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Ultrasound screening for pyelectasis in pregnant women. Clinical necessity or "art for art's sake"?

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Abstract

Renal pelvicalyceal dilatation is caused by urine retention in the upper urinary tract. It is referred to as pyelectasis in medical literature. This term does not indicate the cause that leads to the dilatation of and urine retention in the renal pelvicalyceal system. Mild pelvicalyceal dilatation during pregnancy is usually considered to be physiological in nature – it can occur in up to 90% of pregnant women. Retention is more common in the right kidney, in primigravidae, in the second half of pregnancy and in multiple pregnancies. Pyelectasis during pregnancy rarely causes clinical symptoms and often does not require treatment. Nevertheless, urine retention in the renal pelvicalyceal system is conducive to the development of asymptomatic bacteriuria and may be a risk factor for recurrent urinary tract infections, pyelonephritis and acute kidney failure; it may also cause renal colic. In consequence, this condition can lead to intrauterine infection and premature labor in the pregnant woman and to prematurity, anemia, congenital pneumonia or sepsis in the child. In a study conducted at the 3rd Department of Gynecology of the Medical University of Lublin it was concluded that unilateral pyelectasis of more than 20 cm^3 is associated with a significant increase in the risk of asymptomatic bacteriuria. This volume corresponds to grade 3 and/or 4 pelvicalyceal dilatation according to the Society for Fetal Urology/European Federation of Societies for Ultrasound in Medicine and Biology classification. The pyelectasis volume measuring method using three-dimensional ultrasound scanning included in the criteria for the assessment of asymptomatic bacteriuria was assessed as sensitive and specific. The ultrasound-based evaluation of the kidneys for the presence of pyelectasis and its grade in pregnant women has some clinical implications. It allows for identifying cases with an increased risk of asymptomatic bacteriuria, which requires treatment in pregnant women. Screening during pregnancy for pyelectasis seems to be important in preventing asymptomatic bacteriuria from progressing to symptomatic urinary tract infection.

Introduction

Renal pelvicalyceal dilatation is caused by urine retention in the upper urinary tract (UUT). Renal pelvicalyceal dilatation is called pyelectasis in the available literature on the subject. This term does not indicate the cause that leads to the dilatation of and urine retention in the pelvicalyceal system. The pathomechanism of pyelectasis usually involves impaired draining of urine from the kidney, i.e. obstructive uropathy, which may be unilateral or bilateral, complete or partial. Pyelectasis is also caused by non-obstructive factors. Pelvicalyceal dilatation can also be of various sizes and may be found in the renal pelvis alone as well as in the pelvis and major and minor calyces. Mistaking severe pyelectasis for hydronephrosis is a common misunderstanding. Hydro-

nephrosis is present if urinary retention has led to the thinning of the renal parenchyma and is usually associated with the risk of renal cortex damage. In contrast, pyelectasis does not lead to parenchymal damage and kidney function deterioration, which is an important difference between the two conditions and affects the selection of treatment[1–3].

Pregnancy has an impact on the urinary tract function. During pregnancy kidney length increases by 1–1.5 cm and returns to its previous size within 6 months of delivery[4]. Christensen *et al.* demonstrated an increase in kidney volume in 24 healthy pregnant women, despite it being initially associated with pyelectasis[5]. Kidney volume increases during pregnancy by approximately 30% and is associated with the development of renal vessels and with growing interstitial volume, but not with a change in the number of nephrons[6,7].

Other changes observed in the urinary tract of pregnant women are associated with the compression of the ureters by the pregnant uterus, high blood progesterone level as well as glycosuria and proteinuria, which occur periodically during pregnancy. Urine pH and estrogen level also increase. Progesterone reduces the tone of muscle tissue and reduces the rate of ureteral peristalsis, leading to urinary tract hypotonia. These factors may contribute to the development of pyelectasis[4].

Mild renal pelvicalyceal dilatation during pregnancy is usually considered to be physiological in nature and may be present in up to 90% of pregnant women. Retention is more common in the right kidney, in primigravidae, in the second half of pregnancy and in multiple pregnancies. In 62% of pregnant women pyelectasis is larger in the right kidney than the left one, in 32% retention is even in both kidneys, and in 6% these proportions are reversed. The higher propensity towards right kidney retention is due to the more superficial course of the right ureter and compression of a twisted uterus to the right as well as the protective effect of the sigmoid colon on the left ureter. Pyelectasis resolves up to a few weeks after delivery[8–12].

