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Renal sinus hyperechogenicity in acute pyelonephritis: description and pathological correlation

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Abstract This paper reports on the association between renal sinus hyperechogenicity and acute pyelonephritis. The medical records and imaging studies of 18 children displaying this pattern were retrospectively studied. Thickening of the renal pelvis and renal enlargement were the most frequent associated sonographic abnormalities. Further subtle findings can be found on sonography and colour/power Doppler. Their identification can help in the diagnostic approach to acute pyelonephritis and may obviate the need for other imaging modalities such as enhanced CT or ^{99m}Tc-DMSA scintigraphy. Renal sinus hyperechogenicity was also identified in a parallel study performed in female rabbits with experimental pyelonephritis and was shown, histologically, to be related to exudates of fibrin and polymorphonuclear leukocytes, interstitial oedema and micro-abscesses.

Introduction

To our knowledge, renal sinus hyperechogenicity (RSH) has never been described in children. The aim of this retrospective study was to report on its possible association with acute pyelonephritis (APN).

Materials and methods

This retrospective study was performed at two institutions. It was based on the review of medical records and imaging studies of 18 patients (12 girls, 6 boys) aged 3 months to 13 years (mean 47 months) with APN. All displayed RSH of their infected kidneys. Sonography was performed with either a 5- or a 7.5-MHz transducer. Four different US units were used: Toshiba 270, Acuson 128, ATL 3000 or ATL UM9 HDI. Studies were started in the supine position and were followed by a comparative study of kidneys in axial and longitudinal planes in the prone position, including power Doppler in the most recent cases. No spectral analysis was performed. Proof of APN was based on clinical findings, blood tests and urine cultures in all cases. ^{99m}Tc-DMSA scintigraphy was performed in eight patients. In all patients, voiding cystourethrography (VCUG) was subsequently performed.

Results

RSH was found in 18 children (19 kidneys). RSH was present on the left side in 13 patients, on the right side in 4 and bilaterally in 1. Other US findings were found in 17 patients. Renal enlargement was found in ten patients, but in three of them severe scarring of the contralateral kidney was present and compensatory hypertrophy was likely. In seven patients, RSH was associated with ipsilateral abnormal echogenicity of the

renal parenchyma; a focal triangular hyperechogenicity was found in five patients (one patient had two lesions) and a rounded hypoechoic focus was found in two children (one displayed a tumour-like pattern). Five of those seven children were also investigated by power Doppler; all were found to have decreased vascularity of the focus, which was abnormal on grey-scale sonography.

Bladder wall thickening was identified in six patients and an intra-vesical fluid-debris level was found in one case. Mild dilatation of the ureters and pelvicalyceal system was found in five patients. Pelvic wall thickening was found in 12 children, and ureteric wall thickening in 3.

In the eight patients who had ^{99m}Tc-DMSA scintigraphy, the diagnosis of APN was confirmed on the side of RSH.

VCUG subsequently identified ipsilateral vesicoureteric reflux (VUR) in three patients. Bilateral VUR was shown in two children.

Two patients had a history of treated VUR. A 13-year-old girl presented with right APN and RSH, although she had previously undergone successful bilateral submucosal injection of Teflon. Another 6-year-old girl had previously undergone bilateral Cohen re-implantation for bilateral VUR. VUR was no longer present on follow-up VCUG. However, she presented with left APN with RSH, and further evaluation demonstrated bladder sphincter dysfunction.

Two children had complex underlying urinary tract malformations. A 9-year-old girl was found to have a non-refluxing, right orthotopic ureterocoele and a severely scarred right kidney. She presented with left APN and RSH. She was subsequently found to have bladder sphincter dysfunction. A 3-year-old girl presented with APN and RSH developed in the lower pole of a renal duplication with ectopic ureter on the upper pole. No VUR was identified on either side or pole of the duplex system in this patient.

Discussion

APN is an infection involving both the collecting system (pyelitis, ureteritis, and sometimes associated cystitis) and the renal interstitium (nephritis). Inflammation of the pelvicalyceal lining (the so-called pyelitis) can develop without any parenchymal involvement [1]. It has been postulated that those patients with urinary tract infection, lumbar fossa pain and negative ^{99m}Tc-DMSA scintigraphy [2] could be affected with pyelitis, a preliminary stage of APN [3].

