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The importance of ultrasonography examination in renal abscesses in pediatric patients

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ABSTRACT

Introduction and aim. Renal abscess is a rare finding in the pediatric population, estimated at 0.2% of all intra-abdominal abscesses. The most common manifestations are fever, flank pain and simultaneously increased inflammatory markers in laboratory tests. Symptoms of this condition are non-specific and can be dismissed with other pathologies like renal tumor. Although the management is based on widespread antibiotic therapy, some cases need surgical intervention because of poor general condition and major diameter of abscess (>5 cm). We undertook this study to analyze the ultrasonography findings correlated with the clinical manifestations of renal abscesses in children that can potentially improve detecting renal abscesses in children earlier.

Materials and methods. We retrospectively studied 9 patients with renal abscesses treated in our hospital.

Results. All patients were diagnosed with renal abscesses based on ultrasonography (US) examination and each of them had elevated inflammatory parameters at the time of admission. For treatment, all patients were treated with intravenous antibiotics and two of them were treated with surgical drainage. All study group recovered completely or received a reduction of abscesses diameters. The renal abscesses were monitored by ultrasonography.

Conclusion. In our study, we assessed the usefulness of the US examination for diagnosis and treatment monitoring in pediatric patients. US is a gold standard due to its wide availability, noninvasiveness and low price. It also allows for immediate diagnosis, which is crucial to institute proper treatment. Treatment of abscesses depends on the clinical condition of the patient, other comorbidities, imaging presentation and the size of the abscess.

Keywords. pediatrics, renal abscess, ultrasonography

Introduction

Renal abscesses are structures composed of purulent and necrotic organic material in the renal parenchyma. It is a rare disease in the pediatric population.[1,2] Their incidence can be estimated at 0.2% of all intra-abdominal abscesses.[3] We can also distinguish perirenal abscesses, which are located outside the renal parenchyma between the renal capsule and Gerota's fascia and constitute 0.02% of all abdominal abscesses.[3,4]

Until now, the most common etiologies of renal abscesses were *Escherichia coli* and *Staphylococcus aureus*.[5,6] An abscess may be a consequence of urinary tract infection, hematogenous spread of pathogens or direct spread from local infection.[2,7,8] Currently, with the widespread use of antibiotic, Gram-negative bacteria, represented by *E. coli* and *Proteus* spp., have gained the advantage.[5] Conditions identified that are risk factors for renal abscesses, such as: diabetes, immune deficiencies, vesicoureteral reflux, nephrolithiasis and urological abnormalities (duplication of the urinary tract, ureteropelvic junction stenosis, calyceal diverticulum).[9,10]

Symptoms associated with abscesses are most often non-specific and systemic, which delays proper diagnosis. The most common are fever, general malaise, appetite loss, weight loss, abdominal pain, lumbar pain, painful urination, chills and vomiting.[4,5,11,12]

It should be noted that prolonged fever after infections in children can be caused by kidney abscesses. Then, with oncological vigilance, a differential diagnosis of the kidney lesion should be made to exclude cancer and make a final diagnosis of an abscess.[8]

In diagnostic imaging are used ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI). A quick and accurate diagnosis and appropriate therapeutic procedures are essential for better treatment results and reduced mortality.

The management of kidney abscesses can be divided into conservative and invasive treatment. The choice of treatment method should be selected individually based on the general condition of the patient, the severity of the infection and the size of the abscess on imaging tests.[2,5]

Aim

The main purpose of this study is to prove the significance of ultrasonography in prediction of renal abscesses, choice of treatment method and monitoring results. We retrospectively studied 9 patients with renal abscesses treated in our hospital to analyze our experience in the diagnosis and treatment of these rare disorders. Small study group and retrospective character of this paper are the main limitation of our article.

Material and methods

Between 2012 and 2023, nine pediatric patients were admitted to the Pediatric Surgery and Urology Clinic of the Provincial Clinical Hospital No. 2 Saint Jadwiga Queen in Rzeszów with the final diagnosis of a renal abscess. Age, sex, presentation, laboratory test results, imaging diagnostic and treatment were recorded retrospectively. All patients underwent an abdominal ultrasound examination, four patients had CT and one had only MRI. Ultrasound is more readily available than more advanced cross-sectional modalities such as CT or MRI. In laboratory tests we considered white blood cell (WBC) counts, platelet counts, C-reactive protein (CRP) levels and procalcitonin (PCT).

Results

Nine pediatric patients, 3 girls and 6 boys with a median age of 57.4 months (2–147 months) were retrospectively identified. Eight patients (88.89%) had pyuria. Routine urinalysis showed that 88.89% of children had a significant increase in urinary leukocytes. Blood culture was made in 6 patients and was negative in each case. Urine culture was positive in three cases, two Escherichia coli and one Staphylococcus aureus. The most common symptoms at the time of presentation were fever and flank pain, a patient was admitted because of appendicitis. Moreover, one patient had malformation syndrome with atrial septal defect, cleft palate and epilepsy. All patients were diagnosed with renal abscesses based on US examination. On ultrasound, this was determined by well-defined hypoechoic lesions with a surrounding hypervascularized parenchyma (Fig. 1, 2, 5–8). Color Doppler showed no internal vascular signal (Fig. 4). Contrast-enhanced CT in four patients in the acute phase revealed focal areas with a reduced absorption coefficient and obliteration of the renal calyces with enhancement of normal renal tissue (Fig. 3 and 9). MRI performed in one patient showed hypointense lesion on T1-weighted images and a hyperintense lesion with increasing signal intensity around the lesion (edema) on T2-weighted images (Fig. 10 and 11)

Two patients had a peri-nephric and intra-renal abscess and the remaining patients had intra-renal lesions. In 5 (55.6%) patients, the abscesses were confined to the right kidney and in 3 patients the abscesses were in the left kidney (33.3%). One patient had bilateral abscesses (11.1%). The average size of the abscess was 3.4 cm, with a range of 5 cm to 2.1 cm in our study group. Three of the children had renal lesions suspected of being a tumor during the diagnostic process. In our group of patients, the smallest abscess detected was

2.1 cm. The diagnosis of these changes depends on the experience of the doctor performing the ultrasound and the patient's preparation for the examination and his cooperation.

