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Assessment of the relation between pelvicalyceal dilatation in ultrasound and features of obstructive uropathy in dynamic renal scintigraphy

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Abstract

BACKGROUND: Ultrasound is the first-line imaging in the diagnostics of the urinary system. It provides valuable morphological information, but its usefulness in assessment of the function of renal parenchyma is limited. Dynamic renal scintigraphy provides much more accurate information about parenchymal function of kidneys and urinary outflow. The aim of the study was to establish morphological ultrasound criteria for high likelihood of obstructive uropathy.
MATERIAL AND METHODS: 59 patients (38 women, 21 men, between 18 and 82 years old, average age 50) with the pelvis dilatation > 10 mm in one or both kidneys newly diagnosed in ultrasound, without earlier history of kidney and urinary tract diseases or renal surgery. A total of 79 kidneys were included in the study.
Ultrasound and dynamic renal scintigraphy were performed on the same day. In ultrasound, maximum anteroposterior diameter of the renal pelvis (mAPD) and anteroposterior pelvic diameter at hilum (hAPD) were obtained. The ratio of total pelvicalyceal area to the whole kidney area (%PCS) was also calculated. Uropathy was determined by the positive diuretic test in renal scintigraphy performed using 111 MBq of 99mTc-EC.
RESULTS: In dynamic renal scintigraphy, features of uropathy were found in 18 out of 79 kidneys (23%). Optimal thresholds for detection of obstructive uropathy for measured ultrasound parameters were determined based on the ROC curves: mAPD ≥ 23 mm (sensitivity 94%, specificity 76%, accuracy 80%, AUROC 0.91) hAPD ≥ 20 mm (sensitivity 78%, specificity 87%, accuracy 85%, AUROC 0.82) PCA/WKA ≥ 22% (sensitivity 83%, specificity 74%, accuracy 76%, AUROC 0.85)
CONCLUSIONS: Determined thresholds of parameters measuring pelvicalyceal dilatation in ultrasound, including the easiest one to obtain in routine diagnostics — mADP, provide satisfactory effectiveness in isolating kidneys with high likelihood of obstructive uropathy. Their application can optimize the selection of patients for further kidney diagnostic imaging (dynamic renal scintigrapy or urography).

KEY words: diagnostic techniques and procedures, urinary tract, scintigraphy, ultrasonography, hydronephrosis

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Introduction

Imaging studies play an important role in the diagnosis of urinary tract diseases. They provide information, both morphological and functional, allowing a comprehensive assessment of the kidneys, ureters and bladder. The methods used in renal imaging include ultrasound (USG), X-ray examinations: urography and computed tomography (CT), and magnetic resonance (MR), as well as, nuclear medicine methods — dynamic renal scintigraphy (DSN) and static scintigraphy.

Ultrasonography is the most commonly used modality in the diagnostic imaging of the urinary system. It allows visualizing kidneys in the form of a two-dimensional image obtained in real time. It is a non-invasive, cheap and relatively simple study characterized by an absence of exposure to ionizing radiation [1–3].

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Ultrasonography provides valuable morphological information, but the assessment of renal function is limited and of an indirect nature. There are no specific values of morphological parameters to assess urinary retention in the renal pelvicalyceal system (PCS). The assessment of the dilatation of a calyx and pelvis is not directly related to the presence or severity of urinary outflow disorders. On the basis of an analysis of blood flow in kidney arteries in Doppler ultrasound, it is possible to determine the resistance index (RI), whose value increases in the early urine retention in PCS, but due to technical difficulties of measurement and its low repeatability, this method is not used in routine ultrasound examination [4–7].

Due to doubts, when and with what credibility a physician performing ultrasonographic assessment of the urinary tract can draw conclusions on renal urine outflow disorders, the aim of the study was to determine the morphological ultrasound criteria that may suggest the presence of obstructive uropathy and indicate the need to refer a patient to a deeper, specialized diagnostics of the urinary system (such as urography or dynamic renal scintigraphy).

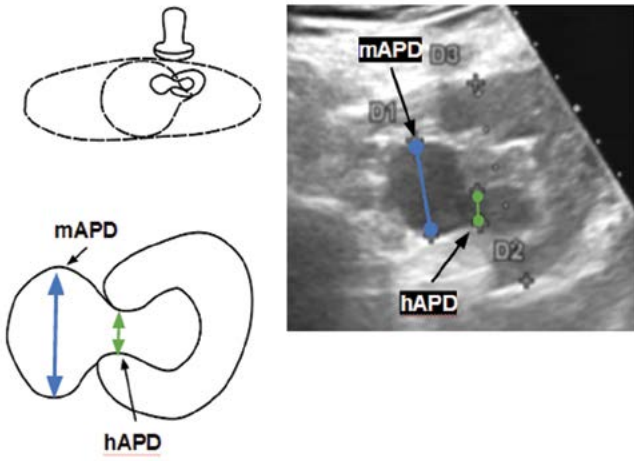

Figure 1. PCS cross-section of the right kidney in ultrasound and the place where the values of mAPD and hAPD are measured

