Genitourinary Pediatric Ultrasonography: Basic Techniques, Tips and Pitfalls.

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ABSTRACT

Sonography is a robust modality and the mainstay of pediatric radiology, but has a steep learning curve. There are several ways to exploit the full capacity of sonography. This paper first provides a specific overview regarding how to manage gas within the abdomen in children, which is essential in sonography. There are also many tips and pitfalls when using sonography in the genitourinary system in children. This article thus describes basic sonography techniques along with some tips and possible pitfalls.

Keywords: Ultrasonography, Ultrasound, Sonography, Pediatrics, Genitourinary, Bladder, Kidney, Ovary, Uterus, Vagina

INTRODUCTION

Sonography is a robust modality and the mainstay of pediatric radiology, but it has a steep learning curve. Beginners arepuzzled by how more experienced operators can easily identify organs or diseases. There are several ways to exploit the full capacity of sonography. This article provides information on sonography, which is divided into two sections: "basic techniques" and "tips and pitfalls."

BASIC TECHNIQUES

Gas is undesirable for sonography because it obstructs the penetration of ultrasound waves. There are several ways to address this issue: deep breathing, changing the patient's position, use of a compression technique, waiting, and use of a sonographic window. The two simplest techniques are deep breathing and changing the body position. These are effective because they change the relationship between the target organ and the gas. For example, deep breathing allows the liver or spleen to cover the target organ, serving as a sonographic window. However, inexperienced practitioners use these two techniques frequently, which may be burdensome to patients and sometimes difficult because of uncooperative patients.

An alternative to these options is the compression technique, although initially its potential benefits may be underestimated. Compression of the abdomen can move gas away from the front of the target organ in various situations. As the benefits of compression have been particularly emphasized in the diagnosis of appendicitis (1-3), this technique is extremely useful and mastering it is one of the keys to success in the use of sonography. Another simple technique is waiting, which refers to two different options: The first involves attempting the selected procedure again after a few minutes, after waiting for the gas to move away. The second option involves re-examination to determine whether the bladder is sufficiently distended. Appropriate distention of the bladder is essential when evaluating it, especially when. the wall of a collapsed bladder appears severely thickened and irregular, re-examination is necessary for precise evaluation (Figure 1).

If a bladder is sufficiently distended, it can be used as a sonographic window (Figure 1b). A sonographic window is a strong ally and its use is another key to mastering sonography. For example, if a uterus is obscured by gas (Figure 2a), sliding a probe caudally can allow its evaluation through the bladder (Figure 2b). This sonographic window technique is also applicable to evaluation of the ovaries. If an ovary is obscured behind the pelvic wall or iliac vessels, sliding the ultrasound probe to the contra-