All patients had elevated inflammatory parameters at the time of admission to the hospital. In all cases CRP, white blood cells were significantly increased. We present the results of the laboratory examination of inflammatory markers in Table 1 with its highest value during hospitalisation.

Table 1. Inflammatory markers

Patient	Age (months)	CRP (H mg/l)	PCT (ng/ml)	WBC (H 10^3/µL)	Platelets (10^3/µL)
1	2	26.7	0.09	21.63	721
2	26	227.2	26.97	24.64	620
3	2	107.3	1.52	14.76	870
4	147	160.7	1.27	30.63	535
5	26	242.1	2.18	12.48	549
6	142	154.5	8.74	9.95	759
7	24	178.1	–	19.34	561
8	69	71.7	0.12	18.88	700
9	79	74.4	0.12	23.48	691

In our study group, there were two patients who were treated with surgical drainage (22.2%). The procedure was performed under general anesthesia in the theatre by pediatric surgeons. One of them had multiple renal abscesses with the largest 2.6 cm in the US and drainage was performed due to immune disorders and malformation syndrome. The second patient had abscess with diameter 5 cm complicated by urosepsis. Pus culture was performed in one drainage case and was compatible (*S. aureus*) with urine culture. The remaining group of patients were treated with preservative management. All study groups recovered completely or received a reduction of abscesses diameter. The renal abscesses were monitored by US.

For treatment, all patients were treated with intravenous antibiotics mainly as third-generation cephalosporins presented in Table 2.

Table 2. Treatment method, antibiotics and time of treatment in our study group

Patients	Treatment method	Antibiotics	Time of treatment (days)	Other information
1	Conservative	Amikacin + cefotaxime	10	
2	Surgical	Amikacin + ceftazidime + metronidazol + vancomycin	8	Malformation syndrome
3	Conservative	Amoxicillin with clavulanic acid + cefotaxime	18	Bilateral abscess
4	Conservative	Amikacin + ceftazidime	17	
5	Surgical	Cefotaxime + vancomycin + cotrimoxazol	14	
6	Conservative	Amikacin + ceftazidime + meropenem + amoxicillin with clavulanic acid	24	Appendectomy
7	Conservative	Cefotaxime	15	Sepsis
8	Conservative	Amikacin + ceftazidime	28	Pyelonephritis
9	Conservative	Amikacin + ceftazidime	14	

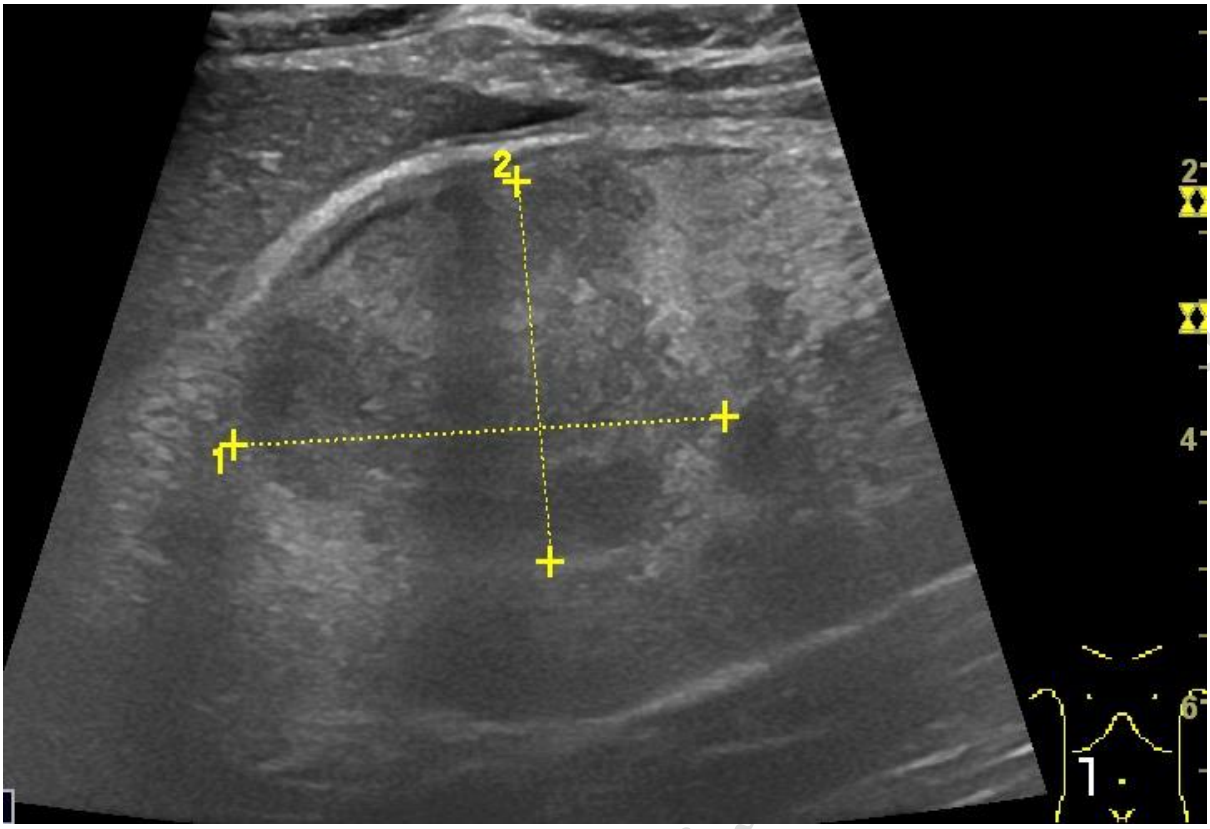

Fig. 1. A heterogeneous hypoechoic area – an abscess with renal parenchyma edema in the vicinity, as well as a narrow layer of fluid around the periphery, subcapsularly, and thickened hyperechoic Gerota's fascia. Blurring of the corticospinal differentiation of the kidney