Material and methods

The study included 59 patients (38 women, 21 men, aged 18 to 82 years, mean age 50) referred to DSN, who were diagnosed in the USG for the first time as having PCS dilatation exceeding 10 mm in one or both kidneys. The study included 79 kidneys without the history of previous or current diseases. In each of the patients, USG of the urinary system and dynamic renal scintigraphy were performed on the same day.

Ultrasound was performed after emptying the bladder, in the prone position. The location and size of kidneys, the presence of focal lesions in the parenchyma, and features of urinary retention in the PCS were assessed.

Dynamic renal scintigraphy was performed on Mediso Nucline AP, Infinia Hawkeye, Infinia Hawkeye 4 or Optima NM/CT 640 cameras equipped with low-energy general purpose collimators (LEGP) according to the standard protocol. Studies were carried out after previous patient hydration (500 ml water approx. ½ h before the study) and after emptying the urinary bladder immediately before the examination. Image registration was initiated at the time of intravenous injection of 111MBq 99Tc-EC, obtaining 60 twenty-second images within 20 minutes, in a matrix 128 x 128 in the posterior projection, with the field of view encompassing both kidneys and heart.

In ultrasound examinations, apart from the typical assessment of the urinary tract, 3 parameters were also evaluated in terms of their usefulness in detecting retention in PCS:

— mAPD — the maximum dimension of the pelvis in the antero-posterior projection (in the cross-section) [8],
— hAPD — the dimension of the renal hilum measured in the antero-posterior projection (in cross-section) [8],
— % PCS — the percentage ratio of two areas: PCS field and a whole kidney field on the image in the B presentation.

These parameters were determined as follows:

— mAPD — in the first place the largest dimension of the kidney was obtained in the long axis, then the probe was rotated by 90 degrees and in this cross-section of the kidney, the pelvis was measured in the widest dimension (Figs 1, 3a).
— hAPD — in the same section in which mAPD was assessed the largest dimension of the pelvis in the renal hilum was measured (the distance between the two edges of the hilum in its maximum width) (Figures 1, 3a).
— % PCS — the probe was applied in the middle axillary line, in such a way as to obtain a frontal cross-section of the kidney (image depicting the kidney in the long axis with the pelvis on one side and the cortex on the opposite side of the kidney). In the obtained image, an operator outlined the field of the dilated PCS and the cross-sectional area of the whole kidney using ultrasound software (Figures 1, 3b).

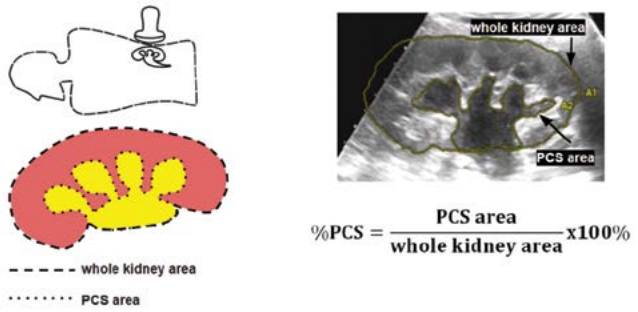

Figure 2. Schematic image of the frontal cross-section of the right kidney with marked cross-sectional areas of the entire kidney and of the PCS

In dynamic renal scintigraphy using 99m Tc-ethylenedicysteine (EC), a sequence of 1-minute summation images and shapes of renographic curves were evaluated. Impaired renal outflow from kidneys was diagnosed on the basis of a positive diuretic test (F + 20 protocol). A lack of decline in the cumulative renographic curve after intravenous administration of 0.5 mg / kg. furosemide or a decrease in this curve by less than 50% of the original value were accepted as criteria of obstructive uropathy. The ultrasound and DSN results were compared with each other.