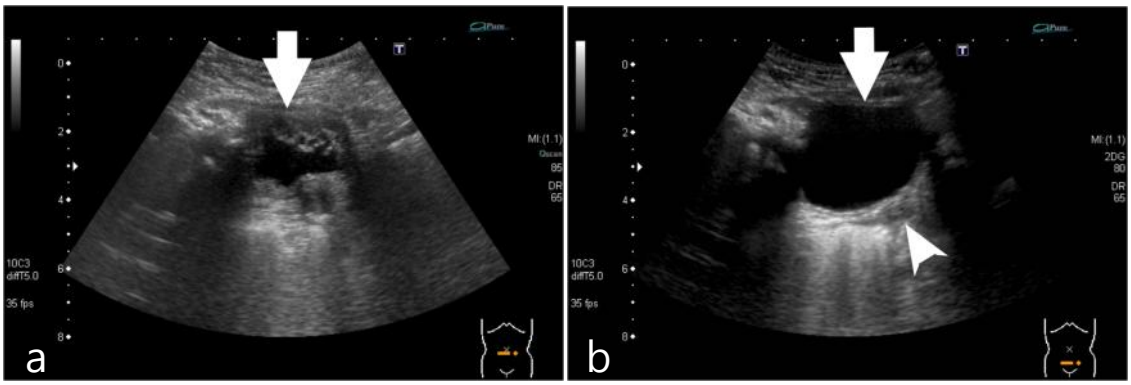


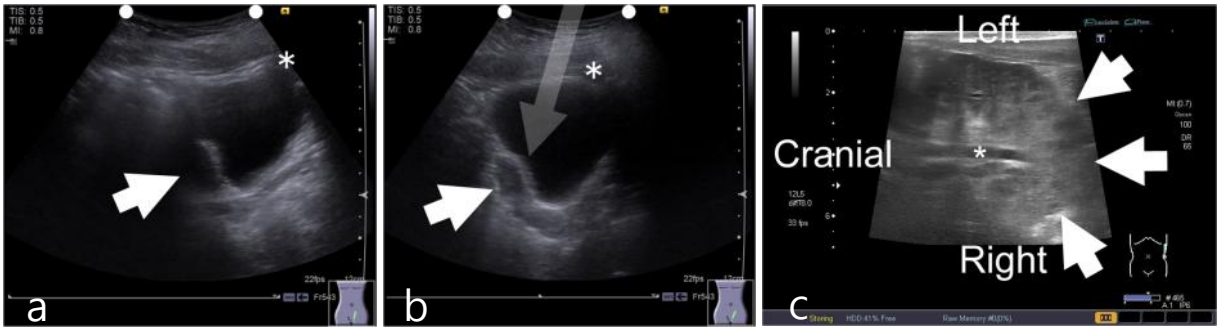
Figure 1: Importance of distention of the bladder to evaluate pelvic organs.

A 4-month-old female presenting with urinary tract infection. (a) Initial sonography: The bladder wall (arrow) appears severely thickened and irregular, while the bladder is collapsed. (b) Re-examination after 30 minutes: The bladder (arrow) is distended and its appearance has changed dramatically. There is no thickening or irregularity. Note that the uterus (arrowhead) can be clearly seen behind the bladder because the distended bladder serves as a sonographic window. This case highlights the importance of distention of the bladder to evaluate pelvic organs.

lateral side will allow a much more clear visualization of the ovary through the bladder. The flank approach is also useful to create a sonographic window in various situations (Figures 2c and d). The small body size and abundance of water in children are advantageous for this approach. Even in cases with substantial abdominal gas, the flank approach widens the sonographic field of view (Figure 2c). Furthermore, for evaluating renal arterial flow, though the front approach is commonly used, angle correction is mandatory in this view, and as the angle is often more than 60° it can lead to a large correction error. However, in the flank approach, the renal artery runs directly toward the probe, so its flow can be measured easily and accurately (Figure 2d).

TIPS AND PITFALLS

Besides learning the basic techniques, there are also



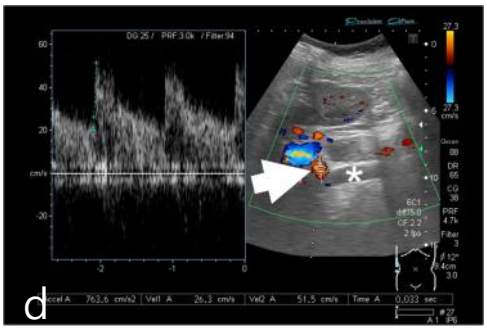


Figure 2: Various examples of the sonographic window.

(a and b) A 16-year-old female with hypogonadism. (a) Initial image obtained by a resident. The uterus (arrow) is obscured behind gas. Note that the probe position (circles) is superior to the pubic bone (asterisk). (b) Image obtained more caudally. The uterus (white arrow) is clearly seen through the bladder (translucent long arrow). Note that the sonographic probe (circles) overrides the pubic bone (asterisk) to use the sonographic window.

(c and d) Examples of the flank approach. (c) A case of a horseshoe kidney shown using the flank approach. From the front, the isthmus is not seen because of gas (not shown). The left flank approach clearly depicts the isthmus of the horseshoe kidney (arrows) overriding the aorta (asterisk). (d) Renal arterial velocity measurement using the flank approach. The renal artery (arrow) runs directly towards the probe, allowing correct and easy assessment of its velocity with the flank approach. *Asterisk: abdominal aorta.

many tips and pitfalls of which practitioners need to be aware. Some of these are outlined in this section.

