Sonography of fetal micturition

S. BOOPATHY VIJAYARAGHAVAN
SONOSCAN, Ultrasonic Scan Centre, Coimbatore, India

KEYWORDS: fetal micturition; hypospadias; posterior urethral valves; sonography

ABSTRACT

Objective To describe the sonographic visualization of fetal micturition and its role in the diagnosis of posterior urethral valves and hypospadias.

Methods This was a prospective study of 25 male fetuses (21 with bilateral pyelectasis, one whose bladder was being studied because of ureterocele and three with hypospadias), and five female fetuses (with bilateral pyelectasis). A midline sagittal scan of the fetal pelvis, perineum and external genitalia was obtained and observed continuously during fetal micturition.

Results In 19 of the 21 male fetuses and the five female fetuses with bilateral pyelectasis micturition was normal, with visualization of urinary bladder contraction, slight fluid distention of the urethra and a urinary stream from the external urethral meatus. In three male fetuses, two with bilateral pyelectasis and the one with ureterocele, the posterior urethra was normal at rest and it ballooned out during micturition, diagnostic of posterior urethral valves. In the three male fetuses with hypospadias the ventral jet of the urinary stream was visualized.

Conclusion Fetal micturition can be visualized on sonography. It may be of value in the diagnosis of posterior urethral valves and hypospadias. Copyright © 2004 ISUOG. Published by John Wiley & Sons, Ltd.

INTRODUCTION

Fetal micturition is a physiological event involving contraction of the urinary bladder and emptying of the urine in the bladder through the urethra into the amniotic fluid. Indirect documentation of the occurrence of micturition has been achieved using sonography by the visualization of the contraction and emptying of the urinary bladder. The urinary bladder distends and contracts cyclically and the bladder cycle has a positive linear association with advancing age1,2. In a study of fetal lambs, it was shown that in partial urethral obstruction, there is bladder overactivity3. Documentation of the stream of micturition has been reported previously in normal male fetuses4,5 and in fetuses with hypospadias6,7,8. Documentation of the complete process of micturition, i.e. the sonographic micturating cystourethrogram (MCU), has not been reported so far. This study aimed to describe the sonographic visualization of this event.

METHODS

This was a prospective study over a 3-year period (December 2000–November 2003) of two groups of fetuses at 25–35 weeks’ gestation. Included in the first group were fetuses showing bilateral pyelectasis, with an anteroposterior diameter of the renal pelvis (APRPD) measuring 10 mm or more on one side and 5 mm or more on the other side (n = 26 fetuses; 21 males and five females). We excluded those fetuses in which the cause of the bilateral pyelectasis could be determined: those with a definite diagnosis of urinary bladder outflow obstruction, such as urethral atresia, and, in the case of the males, those with the classic features of posterior urethral valves. The second group consisted of three male fetuses with features suggestive of hypospadias, namely a short and ventrally curved penis with a broad tip. One further fetus was included because of accidental visualization of a ballooning posterior urethra while studying the bladder with ureterocele.

In these fetuses an attempt was made to visualize micturition both on gray-scale and color/power Doppler sonography. Ultrasound examinations were done using an HDI 5000 (Philips Medical Systems, Bothell, WA, USA) ultrasound machine, equipped with a 2–5-MHz convex and a 5–12-MHz linear transducer. The first step was to look subjectively for a well-distended urinary...
bladder, in order to reduce the scan time. Then a midline sagittal section of the fetal pelvis, perineum and external genitalia was obtained and the same section was observed continuously for the occurrence of micturition. During micturition the urinary bladder was seen to contract, the urethra distended slightly with fluid and a urinary stream from the external urethral meatus was observed. The urinary stream could be seen on both gray-scale and color Doppler sonography. When micturition was observed, it was stored as a cine loop. This cine loop could then be reviewed as either cine or freeze frames. The micturition was also captured on a personal computer using the Dazzle digital video converter (Dazzle Multimedia Inc, Fremont, CA, USA). The study was cross-sectional with none of the fetuses being studied in a longitudinal manner during the course of the pregnancy.