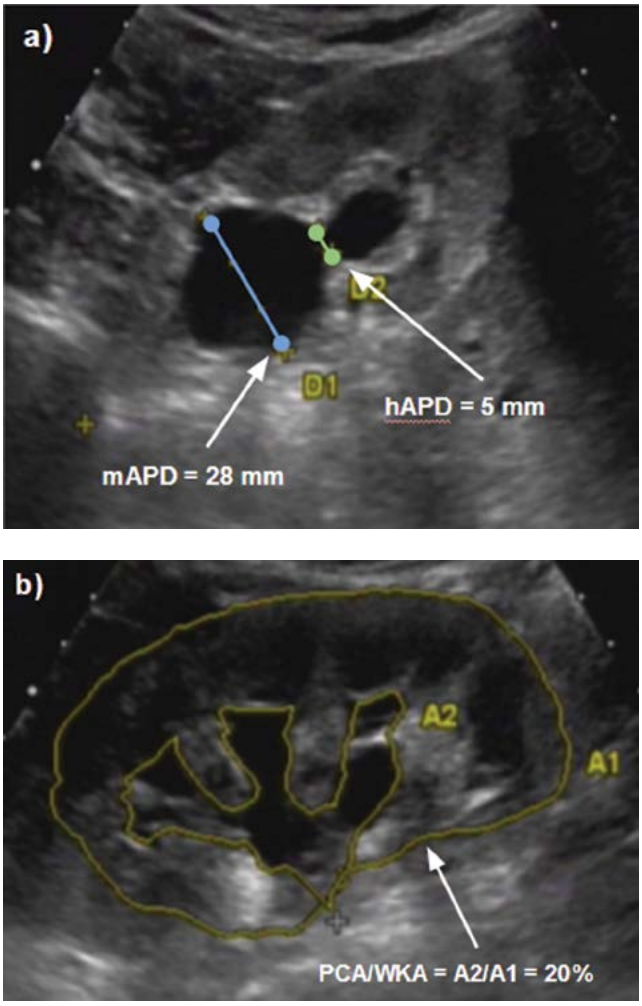

Figure 3. Measurement of mAPD, hAPD (a) and% PCS (b) values in a kidney with dilated renal pelvicalyceal system

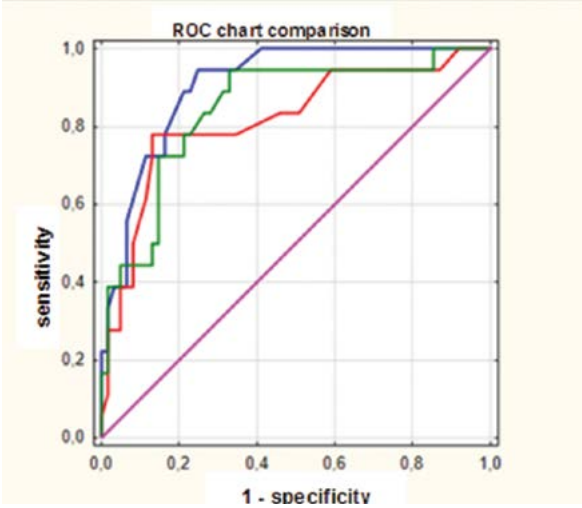

Figure 4. Comparison of areas under ROC curves. mAPD (blue) — 0.91 (0.84, 0.97); hAPD (red) — 0.82 (0.70, 0.94); % PCS (green) — 0.85 (0.74, 0.95); Reference line (pink color); Differences between AUROC areas — NS

Table 1. Diagnostic efficacy of decision thresholds selected for ultrasound parameters

	Threshold	Sensitivity (%)	Specificity (%)	Accuracy (%)
mAPD	23 mm	94	76	80
hAPD	20 mm	78	87	85
%UKM	22%	83	74	76
mAPD or %UKM		100	62	71

Statistical methods

The diagnostic usefulness of ultrasound measured parameters (mAPD, hAPD, % PCS) in the detection of uropathy in DSN was analyzed using ROC curves. For each parameter, a ROC curve was created where an optimal threshold value was selected for the classification and the AUROC (area under the ROC curve) with 95% confidence interval was taken as the overall suitability of the given model. Statistical analysis was developed using the Statistica v12.0 software.

Results

Features of obstructive uropathy in dynamic renal scintigraphy were detected in 18/79 kidneys (23%). The AUROC values for all ultrasound parameters were high and did not significantly differ from each other (Fig. 4). Based on the ROC curves, the optimal decision thresholds of USG parameters were determined for the detection of obstructive uropathy. Basic indices of diagnostic efficacy for the determined parameters are presented in Table1.

Discussion

A physician performing a routine ultrasound of the urinary system may see an image of the dilated renal pelvicalyceal system in different situations. The widening of the renal pelvis occurs most often due to impeding urine flow by a kidney stone or narrowing of the ureteropelvic junction. If the obstacle in urine outflow to the bladder is removed (e.g. surgical removal of the deposit), the kidney pelvis does not have to return to the previous dimensions and sometimes its ultrasound image is widened. Dilatation of PCS may also be a consequence of pyelonephritis — post-inflammatory changes may disturb the morphology of the pelvicalyceal system and give an atypical image of uropathy in ultrasound. Another potential source of errors is filled the urinary bladder. When it is strongly filled, it may cause widening of PCS in an ultrasound study.