Renal pelvicalyceal dilatation is rarely symptomatic in pregnant women. However, impaired urine draining causes its retention in UUT. This is conducive to bacterial proliferation and can lead to bacteriuria[5,6,9].

There are currently no diagnostic standards for kidney assessment in pregnant women. For this reason, this problem should receive more attention than before. Pyelectasis in the renal pelvicalyceal system can lead to the development of hydronephrosis, renal colic, recurrent urinary tract infections and, in rare cases, to acute renal failure in a pregnant woman[13–15]. Considering the fact that ultrasound examination is currently a relatively simple and a very popular procedure, the present author would like to draw more attention to the problem of pyelectasis in pregnant women.

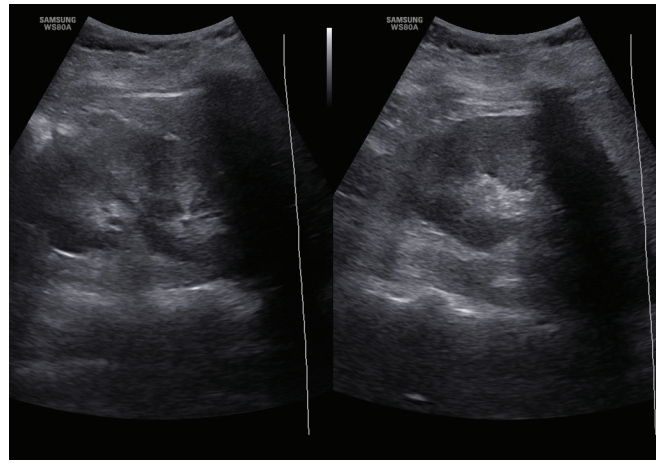

Fig. 1. *Ultrasound assessment of the right kidney. Longitudinal section of the organ on the right, transverse section on the left. On both images a hypoechoic area consistent with the dilatation of the renal pelvis is visible in the middle of the central field*

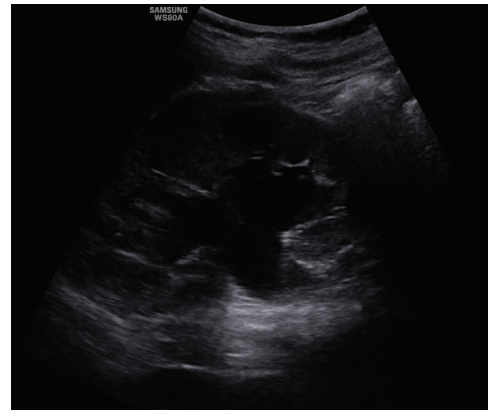

Fig. 2. *Ultrasound assessment of the right kidney (longitudinal section). Visible dilatation of the pelvis and major calyces*

Fig. 3. *Ultrasound assessment of the right kidney (longitudinal section). Visible dilatation of the pelvis and of major and minor calyces*

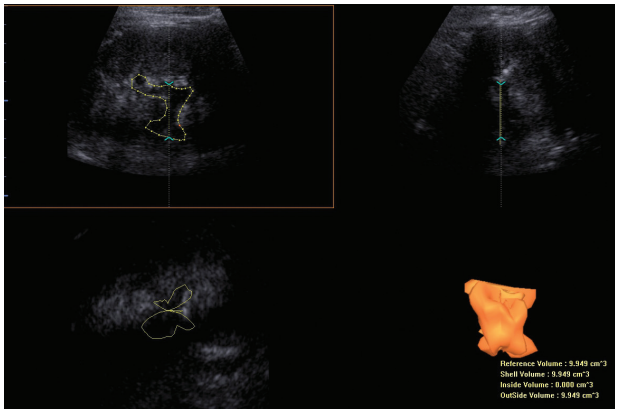

Fig. 4. *Three-dimensional ultrasound assessment of urine retention volume in the pelvicalyceal system. The VOCAL software has been used for volume calculations. Estimated pelvicalyceal volume = 9.95 cm³. The case presented in Fig. 1*