RESULTS

During the study period, we observed a group of 21 male fetuses with bilateral pyelectasis, the results of which are shown in Figure 1, and five female fetuses with pyelectasis. The amniotic fluid volume was normal in all cases. In 19 of the 21 male fetuses micturition was normal, with visualization of a normal urethra. Normal micturition was seen as contraction of the urinary bladder with fluid distension of the urethra and visualization of a urinary stream from the external urethral meatus (Figure 2; Videoclip S1). This could also be visualized in all five female fetuses (Figure 3; Videoclip S2).

Two of the 21 male fetuses, at about 34 and 35 weeks, showed bilateral hydronephrosis and a urinary bladder that was well-distended and thick-walled.
Fetal micturition

Figure 3 Gray-scale (a) and color Doppler (b) ultrasound images of micturition in a 27-week female fetus, showing the urinary bladder (BL), the urethra (arrow) and the urinary stream (arrowhead).

Figure 4 Gray-scale ultrasound images of a 34-week male fetus with posterior urethral valves at rest (a) and during micturition (b). The posterior urethra is seen ballooned out during micturition (arrows). The urinary bladder (BL) and the urinary stream (arrowhead) are indicated.

(3 mm and 4 mm in thickness, respectively). The posterior urethra was not dilated at rest (Figure 4a). During micturition the posterior urethra ballooned out, diagnostic of posterior urethral valves (Figure 4b; Videoclip S3). These two fetuses which showed ballooning of the posterior urethra were investigated postnatally by MCU and were confirmed to have posterior urethral valves; they were managed appropriately.

The 19 fetuses with normal micturition had postnatal sonography at 4–6 weeks of age. This revealed normal kidneys in nine and these were not investigated further. Four infants had unilateral mild hydronephrosis and are under clinical follow-up. Two were shown to have unilateral pelviureteric junction obstruction. The remaining four had moderate unilateral hydroureronephrosis and were investigated with MCU. The MCU showed a normal urethra in all of them; in three there was vesicoureteric reflux and the fourth was diagnosed with primary non-refluxing megaureter. The postnatal scan in all five of the female fetuses was normal.

In the second group of three fetuses, there were two that showed features suggestive of hypospadias; in both the study of micturition showed a ventral jet from the shaft of the penis, confirming hypospadias (Figure 5; Videoclip S4). One fetus displayed hypospadias as part of penoscrotal transposition. In this fetus also the study of micturition showed a ventral jet. These three fetuses were confirmed postnatally to have hypospadias.

The 25-week fetus under investigation for ureterocele, that was included in neither the pyelectasis nor the hypospadias group, was found to have a unilateral multicystic right kidney. There was mild pyelectasis of the left kidney, the APRPD measuring 4 mm. While trying to determine to which side the ureterocele connected, there was suggestion of ballooning of the posterior urethra during contraction of the urinary bladder. Therefore, the midline sagittal section was observed as described above, which revealed a non-dilated posterior urethra at rest and ballooning of the posterior urethra during micturition suggestive of posterior urethral valves (Figure 6; Videoclip
Figure 5 Color Doppler ultrasound image of a 31-week male fetus with hypospadias showing the flow in the urethra (arrow) and the ventral jet of urinary stream (arrowhead).

S5). This fetus was confirmed to have posterior urethral valves on postnatal MCU.