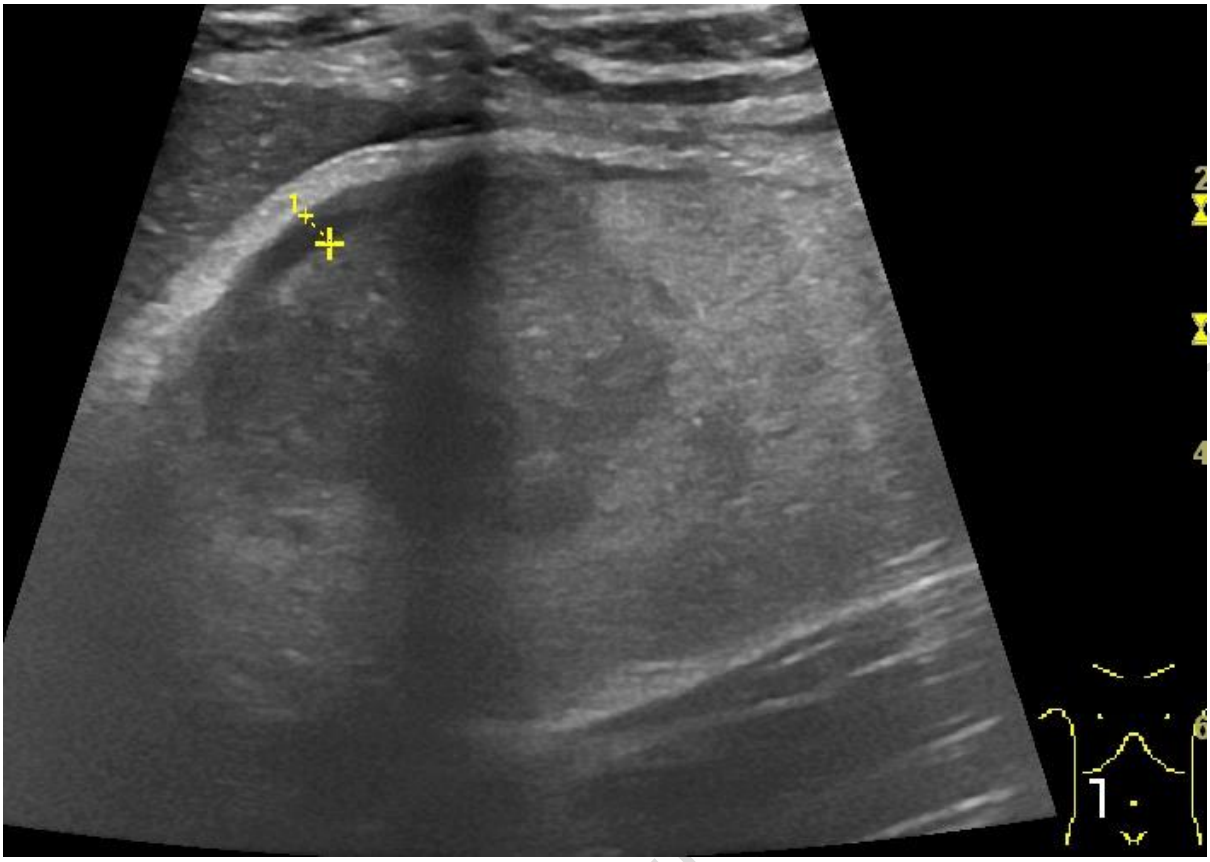

Fig. 2. A heterogeneous hypoechoic area – an abscess with renal parenchyma edema in the vicinity, as well as a narrow layer of fluid around the periphery, subcapsularly, and thickened hyperechoic Gerota's fascia. Blurring of the corticospinal differentiation of the kidney

Fig. 3. CT with contrast, coronal and sagittal

There is limited medial focus at the upper pole of the left kidney, which is enhanced by contrast. The lesion highlights the outline of the kidney, presses the upper renal calyx and reaches into its hilum.

