The accuracy of virtual magnetic resonance cystoscopy in detection of ureterocele

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Purpose

This study aims to evaluate the application of magnetic resonance imaging-based virtual cystoscopy in patients with ureterocele compared with conventional cystoscopy as the gold standard and other imaging modalities. The accuracy and the appropriate indications of this novel modality are determined as well.

Methods and Materials

Patients:

A total of 30 children (17 girls and 13 boys) ranged from 8 to 120 months (mean age 60, median age 84 months) enrolled in this study. All the patients had duplex collecting system and l dashtim? Ectopice vaginal darim? ureterocele diagnosed with conventional cystoscopy. The patients presented various clinical histories and most of them suffered from painless hematuria or dysuria. All the cases underwent virtual MR cystoscopy after giving informed consent, following conventional cystoscopy and other imaging techniques including ultrasonography, MR urogram, VCUG, and renal scan. The interval between virtual imaging and conventional cystoscopy was between 4-14 days. The local ethics committee of our university approved the study and written informed consent was obtained from all participants.

Cystoscopy:

Conventional cystoscopy was carried out with unaware of virtual cystoscopic results using rigid 10 F cystoscope (Storz, Germany) with a field of view of 30 degrees under general or local anesthesia. The whole data achieved by cystoscopy, including the type of abnormality, number, size, and location was individually noted to be compared with MR-based virtual endoscopy and other imaging techniques.

MR-based technique:

Prior to take the source images for virtual cystoscopic examination, adequate filling of the bladder was required. For this purpose,ONE, the children started drinking water one hour before the MR study and received Lasix (5mg), as diuretic about 5 minutes before starting the examination. The intravenous 15 ML (depend wieght) of contrast medium (gadoteric acid) was administered by a power injection to make the appropriate extravesical invasion of the bladder pathologies. The MR cystoscopy started with obtaining adequate bladder distension (150 to 200 cc) in children with the primary sense of urination in supine
position. No additional bladder distention with air or extravesical bladder filling was performed in this method. Two methods, in the case of contraindication for using IV injection of contrast medium, the bladder was filled with retrograde injection of diluted medium of 10 to 15 cc meglumine in 400 to 600 cc normal saline. The three-dimensional spoiled grass echo was performed on a T1 scanner (General electric, USA) signal counter. The images were obtained by using the pulse sequences, which use the continuous phase shifting of the RF excitation pulse to spoil and eliminate the residual transverse magnetization. The effect of T2 weighted echo was reduced by using the minimum TE (2-8 ms) when combined with a short TR (30-50 ms) and moderate fillip angle of 30-40° resulting in T1 weighted images. The sequences were achieved with thin slices in multi plane and increased reconstruction matrix (320*224) and other parameters for increasing the spatial resolution. No reconstruction interval was performed and no other medication was given to the patients. The acquisition time of the sequence was 2-3 minutes.

**Image reconstruction:**

The size and filling statue of bladder and the accurate anatomy of lower urinary tract was fully observed and confirmed in all children at a coronal scout image. Subsequently the data were collected and downloaded to an independent post-processing workstation (adw 4.2). The data were transferred by using DICOM (Digital Imaging and COmmunications in Medicine) standards. The workstation was equipped with the inner surface rendering software, which was based on a shaded surface display algorithm to produce standardized interactive intravesical navigation. A central observation point was placed in the middle of bladder lumen and was advanced to each quadrant of the bladder in turn. The obtained reconstruction was standardized to view the internal surface of bladder in all areas by visualization in horizontally and vertically rotations. The overall view provided the possibility of visualizing the entire bladder surface, walls, uretric orifices, internal urethral orifice, bladder dome and trigon. When a possible abnormality was detected, it was completely evaluated from different angles. The volumetric data was associated with the powerful post processing trials and permitted imaging of the bladder surface in excellent details. The reconstruction time was about 15-20 minutes. The abnormal findings were individually determined in various characterizations including number, location, size, morphologic features and type of the ureteroceles. The results of all imaging methods were documented separately for each patient. Complications due to MR cystoscopy were recorded.