1) Bladder

Adequate bladder distention is essential, as mentioned above. Evaluation of a collapsed bladder wall leads to overestimation of its irregularity (Figure 1). Re-examination is necessary in this situation.

Congenital cystic dilatation of the lower ureter into the bladder is known as ureterocele (Figure 3a). Recognition of ureterocele is important because this is frequently associated with other anomalies (4). For example, a duplex kidney is commonly accompanied by a ureterocele. An upper ureter has a caudal ectopic insertion, and a lower ureter has an orthotopic insertion (the Weigert-Meyer rule) (5). An upper ectopic ureter can be the cause of urinary incontinence in girls. Even in cases without apparent ectopic insertion, ureterocele, which frequently has a connection with an upper part of the ureter, causes obstruction of urinary flow, resulting in hydronephrosis of the upper moiety of the kidney (Figure 3b). On the other hand, a lower orthotopic ureter is associated with vesicoureteral reflux. Ureterocele can be a sign used for the simple prediction of these abnormalities. If ureterocele is present in the bladder, a careful search for double renal pelvis and associated abnormalities should be carried out by the radiologists.

2) Kidney

In the setting of ureterocele, hydronephrosis of the upper moiety occurs, leading to atrophy. An atrophic upper

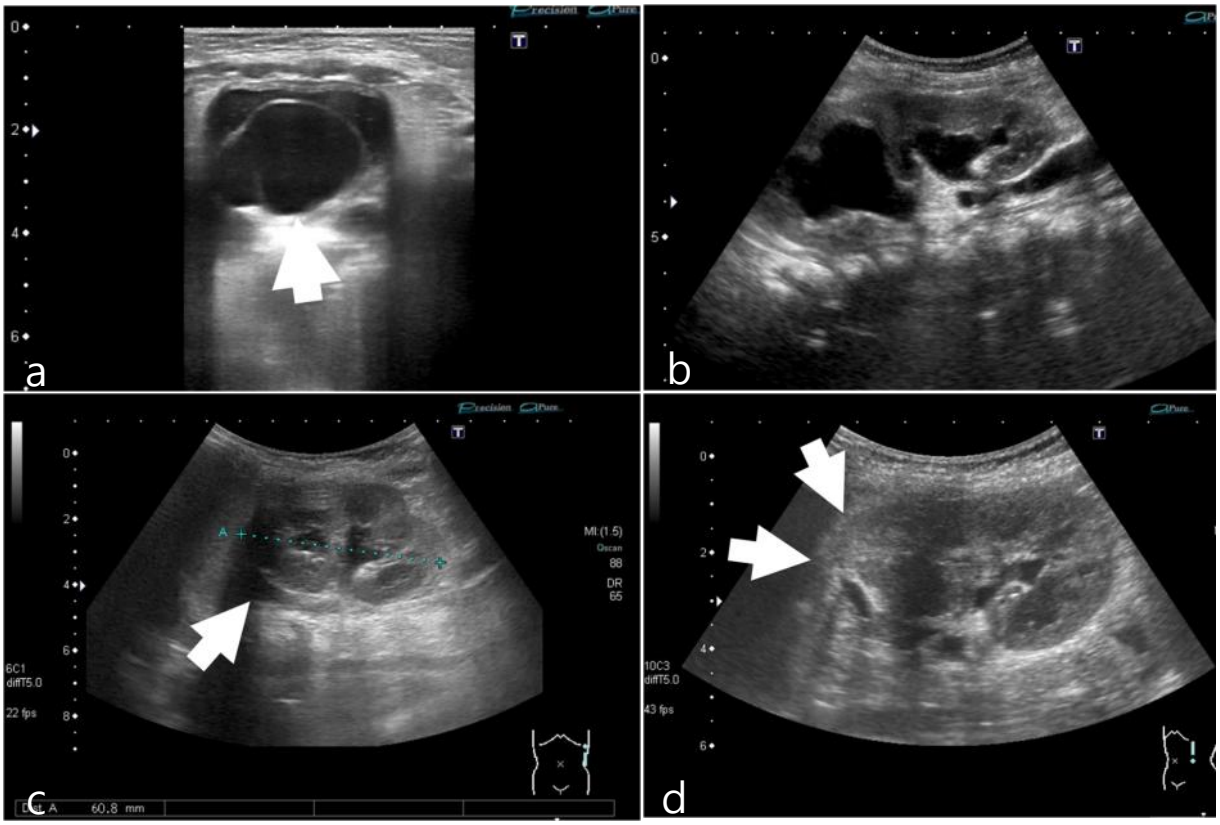


Figure 3: Cases of ureteroceles with in duplex renal system (double renal pelves).