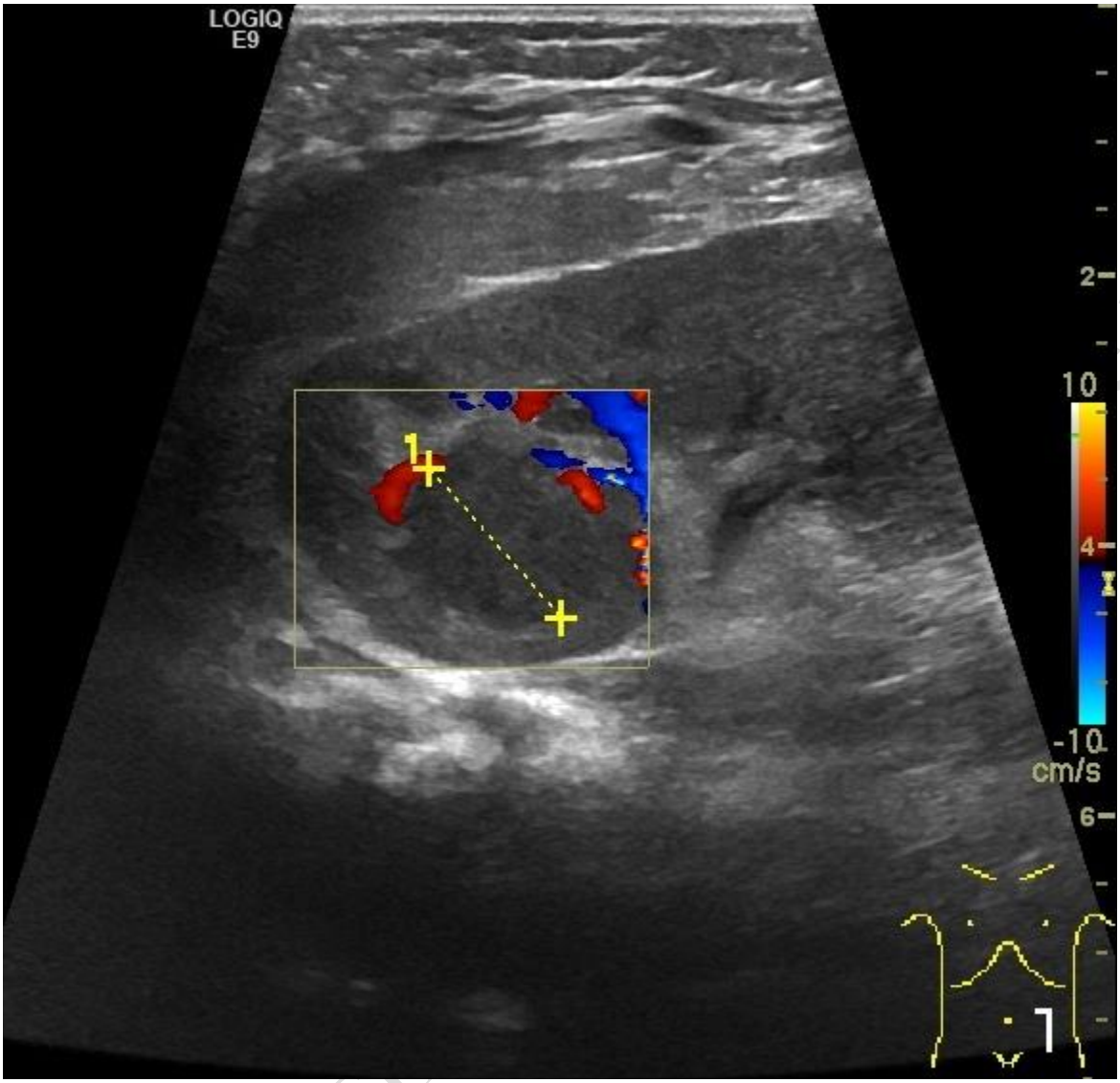

Fig. 4. Image with Color Doppler – no central vascularity, visible vascularization on the periphery of the abscess capsule

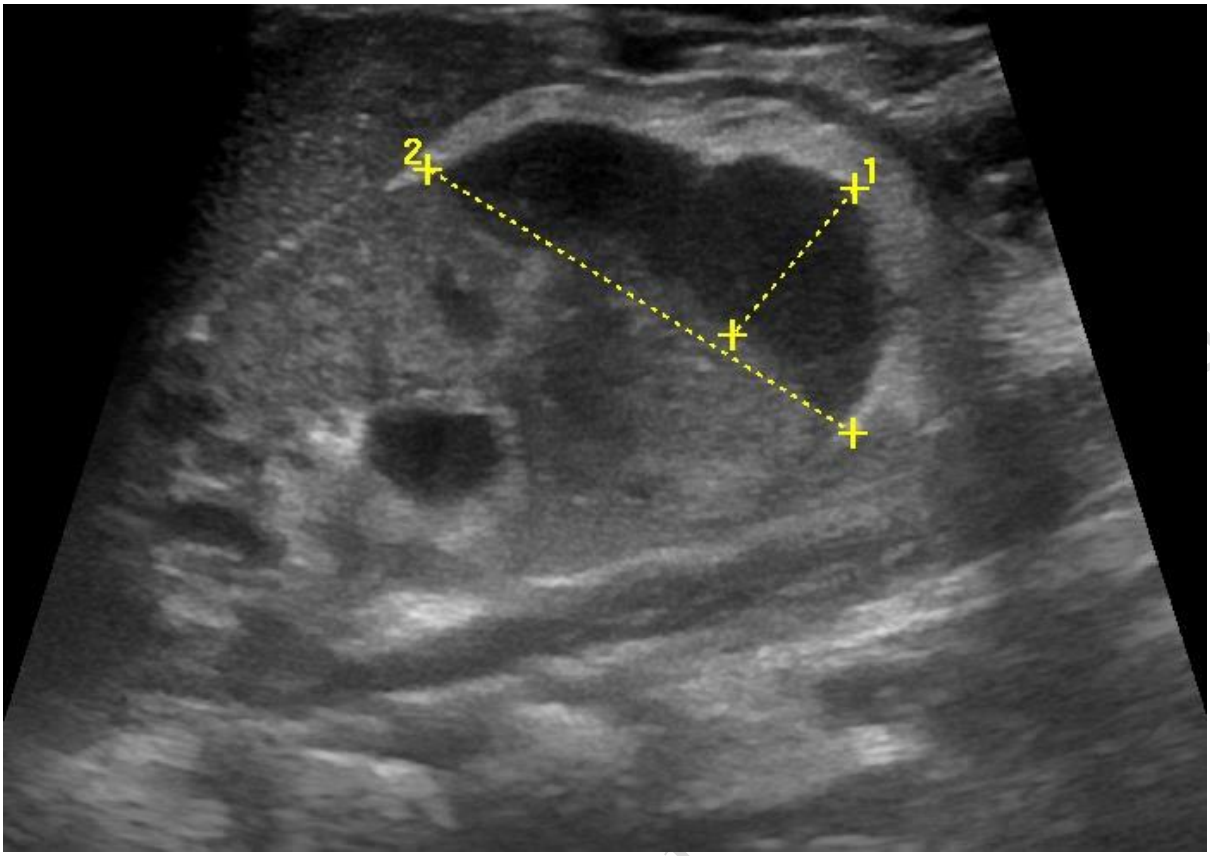

Fig. 5. Hypoechoic banded subcapsular area on the periphery of the renal parenchyma – perirenal subcapsular abscess