**Statistical analysis:**

Using conventional cystoscopy as the gold standard, we analyzed the results of this modality unaware from other imaging outcomes to compare the VMRC findings with
conventional cystoscopy and other imaging modalities and to determine the detection rate of MR imaging-based virtual cystoscopy in diagnosis of ureterocele.

Images for this section:

Fig. 1: Unilateral urterocele in top view
Fig. 2: Bilateral urerocle in top view
Fig. 3: other view of same patient
**Fig. 4:** Bilateral uretrocele VMRC movie.
Fig. 5: Unilateral huge urterocele VMRC movie
Results

Figure 4. A. Virtual MR cystoscopy showing the insertion of ectopic vaginal ureter and ectopic ureterocele in the vagina, B. Intravesical navigation view, showing the precise location of the ectopic ureterocele.

185x101 mm (300 x 300 DPI)

Fig.: A. Virtual MR cystoscopy showing the insertion of ectopic vaginal ureter and ectopic ureterocele in the vagina, B. Intravesical navigation view, showing the precise location of the ectopic ureterocele.

References: A. Zahiri; MRI, Paytakht Medical Imaging Center, Tehran, IRAN, Islamic Republic of.
Fig.: Comparison of detection rate in different imaging modalities for detection of ureterocele in children

References: A. Zahiri; MRI, Paytakht Medical Imaging Center, Tehran, IRAN, Islamic Republic of

All the patients tolerated the Magnetic Resonance cystoscopic procedure and no complication was reported. Images in 27 (90%) of 30 virtual cystoscopies were of high quality, with sufficient bladder capacity. The images in two examinations were suboptimal, because of inadequate bladder distention; the ureteroceles were observed in these patients but the visual defects in the peripheral sites did not permit a whole evaluation of bladder lumen.

Through the conventional cystoscopy three (10%) patients had bilateral non-ectopic ureterocele, 9 (30%) had unilateral non-ectopic ureterocele and in 18 (60%) patients, the ectopic type was observed.

Using conventional cystoscopy as the gold standard for detection of bladder pathologies, we achieved the diagnostic values for identification of ureterocele on VMRC. Evaluation of the results from different imaging modalities are compared in Table-1. Virtual cystoscopy identified all the ureteroceles, which were all with diameter of 5mm or greater. In the cases, which were of suboptimal quality, the ureterocele was detected while the bladder lumen was not completely observed. Therefore, the detection rate of the ureteroceles by VMRC was 100%. No false positive finding was in this study and the presence of ureterocele detected in virtual examination was confirmed at conventional cystoscopy. Thus, the positive predictive value of VMRC was also 100%.

Virtual cystoscopy required approximately 15-20 minutes in 28 patients. In two cases diluted contrast medium instilled to the bladder due to renal damages and high level of creatinin, and the time of VMRC was around 25-30 minutes including catheter placement.

| Table1. Comparison of detection rates in different imaging modalities for detection of ureterocele in children |
|-------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Patients                                             | US     | VCUG   | RS     | MRU    | CC      | VMRC    |
|-------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Bilateral Intravesical ureterocele                    | 3      | 2      | 3      | 2      | 2       | 3       | 3       |
| Unilateral Intravesical ureterocele                   | 9      | 4      | 7      | 5      | 8       | 9       | 9       |
| Ectopic vaginal Ureter and Ectopic Ureterocele        | 1      | 1      | 1      | -      | 1       | 1       | 1       |
| Cecoureterocele                                       | 2      | -      | -      | 2      | -       | 1       | 2       | 2       |
| Sphincteric ureterocele                               | 11     | 5      | 7      | 6      | 9       | 11      | 11      |
| Sphincterostenotic ureterocele                        | 4      | 2      | 3      | 3      | 2       | 4       | 4       |
| Blind Ureterocele                                     | -      | -      | -      | -      | -       | -       | -       |

US ultrasound study, VCUG voiding cystourethography, RS renal scan, MRU magnetic resonance urography, CC conventional cystoscopy, VMRC virtual magnetic resonance cystoscopy
Difficulties for using conventional cystoscopy such as hematuria, urethral stricture, and anterior wall involvement did not affect the procedure of VMRC. The standardized three-dimensional reconstruction reassured a complete evaluation of the urinary bladder and detection of the probable abnormalities.