In order to avoid measurement errors, which could result from the above-mentioned factors, only kidneys without previous diseases were included in the study, and the study was carried out after emptying the bladder.

Ultrasound examination should be primarily characterized by high sensitivity in the detection of pathology. One of its basic tasks is the selection of patients suspected of, among others, disturbances of outflow and who require further, in-depth diagnostic

imaging (e.g. urography, renal dynamic scintigraphy, CT) to determine their character and etiology.

The analysis of ROC curves shows that each of the three assessed morphological indices is characterized by good efficacy in detection of obstructive uropathy. Due to the highest sensitivity, mAPD was considered the most useful parameter in routine USG of the urinary system.

Measuring the % PCS parameter is more time-consuming and more difficult to perform, but it can be useful in patients with mAPD in the vicinity of the decision threshold value. The statistical analysis shows that if the threshold value is exceeded by at least one of the parameters (mAPD or % PCS), the sensitivity of the test is very high (in our material it reaches 100%). This makes it virtually impossible to overlook any patient with obstructive uropathy during qualification for further, in-depth imaging (scintigraphic or urographic) to confirm obstructive uropathy, which is necessary due to the relatively low specificity of morphological parameters.

On the other hand, it should be noted that the absence of dilatation of the urinary tract does not exclude blocking the outflow of urine from kidneys. In the renal colic, PCS may remain unextended because the obstruction of urine outflow is too short to widen the pelvis. It is assumed that in this case, the increasing urinary pressure in the PCS results in diminished diastolic blood flow in the kidney parenchyma by increasing the resistance index (RI) and pulsation (PI). Increased value of the resistance index returns to the original values along with the widening of the urinary tract, so its measurement in the diagnosis of renal urine outflow disorders can only be applied in cases of acute renal colic [9, 10].

Conclusions

Preliminary studies have shown that the use of established thresholds for decision-making parameters determining the widening of PCS in ultrasound is characterized by satisfactory diagnostic efficacy (and especially high sensitivity) in the detection of obstructive uropathy. Their application allows optimizing the selection of patients for further — functional imaging of the urinary system (dynamic renal scintigraphy or urography). Further analysis of the clinical usefulness of the introduced parameters will also include the assessment of their repeatability (inter- and intraobserver reproducibility).

References:

1. Harvey C, Hare C, Blomley M. Renal Imaging. Medicine. 2003; 31(5): 18–28, doi: 10.1383/medc.31.5.18.27655.
2. Walentowicz M, Krzemiński D, et al. Z Kopański, Imaging methods used in the diagnostics of urinary system disorders related to haematuria. Journal of Clinical Healthcare. 2017; 93(3): 20–24.
3. Kaur R, Juneja M. Comparison of Different Renal Imaging Modalities: An Overview. Advances in Intelligent Systems and Computing. 2017: 47–57, doi: 10.1007/978-981-10-3373-5_4.
4. Wieczorek AP, Woźniak MM, Tyloch JF, Errors in the ultrasound diagnosis of the kidneys, ureters and urinary bladder. J Ultrason. 2013; 13(54): 308–318, doi: 10.15557/JoU.2013.0031, indexed in Pubmed: 26674139.
5. Sebastian A, Tait P. Renal imaging. Medicine. 2007; 35(7): 377–382, doi: 10.1016/j.mpmed.2007.04.011.
6. Scout LM, Taylor K. The Kidney. . In: Taylor K, Burns P, Wells P. ed. Clinical Applications of Doppler Ultrasound. Raven Press, New York : 157–159.
7. Neiman H, The Urinary System. In: Goldberg B ed. Textbook of Abdominal Ultrasound. Williams & Wilkins 1993: 356–359.
8. Alkan M, Tiryaki S, Özbek SS, et al. The Maximum Anteroposterior Diameter of Renal Pelvis Changes by Hydration in Cases of Ureteropelvic Junction Obstruction. Turkiye Klinikleri Journal of Pediatrics. 2013; 22(3): 105–109.
9. Rodgers PM, Bates JA, Irving HC. Intrarenal Doppler ultrasound studies in normal and acutely obstructed kidneys. Br J Radiol. 1992; 65(771): 207–212, doi: 10.1259/0007-1285-65-771-207, indexed in Pubmed: 1547446.
10. Miletić D, Fuckar Z, Sustić A, et al. Resistance and pulsatility indices in acute renal obstruction. J Clin Ultrasound. 1998; 26(2): 79–84, indexed in Pubmed: 9460635.