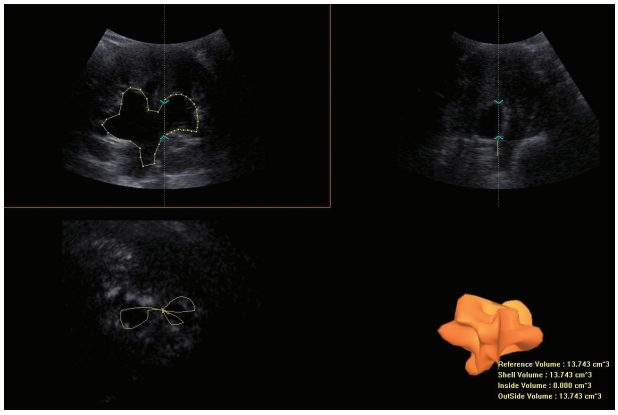

Fig. 5. *Three-dimensional ultrasound assessment of urine retention volume in the pelvicalyceal system. The VOCAL software has been used for volume calculations. Estimated pelvicalyceal volume = 13.74 cm³. The case presented in Fig. 2*

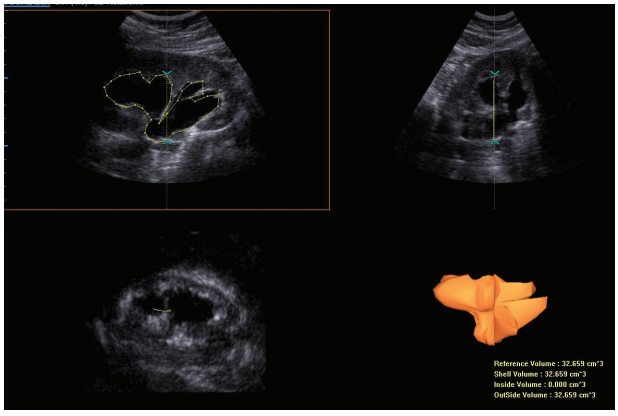

Fig. 6. *Three-dimensional ultrasound assessment of urine retention volume in the pelvicalyceal system. The VOCAL software has been used for volume calculations. Estimated pelvicalyceal volume = 32.66 cm³. The case presented in Fig. 3*

Evaluation of pyelectasis in pregnant women

The normal ultrasound image of a kidney shows three distinct elements. The outermost, hyperechoic border is the fibrous capsule of the kidney, while the hypoechoic middle layer is the renal parenchyma, which encompasses a hyperechoic central field – the pelvicalyceal system. Pyelectasis is not present if the central field is homogeneous and hyperechoic. Pyelectasis can be diagnosed if pelvis- or pelvis and calyces-shaped anechoic areas are observed in the central field (Fig. 1, Fig. 2, Fig. 3)[1,2,16].

According to the Polish Ultrasound Society (*Polskie Towarzystwo Ultrasonograficzne*, PTU) standards, if pelvicalyceal dilatation is found, the diameter of calyces, the pelvis and renal parenchyma thickness should be measured in order to determine the grade of the condition. The measurement of renal parenchyma (the hypoechoic middle layer) thickness enables to differentiate between high-grade pyelectasis and hydronephrosis. PTU also allows subjective assessment of pelvicalyceal dilatation grade to be made, with the use of phrases such as "small", "medium" and "large" retention[2,17].

The volume of pyelectasis, and, consequently, that of urine retention in UUT is calculated in pregnant women hospitalized at the 3rd Department of Gynecology of the Medical University of Lublin. During routine examinations after 20 weeks of gestation both kidneys are additionally assessed using three-dimensional ultrasound scanning (3D US). The procedure is performed with a 4–8 MHz transabdominal convex volume transducer (3D probe) with a frontal width of 38.1 mm, imaging field of 77.2° and 128 elements, which is consistent with PTU standards[2]. During the examination, the pregnant woman lies in a supine position as well as on her left and right side. The examination is performed with the pregnant woman breathing steadily and while holding her maximum breath volume[2]. Once the longitudinal section of the kidney has been visualized and pyelectasis has been diagnosed, 3D US of the kidney is performed. Pyelectasis (urine retention) volume is calculated using the VOCAL software (Medison/Samsung); the examination result is expressed in cm³ (Fig. 4, Fig. 5, Fig. 6). Urine culture is taken twice in pregnant women with a diagnosed uni- or bilateral pelvicalyceal dilatation[18–21].

