Imaging of the Lower Urinary Tract in Adults

SERGE PETER MARINKOVIC, M.D., and GOPAL H. BADLANI, M.D.

ABSTRACT

Imaging of the lower urinary tract is an integral part of everyday urologic practice. Clinical application of less commonly used techniques is discussed to expand their usefulness in an ambulatory setting.

INTRODUCTION

Advances in imaging techniques have improved the accuracy of assessment of symptoms resulting from lower urinary tract dysfunction. Until recently, imaging of the lower urinary tract was in the domain of the radiologist; however, it is now common for a practicing urologist to perform transrectal ultrasonography for prostate and male infertility assessment, bladder ultrasonography for measurement of postvoiding residual urine volume, and renal ultrasonography for localization of calculi. In this paper, we review refinements in some of the available imaging techniques and the modalities on the horizon, all with the intent of improving functional assessment of the lower urinary tract. The techniques considered are: (1) videourodynamics for voiding dysfunction; (2) ultrasonography/color Doppler studies for determining urethral strictures; (3) bladder ultrasonography; (4) ultrasonography/color Doppler studies for varicocele evaluation; (5) power Doppler studies for vasculogenic impotence; (6) endourodynamics; (7) use of 5-aminolevulinic acid (ALA) during cystoscopy to detect superficial bladder cancer; and (8) dynamic fast MRI for pelvic prolapse.

VIDEouroDYNAMICS

Videourodynamics (VUDS)—the use of multichannel urodynamic measurements with concomitant fluoroscopy to define anatomy and function—has been pivotal in enhancing our knowledge of the dynamics of the bladder and outlet. The study can be of benefit in diagnosis and in implementation of a therapy with greater efficacy. Measurement of the vesical and abdominal pressures simultaneously under fluoroscopic control obtains significantly more information than does a cystogram or simple cystometry alone. Digital recording of the study allows postprocessing, storage, reproduction, and electronic transfer for remote assessment. Common indications for VUDS in our laboratory include evaluation of male and female incontinence, neuropathic bladder, bladder outlet obstruction, geriatric incontinence, urinary diversion, and undiversion (Table 1).

Videourodynamic Equipment

A multichannel urodynamics machine with C-arm fluoroscopy and a compatible table to reduce the radiation exposure of the urologist are required. The table allows imaging in the supine, sitting, and upright positions. New software allows the urologist to incorporate a patient history, standardized voiding diary, and quality of life measures into the clinical assessment. A Microsoft Office software package permits professional reproduction of the videourodynamic studies with slide-making capabilities. Statistical software is included. Electronic transfer through a modem enables remote assessment. The software calculates pressure-flow points for nomograms (e.g., Abrams and Griffith).

Despite the availability of sophisticated software, the role of the clinician is significant. Correlation of these findings with symptoms can be done only by the clinician.

Clinical Use

Assessment of Female Incontinence. In patients with mixed urge and stress urinary incontinence, recurrent stress incontinence after surgical procedures, and those with prolapse, concomitant use of fluoroscopy permits precise assessment of the bladder neck position and coaptation in the absence of detrusor contraction. Measurement of the Valsalva leak point pressure (VLPP) can be done without fluoroscopy; however, the image adds significantly in the planning of a surgical procedure. Assessment of detrusor function, both contractility and
TABLE 1. INDICATIONS FOR VIDEOURODYNAMICS

<table>
<thead>
<tr>
<th>Neurologic Disorders</th>
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<tr>
<td>Spinal cord injuries</td>
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<td>Poststroke voiding disorders</td>
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<td>Parkinson’s disease</td>
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<td>Multiple sclerosis</td>
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<td>Myelomeningocele</td>
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<td>Poor bladder compliance</td>
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Incontinence

- Intrinsic sphincter deficiency
- Failed anti-incontinence procedure

Urge incontinence

Type 2 stress incontinence

Bladder Outlet Obstruction

- Urethral obstruction in females
- Bladder neck obstruction
- Poor detrusor contractility

Neurogenic Disorders

- Autonomic dysfunction
- Post abdominoperineal resection
- Post radical hysterectomy
- Post prostatectomy

Miscellaneous

- Pretransplant evaluation
- Malfunctioning artificial sphincter
- Pediatric dysfunctional voiding
- Pelvic prolapse

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ULTRASONOGRAPHY AND COLOR DOPPLER STUDIES FOR ASSESSMENT OF URETHRAL STRICTURES

In 1985, McAninch and associates began to use ultrasonography with a 5 MHz transducer for the diagnosis and management of urethral strictures. Retrograde urethrography (RUG) has its limitations because it is a two-dimensional study that has limited precision in determining the length of a stricture and the depth of periurethral fibrosis extending into the corpus spongiosum. Inaccuracies in measurements of stricture length may also be related to the RUG being a static imaging modality and to variations in penile stretch, urethral distention by contrast medium, and patient positioning. On the other hand, ultrasonography is a dynamic, three-dimensional study without radiation exposure, making it possible to repeat the study as often as necessary without risk of gonadotoxicity. One can readily obtain cross-sectional and longitudinal images, and the procedure is well tolerated.