DISCUSSION

This study was an attempt to visualize the entire act of fetal micturition on ultrasound and to evaluate its role in the diagnosis of anomalies of the urethra. The classic prenatal sonographic features of posterior urethral valves are bilateral hydroureteronephrosis, overdistended thick-walled urinary bladder and a dilated posterior urethra. However, when the combination of these features is applied, some cases of posterior urethral valves are missed on prenatal sonography9–13. In studies where postnatal follow-up was done for fetuses with bilateral renal pelvis dilatation, some of them were diagnosed to have posterior urethral valves11. These observations put forth the possibility of a group of fetuses with posterior urethral valves, in which the posterior urethra does not remain dilated, dilating only during micturition. This is supported by the fact that in cases of posterior urethral valve it is often noted during the procedure of MCU that the posterior urethra fails to opacify with contrast while the urinary bladder is filled and the posterior urethra typically dilates only during micturition. It is also a fact that the diagnosis of posterior urethral valve cannot be made on a retrograde urethrogram, because the valves are displaced laterally and flattened against the urethral wall by retrograde flow of the contrast agent. Thus, one of the aims of this study of sonographic visualization of fetal micturition was to look for dilatation of the posterior urethra during micturition. One group of fetuses selected included those with bilateral pyelectasis with an APRPD diameter of 10 mm or more on one side and 5 mm or more on the other side. Sonographic fetal micturition was observed in all these fetuses. In fetuses with a normal urethra, the sonographic MCU is seen as follows: as the urinary bladder contracts the urethra distends slightly with fluid and a urinary stream is seen from the urethral meatus. This is seen in fetuses of both sexes and the stream can be seen on gray-scale as well as color Doppler sonography.

In two of the male fetuses with bilateral pyelectasis and in one other fetus whose bladder was being studied because of ureterocele, the posterior urethra was not seen

Figure 6 Gray-scale ultrasound images of a male fetus with posterior urethral valves at 25 weeks resting (a) and during micturition (b). The ballooning out of the posterior urethra (arrow) during micturition is evident. The arrowhead points to the dilated lower ureter connected to a ureterocele. (c) Line diagram showing the anatomical orientation of the section. AF, amniotic fluid; BL, urinary bladder; PU, posterior urethra; R, rectum; U, ureter.
dilated at rest, but it dilated and ballooned out during micturition, similar to an MCU. This is diagnostic of posterior urethral valves. It can be concluded that in some fetuses with posterior urethral valves, the posterior urethra may not be dilated in the resting state, but dilates only during micturition. This may be the reason why some cases of posterior urethral valves were not picked up in earlier reports. So, the pathognomonic diagnostic sign of posterior urethral valves is ballooning of the posterior urethra during micturition.

In the normal male fetus, the urinary stream is seen to escape from the tip of the penis. In hypospadias the urinary stream occurs in a direction perpendicular to the shaft of penis from the ventral aspect. In one fetus the hypospadias was seen as a part of penoscrotal transposition, which I have described previously as a case report.8

In conclusion, gray-scale sonographic and color Doppler features of fetal micturition in both male and female fetuses have been described. Sonographic MCU helps to confirm hypospadias in the fetus in whom it is suspected on gray-scale imaging. Sonographic MCU is also useful in the fetus with posterior urethral valves, showing the typical ballooning of the posterior urethra during micturition even when the posterior urethra is not dilated in the resting state. It may also help in future to evaluate the function of micturition in other conditions such as urinary bladder dysfunction.

ACKNOWLEDGMENT
I thank Srambical Sreedharan, EDP, for technical assistance and Padma Ramesh for secretarial assistance in the preparation of this manuscript.

REFERENCES

SUPPLEMENTARY MATERIAL ON THE INTERNET
The following material is available from the Journal homepage:
http://www.interscience.wiley.com/jpages/0960-7692/suppmat (restricted access)

Videoclip S1 Sonographic micturating cystourethrogram in a male fetus with normal urethra.

Videoclip S2 Sonographic micturating cystourethrogram in a normal female fetus.

Videoclip S3 Sonographic micturating cystourethrogram in a 34-week male fetus with posterior urethral valves.

Videoclip S4 Sonographic micturating cystourethrogram in a male fetus with hypospadias.

Videoclip S5 Sonographic micturating cystourethrogram in a 25-week male fetus with posterior urethral valves.