Images for this section:

**Fig. 1:** A&B Virtual MR imaging of the unilatral ectopic ureterocele; the ureterocele is protruding through the urethra.

*Figure 2. A & B Virtual MR imaging of unilateral ectopic ureterocele; the ureterocele is protruding through the urethra. 177×94mm (300 × 300 DPI)*
Fig. 2: Unilateral left urterocele movie with 3 plane navigation
Conclusion

Figure 3. Different imaging modalities showing bilateral ureterocele; A. Ultrasonography, B. Functional reformatted MRU, C. Conventional Cystoscopy, D. Virtual MR Cystoscopy
169x195mm (300 x 300 DPI)
Ureteroceles associate with this abnormality particularly the ectopic type. Although these clinical complications are well known, there are few studies in improving the imaging-based detection rate. Considering the specific radiologic features of ureterocele, application of an imaging modality with the highest sensitivity and capability on visualization of the whole bladder is essential. Virtual endoscopic imaging is recently developed in various clinical conditions. However, the reliability and prognostic value of this technique are still under consideration and require more investigations. This imaging modality has already been applied in endoscopy of urinary tract, mostly based on Computed Tomography. To date, only few of studies have employed the MR imaging-based virtual cystoscopy of bladder. Virtual images of ureterocele can be achieved by the comparable views resulting from the both noninvasive procedures of CT-cystoscopy and MR-cystoscopy. The CT-based virtual cystoscopy requires administration of IV contrast medium or air into the bladder and radiation. Nevertheless, in our study, the bladder distension resulted from contrast-material-filled bladder with no gas insufflation and the patients received no radiation. The risk of allergic reactions was reduced by administration of diluted contrast medium. We did not observe the possible complications of urethral trauma or infection in three patients in which the catheter was inserted.

In all the patients, the ureteroceles were detected by using virtual MR cystoscopy. According to the high detection rate and positive predictive value of VMRC, this modality was the most sensitive and the most specific method in detection of ureterocele. The role of this method was significantly enhanced in detection of bilateral and ectopic ureteroceles. Through this minimally invasive procedure, VMRC provides information on accurate location and volume of the ureterocele due to its broad field of view and potential of manipulation through 360 degrees in every axis. It permits complete observation of bladder neck, orifices, inner surface of the lumen and trabeculations. The contrast medium in bladder provides a high attenuation gradient for visualizing the exact lesion size and intraluminal surface of bladder and orifices.

Considering conventional cystoscopy as the gold standard for detection of bladder abnormalities, this modality follows various complications including infections, perforation, stricture of urethra, and scarring. In spite of this method, VMRC is a developed non-invasive technique and no complication resulted from our study. Virtual imaging may be indicated in cases where conventional cystoscopy is inconclusive, or contraindicated and in conditions that affect the cystoscopic detection rate such as hematuria or diverticula. Furthermore, the access to the entire bladder capacity, especially the anterior bladder wall, and lumen of diverticula is intricate through
the conventional cystoscopy. The cystoscopic evaluation, detects different types of ureterocele. Otherwise, it is unable to delineate the intra-urethral extension of ureterocele and other ectopic types such as vaginal ureterocele or cecoureterocele. The possibility of reconstruction using different choices of angles and the location of observation point permits a whole visualization of bladder and allows the precise detection of complex anatomy of ectopic ureterocele in selected cases. This modality would be useful in determination of the ectopic type prior to ureterocele double puncture and intera-ureterocele fulguration. (Ref)