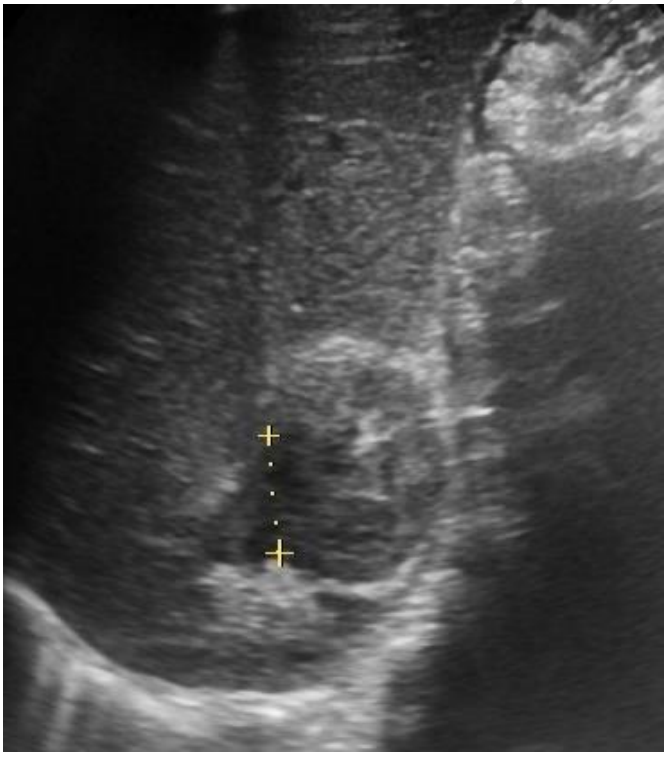

Fig. 6. A heterogeneous and hypoechoic fluid area is visible subcapsularly, organising purulent lesions

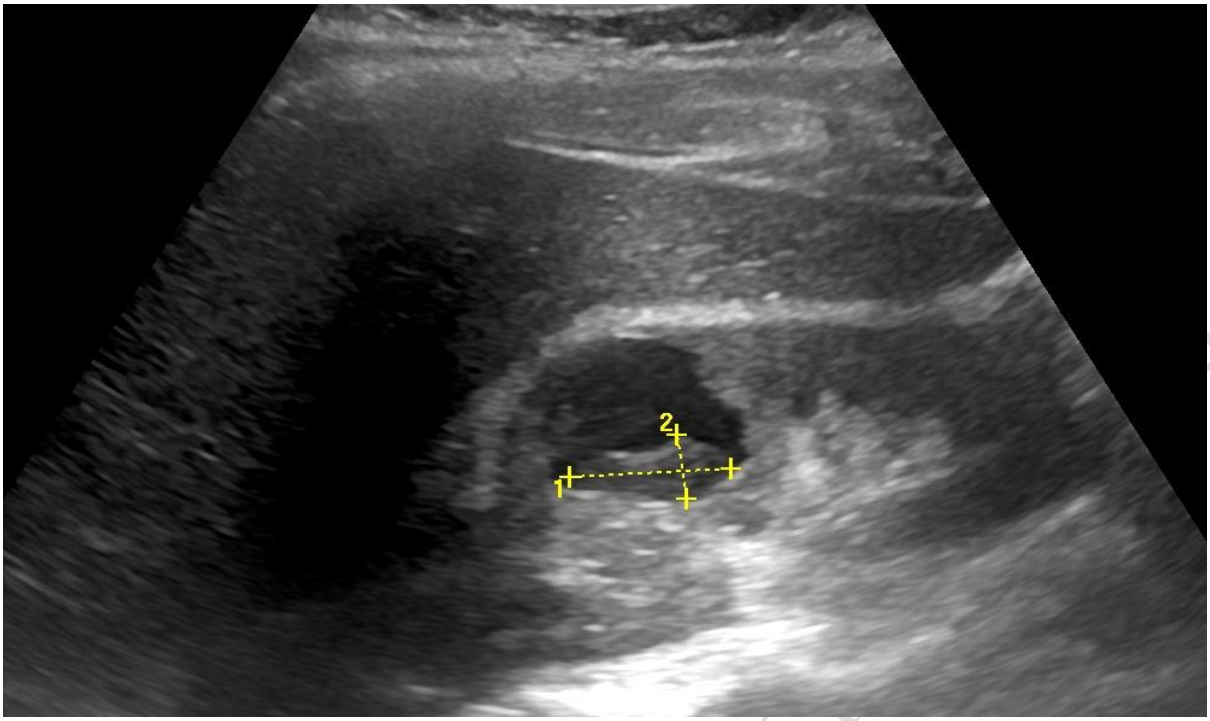

Fig. 7. A single-chamber, anechoic, cystic structure with visible horizontal echogenic bands adjacent to the wall – an abscess that is being cleared

