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Improving the diagnosis of acute pyelonephritis using Doppler ultrasound

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Abstract
This article describes the way of improving the diagnosis of cute pyelonephritis, which is a bacterial infection of the renal pelvis and parenchyma most commonly seen in young women. It remains common and continues to have significant morbidity in certain groups of patients, using dopplerоghraphy.

Keywords: Acute pyelonephritis, magnetic resonance, urinary tract infection, dopplerоghraphy, kidney abscess

Introduction

Pyelonephritis is a nonspecific infectious and inflammatory process, which is a form of interstitial nephritis with a predominant focal lesion of the interstitial substance of the medulla of the parenchyma and renal tubules. Morphological manifestations of pyelonephritis are not specific; there is no correlation with the type and nature of the infectious agent. According to various authors, acute pyelonephritis accounts for about 14-22% of kidney diseases and emergency conditions in urology, women are more likely to suffer from pyelonephritis than men. At the same time, its purulent forms are found in more than 30% of patients, and mortality in purulent pyelonephritis can reach 20 and even 80%.

The ultrasound method of examination in the examination of patients with pathology of the urinary system has now been transformed from a primary method, often only screening diagnostics, into one of the basic methods, which has become a reference in relation to other radiation methods of examination, primarily in the detection of focal lesions of the kidney parenchyma. The availability, non-invasiveness, and repeatability of the study in the absence of radiation exposure to the patient are well known, which is especially important when examining patients with urological pathology during pregnancy. The widespread use of high-quality ultrasound equipment, coupled with an increase in the qualifications of ultrasound doctors, allows us to assume further expansion of the diagnostic field with ultrasound diagnostic methods, primarily due to the complexity of using gray scale and Doppler technologies based on improving the digital processing of the analyzed signal, methods of volumetric virtual reconstruction, special information analysis accompanying the main noise signal. The ideology of ultrasound examination of the kidneys for suspected acute pyelonephritis is determined by the ability to answer the following questions:

1.Functional state of the kidneys 2. State of urodynamics 3. Stage of acute pyelonephritis (serous, purulent, necrotic papillitis) 4. Form of acute pyelonephritis (edema, apostematous nephritis, carbuncle, kidney abscess) The answer to the first question seems to be the most problematic. Ultrasound examination allows quite objectively, based on the analysis of quantitative, primarily morphometric indicators and qualitative characteristics of the interaction of ultrasound with kidney tissues (echogenicity, echostructure, sound conductivity), to assess the morphology of the kidney, but not its excretory ability. Ultrasound does not allow to visualize the process of formation of secondary urine, which is available for excretory urography. At the same time, the ultrasonic method in the gray scale mode is necessary and sufficient for the verification of obstructive uropathy with the identification of not only the fact of urinary tract obstruction, but also the level, and in some cases the cause of the blockade. Therefore, without answering the question about the functional state of the kidney, ultrasound unambiguously separates the cases of obstructive and non-obstructive uropathy, which obviously has a decisive therapeutic and tactical value, due to the need for emergency decompression of the kidney. If gestational pyelonephritis is suspected, the detection of dilatation of the collecting system of the kidney is not as specific as in acute obstructive pyelonephritis outside of pregnancy, since the expansion of the upper urinary tract in the second half of pregnancy does not directly correlate with intracavitary pressure and is due, among other things, to a decrease in the tone of the pelvis wall and ureter.

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Since acute pyelonephritis involves a diffuse lesion of the renal parenchyma, then, as with any other diffuse lesion of the parenchymal organs, the ultrasound method of examination does not allow to identify reliable symptoms of the lesion with high diagnostic accuracy - allowing not only to diagnose the pathology if it is present, but also to confidently reject it if it is present. absence. Consequently, the ultrasound diagnosis of acute pyelonephritis is based on a syndromic approach, which includes the identification of signs of diffuse parenchymal edema, signs of focal organ damage, signs of concomitant paranephric lesions, and signs of organ and tissue hemodynamic disorders. Parenchymal edema syndrome is verified with an increase in the longitudinal and transverse dimensions of the kidney, and an increase in the thickness and height of the kidney is more reliably and earlier recorded than an increase in length. At the same time, the contour of the kidney begins to swell, all the irregularities of the contour are smoothed out, which is especially noticeable when compared with the contralateral kidney with a one-sided nature of the lesion. Irregularities of the contour are determined by the residual lobulation of the kidney and are a bilateral feature of the structure. The asymmetry of the residual lobulation, and hence the unevenness of the contour, is a sign of an increase in interstitial pressure (the formation of a tissue compartment syndrome) due to an increase in parenchymal edema. In addition to alignment and bulging of the parenchyma contour, the usual clarity of the parenchyma-fat capsule interface is lost. The fuzziness of the contour is determined not by the lesion of the fibrous capsule itself, but by a decrease in the acoustic gradient at the boundaries of the "parenchyma - capsule" and "capsule - perinephric tissue" interfaces. than normal. The increase in the linear dimensions of the kidney is determined by the hydration of both the parenchyma and the central echo complex. At the same time, it is possible to reliably register an increase in the thickness of the parenchyma over 20-22 mm in the middle segment. It is difficult to objectively evaluate the central complex morphometrically, and the ranking of the severity of kidney edema by the ratio of the thickness of the parenchyma and the central echo complex can hardly be considered successful, bearing in mind the unidirectional nature of the changes.