In the current literature, US is usually not considered a reference examination for the diagnosis of APN. Moreover, there is great variability of sensitivity according to different authors. For example, the sensitivity of US ranges from 11 % to 69 % in two relatively recent studies [4, 5]. Such variability can be explained by differences in equipment and in the training of sonographers. In spite of its poor sensitivity, sonography usually remains the first examination in evaluating children with urinary tract infection. Once any suppurative disease or renal malformation is eliminated, a search for the subtle findings of APN can be performed. A comparatively high frequency sonographic examination of the child in the prone position is required. If the patient is sufficiently co-operative, colour and power Doppler can also be performed. Colour-coded techniques can help locate subtle changes of parenchymal grey-scale reflectivity and seem to increase the capabilities of sonography in the diagnosis of APN [6, 7]. Recently, it has been suggested that abnormal Doppler findings in APN could be predictive of subsequent scarring with a specificity of 90 % [8].

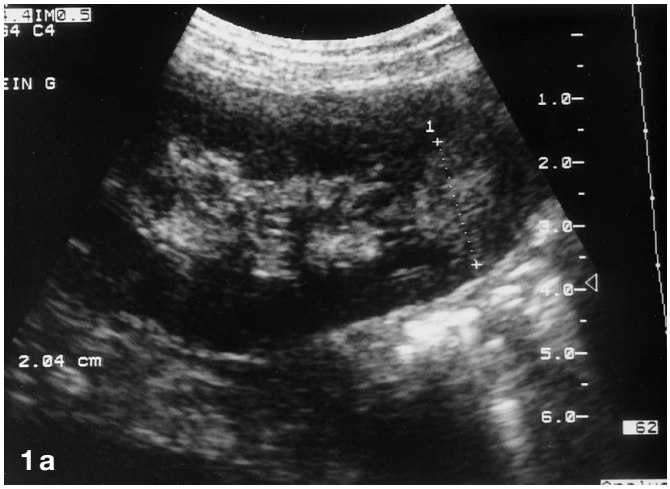
Many US abnormalities have been described in association with APN. Some of them are related to nephritis while others are related to pyelitis or ureteritis.

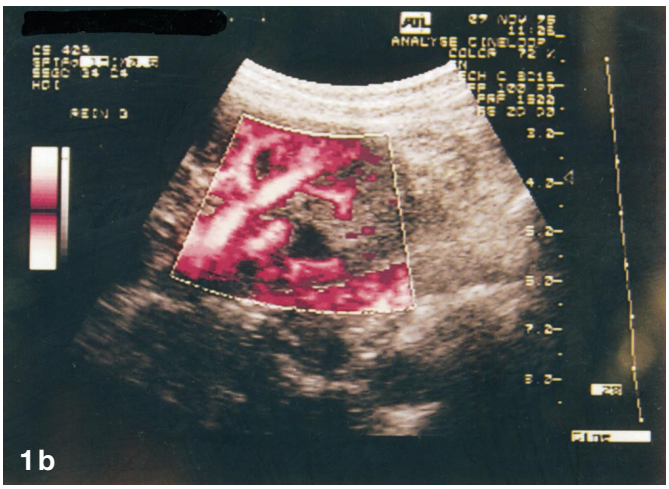
Increase in renal size [9] is thought to be related to diffuse or focal parenchymal inflammatory changes. Triangular hyperechogenicity with loss of corticomedullary differentiation could possibly be due to accumulated pus within medullary rays. A rounded hypoechoic focus or pseudotumour is considered to represent the first stage of renal abscess. Whenever such a change of parenchymal echogenicity is found, decreased flow is usually present on colour or power Doppler (Fig. 1).

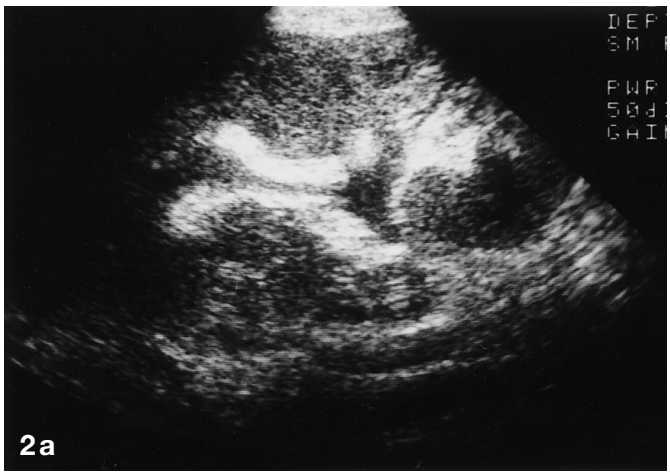
Involvement of the collecting system can induce mild dilatation of the renal pelvis and ureter [10], which is thought to be due to atony caused by infection [5]. Such dilatation can be found even in the absence of reflux, and it may disappear after treatment. Thickening of the pelvic wall can also be identified in APN [11], but this sign has been shown to be non-specific for infection [12–14]. It can also be encountered in VUR, obstruction, acute tubular necrosis, acute rejection of allografts, HIV-associated nephropathy [15] or candidiasis [16].

