG voiding cystourethrogram





completely excluded. During the follow-up period eight children were referred for surgical correction of VUR and remained UTI-free after surgery. All except the two children with chronic renal failure maintained normal renal function and blood pressure.

Although we acknowledge the limitations of our retrospective, single-center study, we believe that our findings are representative of the single referral unit of Crete with both medical and surgical facilities for children and allow for the proposal of a management algorithm for severe UTI forms (Fig. 1). According to current suggestions for UTI management, guidance for children of older ages is very limited [23], and although ultrasound is favoured as a first-line, non-invasive imaging modality [24, 29], concerns of non-specific and probably misleading findings have been raised regarding its use during acute phase [24]. Our policy of acute phase US of severely affected children, irrespective of age and treatment response, facilitated the diagnosis of severe manifestations and reduced the possibility of missed cases of AFBN with a more benign course which, however, cannot be completely eliminated. However, it should be stressed that not only the clinical presentation but also the patient's history and the diagnostic questions which needed to be answered were important in guiding the decision for acute imaging, which cannot be proposed unconditionally.

## Conclusions

In conclusion, AFBN, renal abscess and pyonephrosis may co-exist and should be suspected in children—especially in older children—with severe clinical presentation and urological abnormalities. Acute phase US is essential for the diagnosis of these entities, but further imaging is usually required. It is important that future studies address the true incidence and the optimal management of AFBN, abscess and pyonephrosis among children with febrile UTI.

**Conflict of interest** None

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