(a and b) A 9-month-old female with urinary tract infection. There is a cystic structure (arrow in a) in the bladder, suggesting ureterocele. There is also hydronephrosis, especially in the upper moiety (Figure b), due to urinary obstruction by ureterocele.

(c and d) A 1-year-old boy with urinary tract infection. Ureterocele is present in the bladder (not shown), implying the need for careful observation. Figure c shows the kidney length measurement by a resident. However, it is not appropriate because the upper ureter (arrow in c) is also depicted, suggesting the existence of an upper moiety. Careful observation reveals the upper moiety with atrophy (arrows in d).

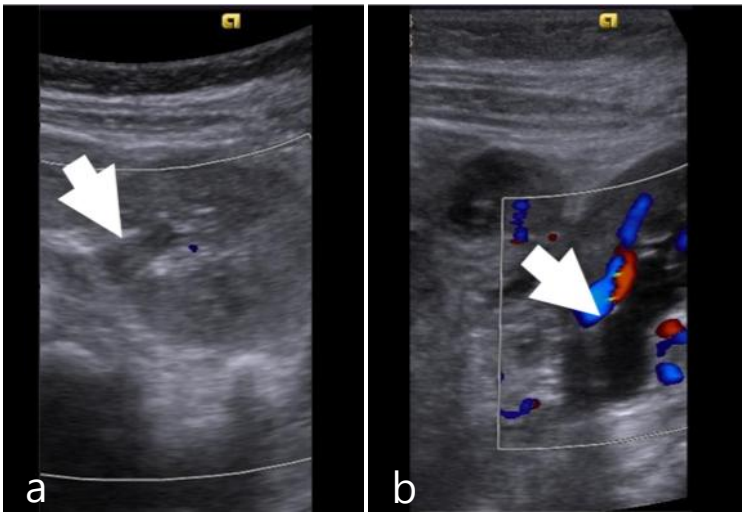


Figure 4: Hydronephrosis after urination, suggesting vesicoureteric reflux in a 3-month-old boy with urinary tract infection

Renal pelvis before (a) and after (b) urination.

There is pelvic wall thickening (arrow in a), but no dilatation. After urination, pelvic dilatation occurred (arrow), suggesting vesicoureteric reflux. The presence of reflux was confirmed on a subsequent voiding cystourethrogram.

moiety frequently escapes observation because this region is often difficult to be seen due to overlying gas (Figures 3c and 3d). This is a frequently encountered problem. Therefore, in cases of ureterocele, a meticulous search for an atrophic upper moiety is particularly important.

If there are indentations in the surface of the kidney, we have to differentiate scars and fetal lobulations, between which there are several differences (6, 7). First, the indentations of fetal lobulations are present between renal pyramids. Second, parenchymal thinning is not a feature in fetal lobulations. On the other hand, scars are usually present over the renal pyramids with parenchymal thinning, occasionally accompanied by pelvic dilatation. Third, fetal lobulations are sharply defined, but scars are wider and less well defined.

When assessing the kidneys after renal biopsy, we have to check for perirenal hematoma, extravasation, and iatrogenic arteriovenous fistula (AVF). To check for AVF, it is necessary to adjust the velocity range on color Doppler images. If the range is inappropriate, aliasing will mask the existence of AVF. This is also a common problem for inexperienced practitioners.

Neonates occasionally urinate during sonography. Although beginners might be embarrassed by this and do not know how to handle the wetting, in such cases, however, we should not let go this gold opportunity to instantly examine for any renal pelvic dilatation because hydronephrosis immediately after urination suggests vesicoureteric reflux (Figure 4) (8). Rapid screening for pelvic dilatation is thus recommended immediately after urination.