In addition to an increase in the echogenicity of the parenchyma and a decrease in its sound conductivity, which is well recorded with high-frequency scanning (sensor frequency over 7.5 MHz), the structural and uniformity of the parenchyma is disturbed. The parenchyma of the cortical layer begins to be represented not only by fine-grained, but also medium- and coarse-grained signals, randomly distributed throughout the entire volume of the cortical layer. These changes are especially evident in unilateral kidney damage. A symptom that determines the severity of parenchymal edema is the respiratory mobility of the kidney, as well as the reaction of perinephric tissue. In acute pyelonephritis, the respiratory mobility of the kidney decreases up to complete absence, while the reliability of the decrease is determined in comparison with the normal respiratory mobility of the contralateral kidney. It should be borne in mind the obvious conditionality of this symptom against the background of the second half of pregnancy, which is associated with a physiological decrease in respiratory mobility, especially in the right kidney, against the background of increased intra-abdominal pressure and mediated compression of the retroperitoneal tissue. Nevertheless, a decrease in kidney mobility in combination with other symptoms of parenchymal edema strongly indicates in favor of acute pyelonephritis. Perinephric exudation confirms the spread of acute inflammation beyond the renal capsule and is primarily a reactive serous effusion that accumulates between the renal fibrous capsule and perirenal tissue. It should be borne in mind that the perinephric tissue is separated from the retroperitoneal tissue by means of a thin fascial plate, as well as from the proper capsule of the kidney. Therefore, reactive effusion begins to accumulate not in the thickness of the fatty capsule of the kidney, but between it and the fibrous capsule, which is located in the form of a thin anechoic strip 1-3 thick. This layer is directly adjacent to the fibrous capsule of the kidney and, as it were, exfoliates the perinephric tissue. At the same time, it is clearly defined along the posterior surface of the kidney, and also emphasizes the lower pole. Retroperitoneal exudation is a polyetiological symptom that may be caused by an inflammatory focus in the retroperitoneal tissue, most often of cologne and pancreatogenic origin. However, with a colonogenic origin, it is always possible to identify a connection between the exudation either with the wall of the colon, or with the area of the atypically located locatable appendix. In this case, the exudation is outward from the fatty capsule of the kidney. To determine the stage of inflammation and its form, the syndrome of focal lesions of the kidney parenchyma is verified. Morphologically destructive pyelonephritis can be represented by apostematous inflammation, carbuncle formation or kidney abscess. Apostemes are a small focus of purulent inflammation against the background of ischemic parenchyma. The size of the focus is so small that even with high-

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frequency scanning it is not perceived as a focal lesion of the parenchyma. Therefore, there are no direct symptoms of apostematous pyelonephritis. The presence of this form of destructive pyelonephritis can be assumed when there is a combination of an obvious gray-scale parenchymal edema syndrome with signs of impaired blood supply to the parenchyma, and in a low-speed angle-independent mode - power Dopplerography. At the same time, symptoms of an uneven diffuse reduction of intrarenal blood flow are detected. The degree of reduction heterogeneity can act as a prognostic criterion for the transformation of serous pyelonephritis into apostematous. There are even schemes for scoring the degree of reduction of renal blood flow by M. Bertolotto. But for the verification of apostematosis, it is more important not so much the degree of blood flow reduction as its heterogeneity, but without the formation of foci. Therefore, ultrasound diagnosis of apostematous nephritis, even with the use of duplex scanning, is only probabilistic in nature and should be combined with clinical and laboratory data of acute destructive pyelonephritis.

The timely detection of a carbuncle of the kidney is extremely important prognostically. Since the renal carbuncle is not, in the strict sense of this term, a cavity filled with pus, as is the case with soft tissue carbuncle, its ultrasonic semiotics is not as obvious as it seems. Kidney carbuncle is, first of all, a zone of irreversible ischemic damage to the parenchyma, which is focal in nature. Therefore, the verification of the carbuncle of the kidney is identical to the detection of the syndrome of focal lesions of the kidney parenchyma against the background of the edema syndrome. In the grey-scale mode, the initially formed carbuncle zone is detected as a local thickening of the parenchyma, significantly larger than in neighboring segments. At the same time, the echogenicity of the parenchyma and its structure in this zone do not differ from the neighboring ones. But in the power Doppler mode, this zone will be characterized by signs of an inhomogeneous reduction in intrarenal blood flow, which are characteristic of apostematosis.