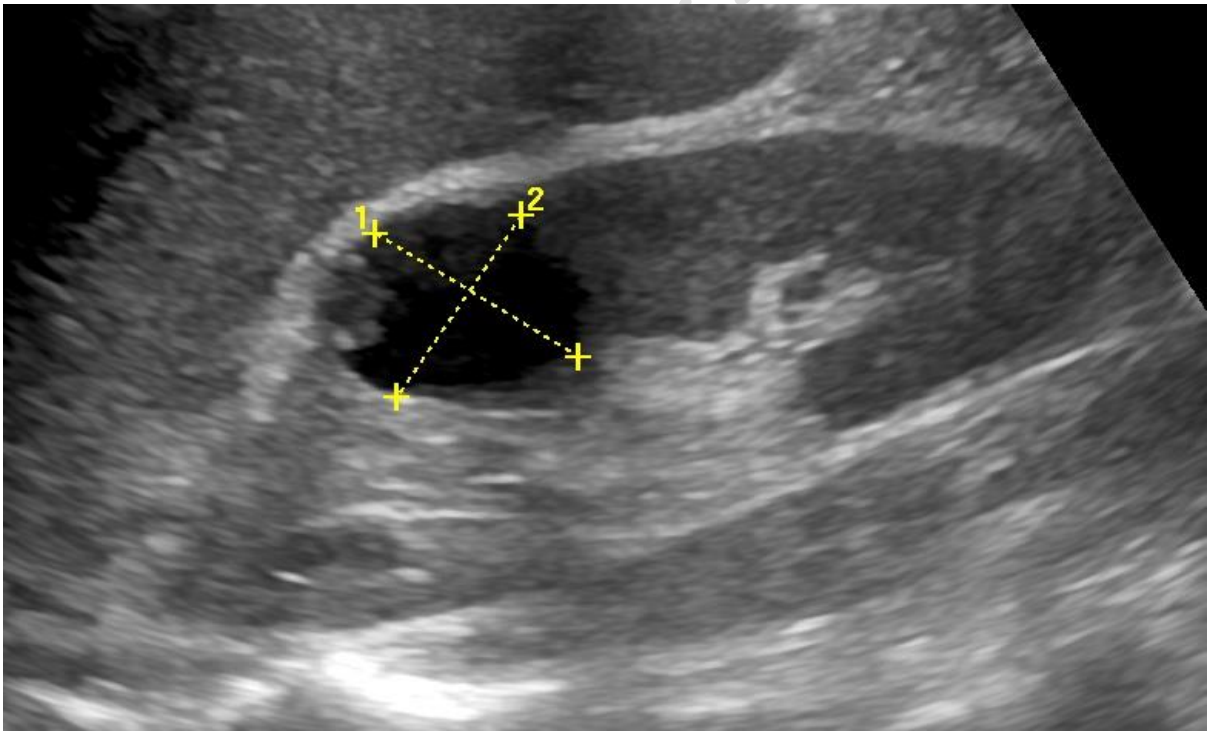

Fig. 8. A single-chamber, anechoic, cystic structure with visible horizontal echogenic bands adjacent to the wall – an abscess that is being cleared

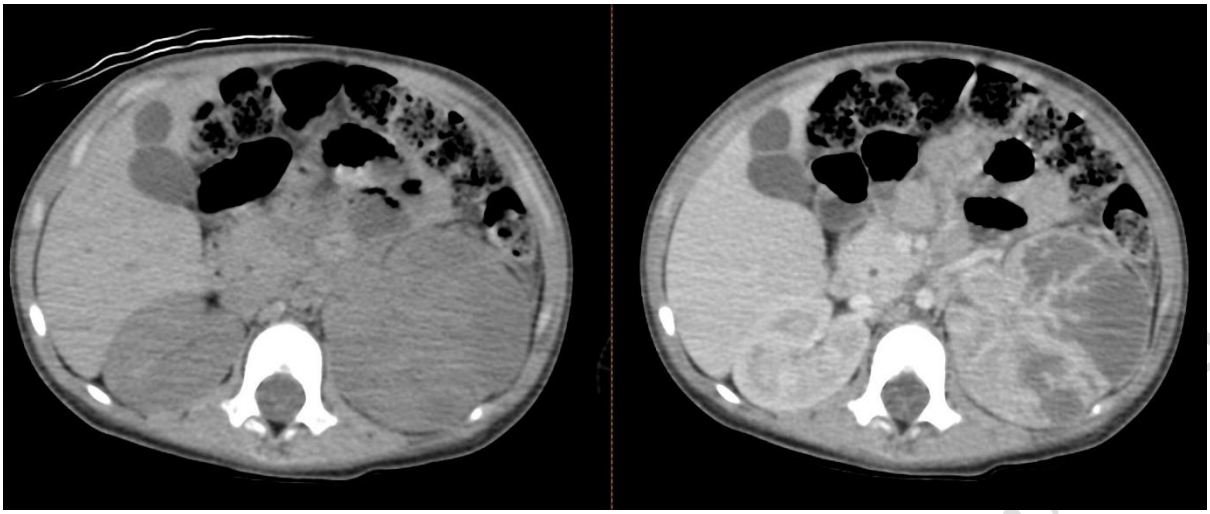

Fig. 9. CT axial

The left kidney has a thin cortical layer with the presence of large, irregular areas of dense fluid density and striated, contrasted parenchyma.