3) Ovary

To assess the ovaries, they must first be found. However, this is sometimes difficult. In contrast, the uterus is easy

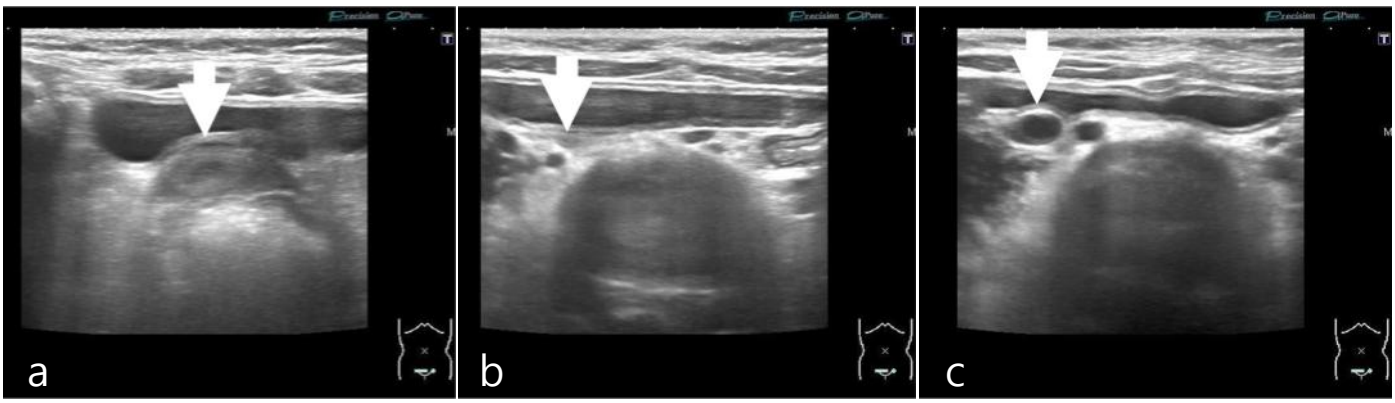


Figure 5: "Follow the fallopian tubes" to find the ovaries: the fallopian tubes as a guide to the ovaries (in an 11-year-old girl) Although the ovaries are difficult to find, the uterus is easy to find because of its location in the center of the pelvis (arrow in a). From the uterus, there is a guide to the ovary, namely, the fallopian tube (arrow in b). By following the fallopian tube, we can find the ovary (arrow in c).

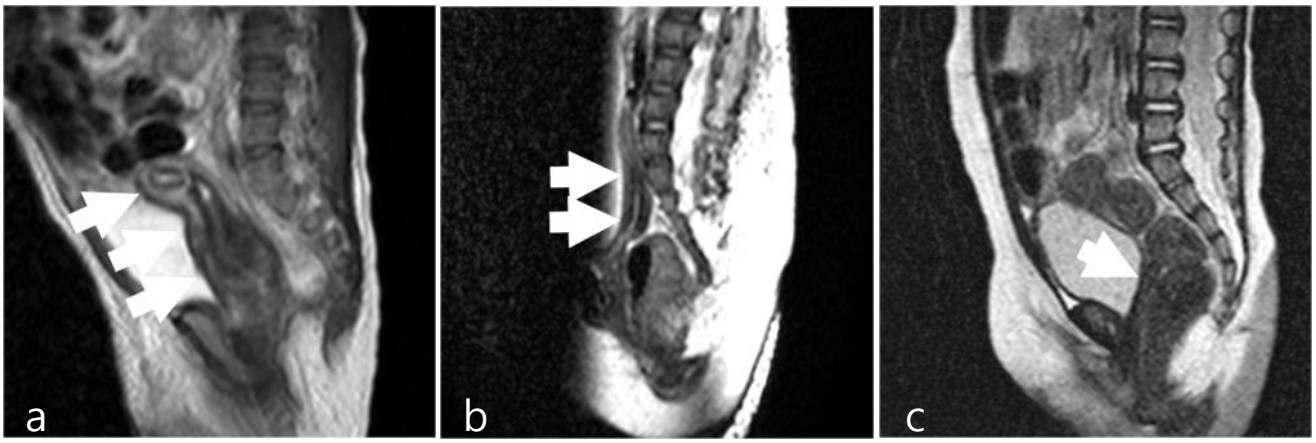


Figure 6. Uterine change on MRI according to age. a) 3 days old, b) 3 months old, c) 5 months old. A few months after birth, the uterus (arrows) becomes small until puberty. During this period, the recognition of uterine anomalies is difficult. In cases with suspicion of a Mullerian duct anomaly, examination should be performed soon after birth.