As the destructive process develops, the echogenicity of the parenchyma in the carbuncle zone increases, the ischemia zone begins to differentiate from the surrounding parenchyma due to greater echo density, heterogeneity and macrofocal structure. In this case, the shape of the ischemia zone is first close to wedge-shaped (with a wide base to the kidney capsule), then this shape is lost and the ischemia focus becomes rounded. Finally, there is a slight decrease in the echogenicity of the central parts of the ischemic focus, but without the formation of zones of structurelessness. Moreover, if there is a clear decrease in the echogenicity of the central zone, then, as a rule, we are talking about abscess formation of the focus of ischemic destruction and the formation of a kidney abscess, which is more favorable prognostically, since it implies the delimitation of the purulent process. With the progression of carbuncles, their multiple nature, there is an increase in the syndrome of focal lesions of the parenchyma without signs of delimitation of each of them. When duplex scanning in the mode of power Dopplerography, foci of intrarenal blood flow reduction are clearly defined, mainly in the cortical layer with the phenomenon of non-uniform amplification or attenuation of the density of color vascular signals along the periphery of the lesion.

Kidney abscess as an outcome of acute destructive pyelonephritis is quite rare. Kidney abscess, as a rule, is of a specific nature (tuberculosis). However, sometimes it can be the result of banal inflammation. At the same time, in the gray scale mode, the syndrome of focal lesions is determined in the renal parenchyma. In contrast to the carbuncle, the zone of central hypo-anechoic lesion predominates without signs of concomitant diffuse edema of the parenchyma. The edema has a local perifocal character and is represented by a narrow strip of heterogeneous, often hypoechoic parenchyma. It should be noted that the destruction zone is also heterogeneous - its peripheral part is practically anechoic, while the central one is of moderately reduced echogenicity. In the power Doppler mode, the picture is similar to that in carbuncle, with the only difference that it is not possible to detect signs of an increase in the density of perifocal vascularization of the parenchyma.

Pulse Doppler with an assessment of high-speed flows (main renal artery, segmental branches in the area of the renal sinus, interlobar and arcuate branches) in the primary and differential diagnosis of acute pyelonephritis is nonspecific. Multidirectional disorders of the main blood flow are recorded, caused by an increase in peripheral resistance in the cortical vessels against the background of acute inflammation of the parenchyma. Nevertheless, as a method for quantifying the effectiveness of the treatment of acute pyelonephritis in terms of the dynamics of the peripheral resistance index, the pulsation index, and the systolic-diastolic coefficient, pulsed Dopplerography seems to be a very clear and effective method.

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Based on a combination of signs, including an increase in the size of the kidney, thickening of the parenchyma, a diffuse increase in its echogenicity, a decrease in sound conductivity, heterogeneity and inhomogeneity of the cortical layer, the appearance of the phenomenon of "protruding pyramids" in combination with a decrease in respiratory mobility, perirenal exudation and edema of the parenchyma of the kidney, sonographically objectify the acute inflammatory process. Identification of foci of intrarenal blood flow reduction during duplex scanning in the power Doppler mode indicates the transition of serous inflammation to purulent inflammation and makes it possible to differentiate its forms (apostematous nephritis, carbuncle, abscess).