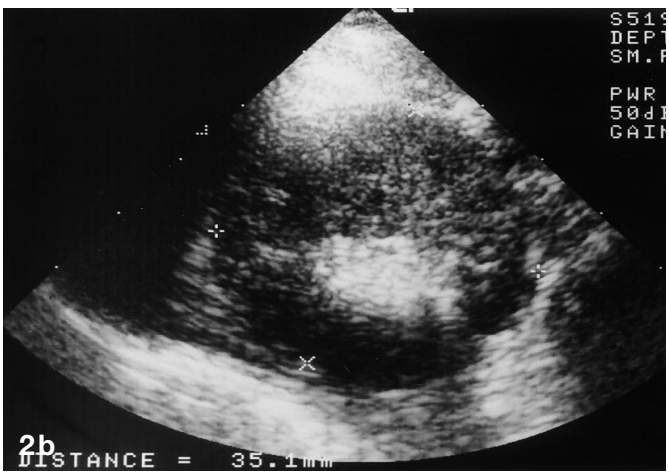
In this study, we found RSH also associated with APN (Fig. 2). Normal hyperechogenicity of the renal sinus is related to the many interfaces between sinus fat, blood vessels and the pelvicalyceal system [17, 18]. The renal sinus is moderately hyperechoic in children because fat is usually not abundant. Therefore, RSH was striking when compared to the usual sonographic pattern and when compared to the opposite renal sinus with the patient in the prone position. RSH can also be found in lipomatosis of the renal pelvis, which is a rare condition in children. Clinical findings help differentiate lipomatosis from APN. Colour Doppler showed that renal hilar vessels accounted only partially for RSH.

Unfortunately, in this study proof of pyelonephritis was weak in 10 of the 18 patients who did not have









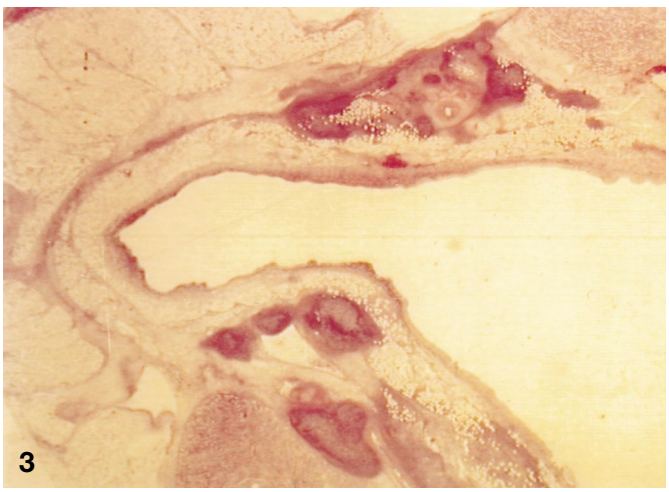


Fig. 1a,b US scan of the left kidney in a 9-year-old girl with left lumbar fossa pain and high fever. **a** Longitudinal view showing thickened and moderately hyperechoic renal sinus plus a hyperechoic focus in the lower pole (*callipers*). **b** On power Doppler there is a triangular focus of decreased flow in the lower pole

Fig. 2a,b The left kidney in a 10-month-old boy. **a** Longitudinal and **b** transverse scans show striking hyperechogenicity of the renal sinus

Fig. 3 Experimental acute pyelonephritis in a female rabbit displaying renal sinus hyperechogenicity. Microscopic view of the renal pelvis (H&E, × 10). Micro-abscesses are distributed in the peripelvic fat. Note also the interstitial oedema

DMSA scintigraphy performed because the technique was not available. Diagnosis was based on clinical and biological findings, and sonographic findings could not be compared to the reference method in these patients.

In a parallel experimental study performed in New Zealand female rabbits (personal unpublished data), RSH was also found. *Escherichia coli* was inoculated into the right ureter, which was then ligated for 1 h. Repeated US and power Doppler studies were per-

formed in the days following surgery and kidneys were examined by a pathologist 5–8 days later. RSH was shown to be related to interstitial oedema, micro-abscesses and exudates of fibrin and polymorphonuclear leucocytes (Fig. 3). Because of that pathologic correlation and because RSH was associated with thickening of the pelvic wall in the majority of the cases of this series, we postulate that RSH could represent severe inflammatory involvement of the collecting system.

In conclusion, RSH may be a supplementary sonographic sign of the pelvic involvement, which may be encountered in acute pyelonephritis. RSH represents severe inflammatory changes of interstitial sinus fat. It may be associated with other sonographic signs of pyelitis or nephritis.

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