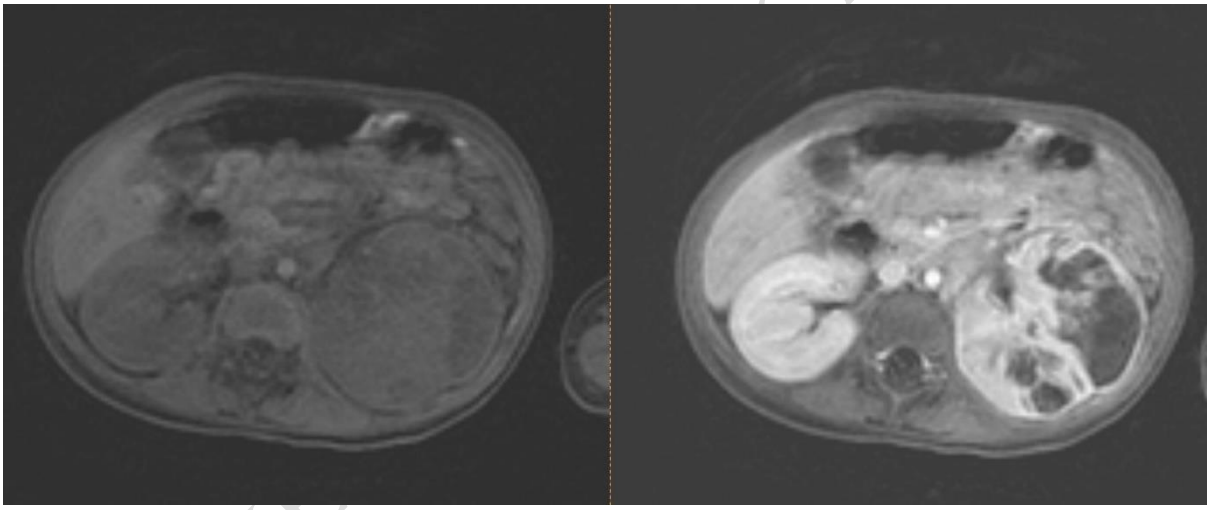

Fig.10. MR T1 axial and axial with contrast

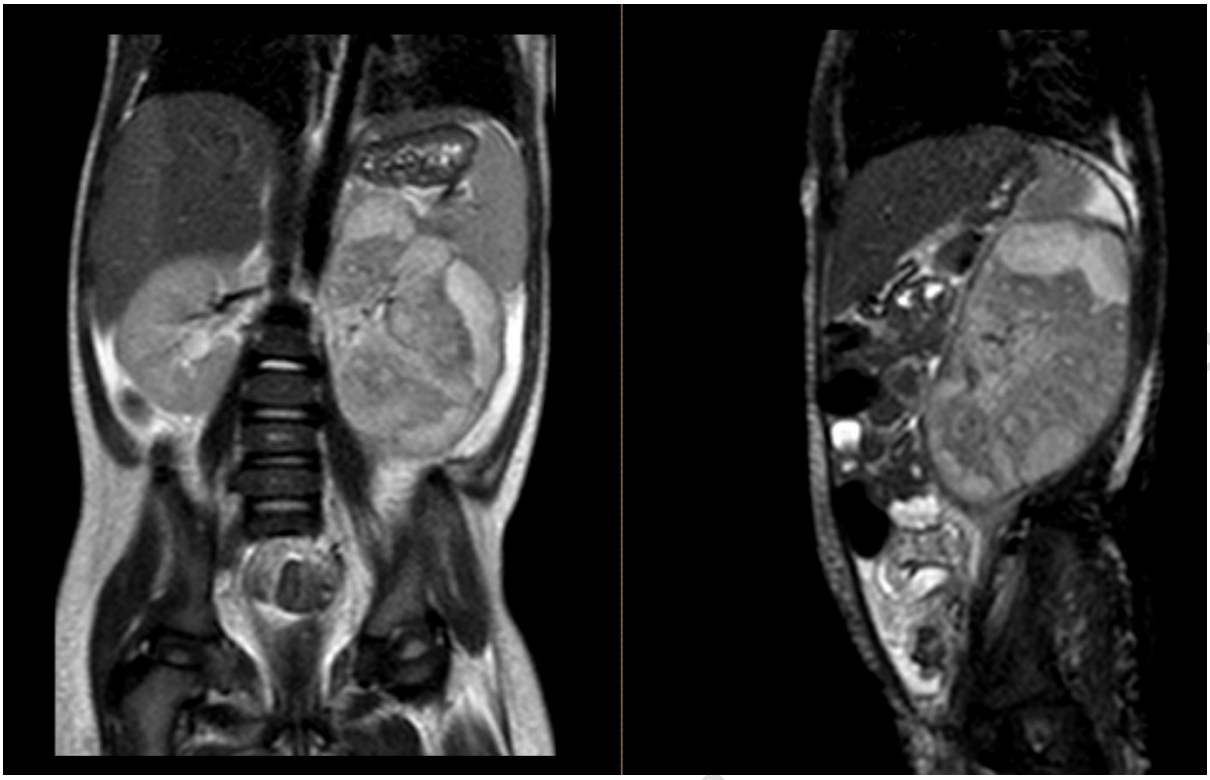

Fig. 11. MR T2 coronal and sagittal

There are bands and areas of fluid space in the left kidney; the fluid signal is moderately increased in T2-weighted images and moderately hypointense in T1-weighted images. After contrast administration, the signal from the distorted renal parenchyma is enhanced.

Discussion

Renal abscesses are infrequent conditions in pediatrics.[2] Previous research found that there is no obvious gender tendency in children with renal abscess.[10] However Buschel et al. found in their study a predominance of male gender.[2] Our study also showed that renal abscesses are more likely to occur in males (6/3). Over the years, the etiology of abscesses has changed in favor of Gram-negative bacteria, including *E. coli*, which is also confirmed in our work.[2,5] Diagnosis and treatment are usually based on guidelines for adults or small sample size data. A small amount of data contributes to the lack of diagnosis or misdiagnosis, that is why early detection and appropriate treatment are important.[2,10]

US and CT scanning seem to be the most common diagnostic tools.[1] The first-choice examination in case of clinical suspicion of renal abscess is ultrasound examination. One can observe an anechoic fluid reservoir merging with the normal image of fatty tissue inside Gerota's fascia. An abscess is a round lesion with a thick or smooth wall with internal reflections of necrotic changes that move with changes in position. There may be gas inside the abscess, which will give the "comet symptom". It is worth noting that we can also see internal partitions or chambers.[1] Color Doppler and Power-Doppler scans can reveal a well vascularized

peripheral ring and no internal vascular signal. Color Doppler in US is an imaging technique that allows obtaining information about blood flow through tissues. This technique generates color maps of flow through tissues that are superimposed on grayscale ultrasound images of anatomical tissues.[13]

The use of intravenous contrast is not required for ultrasound differentiation. One of the possibilities of using US is its use with contrast enhancement (CEUS). The test allows visualization of structures in real time, has a high safety profile and can be performed at the bedside. This method allows for the assessment of renal microvascular perfusion in the case of blood flow disorders, as well as in the case of acute pyelonephritis. It helps differentiate between focal kidney infection and individual stages of kidney abscesses, which determines the decision on the duration of antibiotic therapy. CEUS is also considered a sensitive method for imaging renal post-inflammatory scars in children with reflux nephropathy.[14]

However, computed tomography examination can be performed with or without contrast medium administration. In the case without contrast, the most common image is a single or multiple lesion, unilateral or bilateral, with a round, well-defined shape and a low absorption coefficient. Gas within the collection may also be visible.[15] Abscesses usually have a higher attenuation factor of 10–30 units of H than uncomplicated cysts or the pelvicalyceal system.[16]