Based on this examination protocol in 2007–2008 an analysis was conducted in which urine culture results were correlated with pyelectasis volume. It was assumed that the number of colony-forming units (CFU) in the pelvicalyceal system depends on the size of the environment in which they develop[20]. Thus, larger urine retention volume in the renal pelvicalyceal system represents a larger reservoir for multiplying bacteria, affecting the level of bacteriuria and the associated clinical implications. A hypothesis was made that based on the volume of urine retention in the renal pelvicalyceal system it is possible to predict an increased risk of urinary tract complications in the pregnant woman mentioned in the introduction to this paper and take appropriate preventive measures.

The study included 48 pregnant woman with diagnosed unilateral pyelectasis in the right kidney. The examined patients did not report any symptoms of dysuria.

Bacteriuria was found in 81.2% of pregnant women with diagnosed unilateral pyelectasis. Substantial bacteriuria ($\geq 10^5$ CFU/ml) was present in 35.4% of patients with concomitant right kidney pyelectasis. The median (Mdn) urine retention volume in pregnant women with substantial bacteriuria was significantly larger that in patients with non-substantial bacteriuria ($\leq 10^5$ CFU/ml) (Mann–Whitney $U = 59.50$; $p < 0.001$).

The median pelvicalyceal volume in pregnant women with substantial bacteriuria was 24.48 cm^3 (range: 20.59–33.20 cm^3) vs Mdn = 10.69 cm^3 (range: 8.77–16.79 cm^3) in patients with non-substantial bacteriuria. Pelvicalyceal volume of over 20 cm^3 was found in 81.2% of pregnant women with substantial bacteriuria and in 9.3% of pregnant women with non-substantial bacteriuria. Positive linear correlation was found between pelvicalyceal volume and bacteriuria ($r_S = 0.5207$, $p < 0.001$)[22].

The study was continued in a group of 127 pregnant women with diagnosed unilateral pyelectasis in order to determine confidence intervals (CI), sensitivity, specificity, odds ratio (OR) and likelihood ratio (LR) of the method. The required CI was 95%. The sensitivity of the tested method was 0.90 (CI: 0.82–0.94), while its specificity was 0.86 (CI: 0.72–0.94). Positive LR was found to be 6.66 (CI: 2.93–15.09) and negative LR was 0.11 (CI: 0.06–0.21). OR was 57.60 (CI: 17.92–185.08). The 3D US method for the measurement of pelvicalyceal retention volume in pregnant women was evaluated as sensitive and specific in the assessment of substantial bacteriuria risk during pregnancy[23].

Discussion

Under normal conditions urine is sterile; it is only in the distal urethra that saprophytic bacteria can be found. The urinary tract can be colonized via the ascending route or as a result of blood-borne spread. However, the presence of bacteria in urine (bacteriuria) is not tantamount to the diagnosis of urinary tract infection (UTI).

Bacteriuria is evaluated as substantial if urine culture test reveals at least 100 000 (10^5) of live bacteria (CFU) in 1 ml of urine (CFU/ml) collected from the middle of the stream in asymptomatic patients. There are also other criteria for the diagnosis of substantial bacteriuria, which, however, refer to symptomatic patients and as such they have not been included in the present paper[18,21].

Asymptomatic bacteriuria (ABU) should be understood as the presence of substantial bacteriuria with the concomitant lack of clinical symptoms of UTI. ABU is the mildest clinical form of UTI, which, despite the lack of complaints, is still a common and controversial clinical problem in everyday clinical practice[18,19,21].

It is currently believed that ABU should be detected only in those patients who can benefit from its treatment. For this reason, a bacteriological test is the standard of care in pregnant women, children (aged 6–8 years), diabetics, patients awaiting urologic surgery and individuals with a history of kidney transplantation[19–21,24].

Asymptomatic bacteriuria during pregnancy can lead to symptomatic UTI and have serious consequences both for the pregnant woman and her child[8,11,20].

At this point one should ask about the actual aim of pyelectasis volume measurement in pregnant women. From the clinical standpoint it seems important to differentiate between pyelectasis and hydronephrosis since hydronephrosis leads to impaired renal function that can have a significant impact on the course of pregnancy. The diagnostic criteria for hydronephrosis are clearly defined[2].