Material and methods

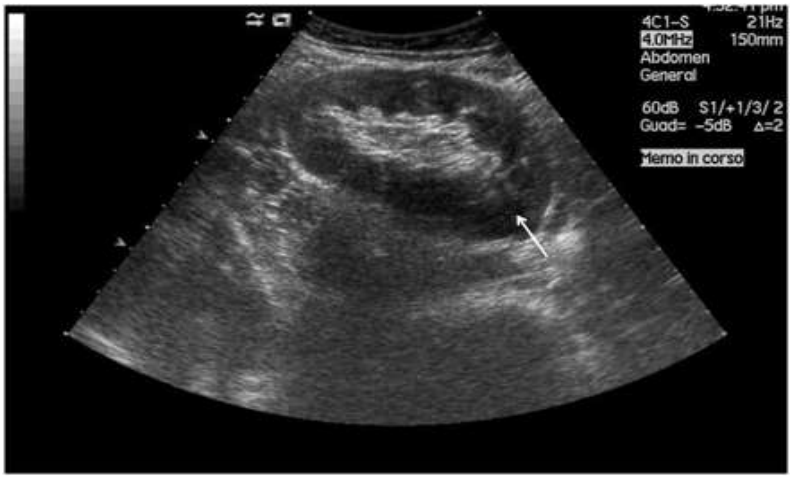
We considered patients admitted to our unit with a clinical diagnosis of APN, who underwent both CEUS and gadolinium-enhanced MRI. The two diagnostic techniques were performed in a blinded manner by two different operators after informed consent was obtained. MRI was performed after CEUS. We used a 6C2 probe for the detection of renal parenchymal changes, including the Cadence™ CPS technology, which is a low mechanical-index (MI) technique with a transmission frequency of 2.0 MHz. We injected a 2.4-mL bolus of the US contrast agent sulphur hexafluoride (SonoVue™, Bracco, Milan, Italy) flushed with 10 mL of normal saline solution. Triangular areas of decreased perfusion visible on both longitudinal and axial scans were considered indicative of APN. The CPS scanning was done at low output power (MI = 0.2). To depict the wash-in/wash-out characteristics, at the peak of the enhancement, a short period of high output power (MI >1) was used to destroy all the bubbles in the scanning field. After such a period, there was visible replenishment of bubbles from outside the field by a new wash-in of bubbles. This manoeuvre enabled repeated evaluations of temporal patterns of enhancement. In addition, all patients underwent MRI examination (Achieva 1.5T, gradient 30 mT, Philips, Best, the Netherlands), performed within 12 h after the CEUS studies had been completed, using 10 mL of i.v. gadobenate dimeglumine (Multihance™ 0.5 M, Bracco, Milan, Italy) contrast agent (flow 1 mL/s), with a slice thickness of 2 mm. Areas of decreased attenuation of the renal parenchyma visible immediately after contrast injection, or areas of increased attenuation on the delayed scans, were considered indicative of APN.

Results

Thirty-seven out of 56 patients (66.1%) resulted positive for APN with the reference test, gadolinium-enhanced MRI. Thirty-five out of these 37 patients showed positive results for APN with CEUS, and 19 patients showed negative results for APN with both MRI and CEUS: sensitivity 95% (CI 82–99), specificity 100% (CI 83–100), accuracy 96% (CI 88–99), positive predictive value 100% (CI 90–100), negative predictive value 90% (CI 71–97) and K statistics 0.92 ($P < 0.01$).

Conclusions

Our results suggest, for the first time, the feasibility of CEUS, a low-cost and low-risk diagnostic procedure, in the diagnosis of APN in kidney using doppler ultrasound.



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References

1. CT, MR imaging, and power Doppler US in an experimental pig model. Radiology. 2001;218 (1): 101-8. Radiology (full text) - Pubmed citation
2. Johnson PT, Horton KM, Fishman EK. Optimizing detectability of renal pathology with MDCT: protocols, pearls, and pitfalls. AJR Am J Roentgenol. 2010;194 (4): 1001-12. doi:10.2214/AJR.09.3049 - Pubmed citation
3. Zagoria RJ. Genitourinary radiology, the requisites. Mosby Inc. (2004) ISBN:0323018424. Read it at Google Books - Find it at Amazon
4. Jennette JC, Heptinstall RH. Heptinstall's pathology of the kidney. Lippincott Williams & Wilkins. (2007) ISBN:0781747503. Read it at Google Books - Find it at Amazon
5. Foxman B, Klemstine KL, Brown PD. Acute pyelonephritis in US hospitals in 1997: hospitalization and in-hospital mortality. Ann Epidemiol. 2003;13 (2): 144-50. Ann Epidemiol (link) - Pubmed citation
6. Fukami H, Takeuchi Y, Kagaya S, Ojima Y, Saito A, Sato H, Matsuda K, Nagasawa T. Perirenal fat stranding is not a powerful diagnostic tool for acute pyelonephritis. (2017) International journal of general medicine. 10: 137-144. doi:10.2147/IJGM.S133685 - Pubmed
7. Chen WL, Huang IF, Wang JL, Hung CH, Huang JS, Chen YS, Lee SS, Hsieh KS, Tang CW, Chien JH, Chiou YH, Cheng MF. Comparison of acute lobar nephronia and acute pyelonephritis in children: a single-center clinical analysis in southern taiwan. (2015) Pediatrics and neonatology. 56 (3): 176-82. doi:10.1016/j.pedneo.2014.08.002 - Pubmed
8. Conley SP, Frumkin K. Acute lobar nephronia: a case report and literature review. (2014) The Journal of emergency medicine. 46 (5): 624-6. doi:10.1016/j.jemermed.2013.08.097 - Pubmed
9. Mariya Belyayeva, Jordan M. Jeong. Pyelonephritis, Acute. (2018) Pubmed
10. Wolfgang Dähnert. Radiology Review Manual. (2011) ISBN: 9781609139438
11. Belyayeva M, Belyayeva JJ, Belyayeva. Acute Pyelonephritis. (2021) . doi: - Pubmed