Typically, ultrasonography provides a whole evaluation on morphology of urinary system; duplex collecting system can alert the physicians to be aware of ureterocele. The renal parenchyma could be also evaluated by this method, since the poor renal function, dysplasia, reflux and hydronephrosis are commonly associated with ureteroceles. Ureterocele is one of the common observations, detected accidentally in sonography of symptomatic patients and the MR urogram can provide additional information to the findings. It appears as a round cyst-like structure into the bladder with thin and smooth well-defined wall. However, in overdistended bladder and duplication at the level of kidney, the ureterocele may be undetectable and only a megaureter would be observed. Many conditions may present similar to ureterocele, called as pseudoureteroceles, in which the intravesical ureter is dilated. These manifestations could result from some other urinary diseases, such as chronic inflammatory disorders, bladder tumors, calculi, and Mullerian duct cyst. The differentiation among these appearances could also be complicated in ultrasonography and cystoscopy may be required to confirm the findings of US.

Although VCUG is one of the useful methods for detection of ectopic ureterocele, the contrast medium can hide ureteroceles in the study. This technique would be practical in detection of vesicoureteral reflux in association with ureterocele and the eversion of ureterocele during urination while the patient has a small diverticulum-like ureterocele. Radionuclide renal scan is another complementary imaging technique to investigate the upper urinary tract and function of renal segments in the duplex system, but it is not useful in prediction of the ureterocele type, precise location and surgical technique.

Despite all these routine imaging modalities, VMRC detects the ectopic types superiorly and differentiate various ureterocele-like abnormalities including diverticula, dilated lower end of an ectopic ureter, ectopic ureter draining into a mesonephric duct cyst, and megaureter.

Management of ureterocele is based on different clinical factors such as the patient's age, ureterocele type, function of renal segments in duplex system, and clinical presentations. The probable complications that associate with ureterocele, composed of bladder outlet obstruction, stone formation, VUR, renal damage, infection, and incontinence, affect the
The principal goal of ureterocele management is preservation of renal function and diminution of surgical morbidity, especially in ectopic types. Several treatment strategies have been suggested for a promising surgery of ectopic ureterocele. However, the application of different treatment strategies depends on the patient's condition and the surgeon's skill. For this purpose, VMRC is a satisfactory non-invasive technique that facilitates the pre-operative evaluation of ectopic types and decision of the superior surgical procedure. Based on the same test, evaluation and follow up of the young children with duplication after surgery would be assisted to detect the location of manipulations and the probable remained parts of ureterocele or other problems in urinary bladder.

By comparing VMRC with differential results on the other complementary imaging studies, we confirmed an important role for VMRC; it may be of help in therapeutic decisions in cases with duplex system ureteroceles in the earlier stage. It is probably the most valuable imaging study for the follow-up of surgical techniques, being non-invasive and reliable. This pilot study makes the opportunity of a new experience in this new field. It found a high overall detection rate for ureteroceles specially the ectopic and bilateral types and it is useful in circumstances when conventional cystoscopy is not appropriate. However, the cost and time commitment place this novel method in grouping of potentially promising and investigational, and the long-term follow up and further radiological studies are required to achieve the statistical significance.

Images for this section:
**Fig. 1:** MRurogram of bilateral hazelnut shaped urterocele. (attention to end of ureter in both sides).
Fig. 2: posterior view of VRT MRurogram of same patient.
Fig. 3: VIRUAL MAGNETIC RESONANCE CYSTOSCOPY of same patient.
Fig. 4: VMRC movie with 3 plane navigation of same patient.
Fig. 5: Bilateral huge urterocele VMRC movie.
Fig. 6: Bilateral uretrocele in other view.
Fig. 7: Bilateral uretrocele in other view.
Fig. 8: Bilateral uretrocele in other view.
Fig. 9: Bilateral uretrocele in other view.
**Fig. 10:** Bilateral uretrocele other view.
References


**Personal Information**