Contrast-enhanced computed tomography in the acute phase is characterized by the presence of focal areas with a reduced absorption coefficient. In the subacute or chronic phase, strengthening of the abscess wall may be visible as a ring or rim symptom. There is obliteration of the renal sinus or calyces with enhancement of normal renal tissue in the absence of central enhancement of the lesion suspected as a renal abscess. Swelling, obliteration of the perirenal fat tissue and thickening of the perirenal septums and Gerota's fascia may raise the suspicion that the lesions have spread to the perirenal space.[15] In addition, the main advantage of CT is that it provides a distinction between renal and perirenal abscess.[9] CT also allows to precisely describes small collections (1–2 cm), renal capsule and Gerota's fascia.[4] Moreover CT can be used to confirm the diagnosis of renal abscesses suggested in US because the method does not always provide a definitive diagnosis.[2,9] Magnetic resonance imaging can also be used in diagnostics. This examination will show the abscess as a hypointense lesion on T1-weighted images, a hyperintense lesion with increasing signal intensity around the lesion (edema) on T2-weighted images, and peripheral contrast enhancement on T1-weighted images with contrast enhancement.[15]

The differential diagnosis should include cystic renal cell carcinoma (especially in the case of chronic, asymptomatic abscesses), metastases or lymphoma, and infected or hemorrhagic cysts. In equivocal cases, a biopsy may be necessary.

Treatment of abscesses depends on the clinical condition of the patient, other comorbidities, imaging presentation and the size of the abscess.[5] Based on literature data, antibiotic therapy is commonly used in patients with abscesses <3 cm and should last 4-6 weeks.[8] Lesions between 3 cm to 5 cm in children who are clinically stable may be considered to treat only by preservative management. The method of choice in

>5 cm abscess is surgical intervention.[2,8] In our study group, the above treatment guidelines are also applicable because surgical treatment was used in two patients, one with malformation syndrome, immune disorders and multiple renal abscesses, and the other with an abscess with a diameter of 5 cm complicated by urosepsis.

We analyzed reviews from the literature and present their data on the treatment of renal abscesses in Table 3. This confirms that prolonged antibiotic therapy is generally considered an initial treatment method, preserving drainage for larger renal abscesses or cases refractory to antibiotic course.

Table 3. Review of the literature on kidney abscesses and their treatment

Renal abscesses treatment in children, literature reviews	**Number of patients**	**Surgical treatment**	**Conservative treatment**
Comploj et al.[1]	6	–	6
Linder and Granberg[7]	16	3 – percutaneous drainage (>3.8 cm)	13
Chen et al.[9]	17	4 – percutaneous drainage	13
Zhang et al.[10]	17	10 (>4 cm)	7
Buschel et al.[2]	14	5 – percutaneous drainage (>5 cm) 2 – surgical drainage	7

It is crucial to remember to always suspect urinary tract infection (UTI) in a febrile child, because approximately 6-8% of febrile infants are ultimately diagnosed with UTI. It is estimated that by the age of 11, 1% of boys and 3% of girls will experience a UTI.[8] UTI is considered to be the most common etiology of renal abscesses.[1,9,10]

The main purpose of diagnostic imaging in UTI is to identify disorders that can cause recurrences of UTI and deterioration of kidney function.[12] In the case of UTI with fever, US is not performed routinely, however the Polish Society of Pediatric Nephrology recommends performing an ultrasound examination in all children up to 24 months after the diagnosis of the first episode of UTI, and in children >24 months after the diagnosis of acute UTI, UTI with an atypical course, with risk factors for recurrence or in the event of recurrence of UTI.[17]

In our study, we assessed the usefulness of the US examination for diagnosis and treatment monitoring in pediatric patients. The main advantages of US are its low price, high availability, non-invasiveness and lack of exposure of the patient to radiation during the procedure. Other tests used in diagnostics are computed tomography and magnetic resonance imaging, but due to lower availability, costs, and the need for systemic anesthesia of the child, ultrasound is the method of choice.[4,10,12]

Each patient in our study group with suspected renal abscess based on US had the diagnosis confirmed by subsequent imaging tests, such as CT or MRI. The experience and skills of the radiologist, as well as the cooperation of the pediatric patient and contact with clinicians, play an important role in the correct interpretation of ultrasound images suspected of an abscess. One of the limitations of US is the obesity of patients and the location of pathology in the retroperitoneal or peritoneal space, which requires the experience and skills of the doctor performing this examination.[12]

Our study has several limitations. First, our analysis is a retrospective cohort study. Secondly, our data span eleven years and includes only nine patients, which is why our study group is too small to obtain a diagnostic algorithm.

Conclusion

Ultrasound is the first-choice examination in the case of clinical suspicion of renal abscess. It is crucial to perform the imaging immediately and correct interpretation, due to non-specific symptoms which may delay the diagnosis. Ultrasound also allows us to measure the diameters of the abscess and make decisions about treatment based on the clinical condition and further follow-up of the patient during and after treatment.

Declarations

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Author contributions

Conceptualization, I.K.M. and A.G.; Methodology, I.K.M.; Software, J.K.; Validation, I.K.M., A.G. and J.K.; Formal Analysis, I.K.M.; Investigation, K.K and K.O.; Resources, I.K.M.; Data Curation, I.K.M.; Writing – Original Draft Preparation, K.K. and K.O.; Writing – Review & Editing, K.K. and K.O.; Visualization, I.K.M.; Supervision, W.G.; Project Administration, I.K.M.;

Conflicts of interest

The authors declare that they have no conflict of interest.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

Not applicable.

Declaration of the authenticity of figures

All figures submitted have been created by the authors, who confirm that the images are original without duplication and are the property of the Clinical Department of Radiology and Imaging Diagnostics, Clinical Provincial Hospital No. 2 Saint Jadwiga Queen in Rzeszow.

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