Renal pelvicalyceal dilatation is observed only in humans and in apes which assume an erect body posture and it is never found in quadrupeds[13]. This condition almost always coexists with ureteral dilatation, although it never occurs distal to the linea terminalis[13]. It is still not entirely clear whether the cause of pyelectasis/hydronephrosis during pregnancy is the impact of progesterone and estradiol on the smooth muscle tissue of the urinary tract, mechanical compression of the ureters or a combination of both these factors. The latest studies have demonstrated that the effect of uterine compression on the ureters is the decisive factor[5,6,9,11].

Pyelectasis during pregnancy rarely causes clinical symptoms and often does not require treatment. Nevertheless, urine retention in the renal pelvicalyceal system is conducive to the development of ABU and may be a risk factor for recurrent urinary tract infections, pyelonephritis and acute kidney failure; it may also cause renal colic. In consequence, this condition can lead to intrauterine infection and premature labor in the pregnant woman and to prematurity, anemia, congenital pneumonia or sepsis in the child[5,6,9,11]. Due to the complex geometric shape of the renal pelvicalyceal system, the measurement of this structure is difficult. The criteria proposed by PTU involving the measurement of pelvis and calyx diameters as well as subjective criteria are very difficult in clinical interpretation due to the variety of pelvicalyceal system types, among other aspects, which is not mentioned in the PTU criteria[25].

The use of 3D US in the assessment of pyelectasis volume is a very sensitive and specific method for the assessment of an increased risk of ABU in pregnant women[23]. It was concluded that pelvicalyceal system volume of more than 20 cm^3 is associated with a significant increase in the risk of ABU and that quantitative assessment of urine retention allows for very precise monitoring of the increase or reduction of pyelectasis[22]. According to the author 3D US/VOCAL measurement of pelvicalyceal dilatation grade should be the reference method.

Unfortunately, three-dimensional ultrasound is currently a costly procedure and there are few devices with transabdominal 3D convex transducer as standard equipment. In addition, the VOCAL software-based method for the calculation of renal pelvicalyceal volume is complicated and time-consuming. For this reason, this method cannot be currently used for screening since it does not meet the criteria of common availability and ease of performance.

The present author has applied the division proposed by the Society for Fetal Urology (SFU) as a screening method for the assessment of pyelectasis volume[26,27]. Similar criteria for the assessment of pelvicalyceal dilatation are recommended by the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB)[3,28]. This division includes 5 grades:

- grade 0 – kidney with no renal pelvicalyceal dilatation;
- grade 1 – dilatation of the renal pelvis;
- grade 2 – dilatation of the renal pelvis and major calyces;
- grade 3 – dilatation of the renal pelvis and major and minor calyces with renal cortex unaffected;
- grade 4 – dilatation of the renal pelvis and major and minor calyces with cortical thinning (hydronephrosis);

The method proposed by SFU and EFSUMB requires basic ultrasound equipment, is not time-consuming and is not based on subjective evaluation.

The comparison of pyelectasis volume calculated using 3D US/VOCAL with the SFU/EFSUMB classification demonstrated that:

- grade 1 correlates with renal pelvicalyceal volume of up to 10 cm^3 (Fig. 1, Fig. 4).
- grade 2 correlates with renal pelvicalyceal volume of between 10 and 20 cm^3 (Fig. 2, Fig. 5).
- grade 3 (and 4) correlates with renal pelvicalyceal volume of over 20 cm^3 (Fig. 3, Fig. 6).

Conclusions

Based on the presented study it has been concluded that unilateral pyelectasis volume of over 20 cm^3 is associated with an increased risk of asymptomatic bacteriuria; this volume corresponds to SFU/EFSUMB grade 3 and 4 pelvicalyceal dilatation. The 3D US-based method used for the assessment of renal pelvicalyceal volume has been evaluated as sensitive and specific.

With reference to the question posed in the title of the present study, it should be concluded that ultrasound assessment of the kidneys for the presence of and the extent of pyelectasis in pregnant women does indeed have some clinical implications. It allows for identifying cases with an increased risk of asymptomatic bacteriuria, which requires treatment in pregnant women. Screening during pregnancy for pyelectasis seems to be important in preventing asymptomatic bacteriuria from progressing to symptomatic urinary tract infection.

Conflict of interest

Author does not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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