to find, being located in the midline. Upon finding the uterus, this provides a guide to the ovaries via the fallopian tubes that connect the two (Figure 5). Although the importance of recognition of the uterine broad ligaments or the fallopian tubes has not been the focus of attention here, this is extremely important in assessing the ovaries by sonography. To find the ovaries, the instruction to "follow the fallopian tubes" is useful (Figure 5).

There are also cases in which the ovaries cannot be found in the pelvis in neonates. In such cases, we also have to search for the ovaries in the upper abdomen. The neonatal ovaries can easily ascend to the upper abdomen because of their loose fixation and the small neonatal pelvic cavity.

If a cystic structure is found, how can it be confirmed to be an ovary? One answer to this is continuity with the uterus, as stated above (Figure 5). However, there are also cases in which the continuity cannot be confirmed because of gas. Another way to resolve this is identification of the "daughter cyst sign." Small follicles adjacent to the mass suggest that the mass is the ovary (9, 10).

Figure 7. Cases with urogenital anomalies.

(a and b): A 12-year-old female with abdominal pain at menarche. Pelvic sonography shows a duplicated uterus (arrows in a) and hydrometrocolpos in the right hemi-vagina (arrow in b), causing abdominal pain at menarche. Concomitant with right renal agenesis (not shown), these findings suggest OHVIRA.

(c and d): Screening of a 9-year-old female. There is evidence of agenesis of left kidney in this patient (not shown). On pelvic sonography, a duplicated uterus is seen: duplicated cervix uteri (arrows in a) and a right uterine body (arrowhead) (the left uterine body is not shown in this figure). Concomitant with these findings, fluid collection in the left hemi-vagina (arrow in b) suggests OHVIRA.

4) Uterus and vagina

If a uterine anomaly is suspected, when should we check it? Uterine size and shape change according to age (7, 11-15). The uterus is prominent at birth due to maternal and placental hormones. Then, a few months after birth, the uterus becomes small until puberty, so uterine anomalies are easily missed. Therefore, in the case of ambiguous genitalia or a renal anomaly (see below), a search should be made for uterine anomalies soon after birth (7).

Besides the association between the kidneys and the bladder, there is also an association between the kidneys and uterovaginal anomalies; that is, renal anomalies and uterovaginal anomalies often coexist. Typically, renal agenesis is accompanied by a duplicated uterus with the obstruction of hemi-vagina or hemi-uterine cervix, resulting in fluid collection. The above phenomenon is known as Herlyn-Werner-Wunderlich syndrome or obstructed hemi-vagina and ipsilateral renal anomaly (OHVIRA) (16-18). These terms are complicated, but it is more important to be aware of the association between the kidneys and the utero-vagina than to know the terms themselves. Obstructed hemi-cervix or hemi-vagina can cause abdominal pain at menarche (menstrual molimina) (Figures 7a and b). We should thus always keep in mind that urogenital anomalies, namely, Wunderlich syndrome or OHVIRA, can cause abdominal pain at menarche.

This is a typical presentation of Wunderlich syndrome and seems to be easy for pediatric radiologists to diagnose. However, these features are frequently misdiagnosed initially by clinicians. To prevent this, we should identify such patients without any symptoms by sonography screening. If a renal anomaly is incidentally found on sonography performed for various reasons, we should also search for utero-vaginal anomalies (Figures 7c and d). If there is a uterine anomaly and fluid accumulation in the utero-vagina, Wunderlich syndrome or OHVIRA should be strongly suspected.

CONCLUSION

The paper has presented various basic techniques as well as tips and pitfalls in imaging genitourinary system by pediatric sonography. Radiologists should exploit the full capacity of sonography using various techniques and make a correct diagnosis based on adequate knowledge of these tips and pitfalls.

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