Initially, ultrasound gel is applied to the penis, scrotum, perineum, and any other area to be studied. Using a catheter-tipped 60-mL syringe, the external urethral meatus is injected with normal saline while simultaneous ultrasound images of the urethra are obtained with a 7.5 MHz transducer. Imaging starts with the distal penile urethra and is advanced proximally toward the bulbular urethra. After multiple instillations of saline, firm suprapubic pressure is applied so that the proximal aspect of the bulbular urethra or that area proximal to the structure is
Lower-tract imaging

Urologists use various imaging techniques to diagnose and treat urinary tract conditions. One such technique is color Doppler ultrasonography, which helps in determining the anatomic position of the arteries in the bulbar urethra while maintaining the capability to evaluate stricture length. The preoperative localization of the urethral arteries has been thought to be helpful in avoiding excessive bleeding with visual internal urethrotomy. The classic teaching is that the urethral arteries are located at 3 and 9 o’clock in the bulbar urethra, so incising at the 12 o’clock, 10 o’clock, or 2 o’clock positions should be possible. However, Chiou and coworkers found great variability in arterial location. Arteries were found 40% of the time at the 3 o’clock and 9 o’clock position, whereas in 25%, they were at the 1 o’clock to 2 o’clock and 11 to 12 o’clock positions. Color Doppler study also aids in discerning the blood flow to the corpus spongiosum.

Bladder ultrasonography for determination of postvoiding residual volumes

Urethral catheterization is the gold standard for the measurement of postvoiding residual (PVR) urine volume. However, there are some concerns about the risk of infection, discomfort for the patient, and accuracy of these measurements. Catheter studies have been found to be inaccurate in determining PVRs in as many as 26% of patients, with differences in volume of as much as 52 mL. Imaging of the bladder with ultrasound has been abundantly described, first with large, departmentally confined machines. But the 1990s have seen the advent of small, portable ultrasound machines becoming the norm in the urologist’s office.
They are a quick, simple, painless, and an accurate means to determine the PVR. Coombes and Millard\(^4\) compared portable ultrasound PVRs with catheter PVRs and found ultrasound to be as reliable as standard determinations. Because the bladder is positioned in the pelvis and can easily be distended with fluids, it can be well seen with ultrasound. Bladder ultrasonography is not limited to determining PVRs but has also been found useful in discerning the size and location of bladder diverticula, radiolucent calculi, and neoplasms. There have also been reports of using intraluminal ultrasound for the staging of bladder neoplasms, but this method has not gained widespread acceptance and is confined to a few medical centers with the appropriate imaging instruments.\(^6\)

GRAY-SCALE AND COLOR DOPPLER ULTRASONOGRAPHY FOR VARICOCELE EVALUATION

The role of varicoceles in male infertility has been studied since the late 19\(^{th}\) century.\(^{17}\) Macleod\(^{18}\) observed the particular semen qualities associated with varicoceles, including decreased sperm concentration and motility and increased numbers of sperm with abnormal morphology. Charney\(^{19}\) reported the improvement in semen quality after surgical correction of varicoceles. Tulloch\(^{20}\) stimulated interest in varicocelectomy for male infertility by reporting a pregnancy in the partner of an azoospermic patient after bilateral varicocele ligation. Now, many investigators have reported the benefits of varicocelectomy in improving semen characteristics.\(^{21,22}\)

Varicoceles, identified by physical examination, are reported to occur in 8% to 22.9% (mean 13.4%) of the general male population with no known fertility problems.\(^{23}\) The incidence of varicocele is higher in the infertile population, approaching 37%.\(^{23}\) The most common method of determining the presence of a varicocele is physical examination.\(^{24}\) However, physical examination is subjective and dependent on the examining physician, although it is easily performed, inexpensive, and noninvasive.

Demas and colleagues\(^{25}\) described diagnostic gray-scale sonographic criteria for varicoceles. A scan should demonstrate two or more veins, one with a diameter >3 mm and increasing in size with standing or Valsalva maneuver. Subclinical varicoceles (<3 mm in diameter) are difficult to palpate even with Valsalva maneuvers, yet have a role in subfertility, such that...
Surgical correction may benefit patients. The pathophysiology of varicoceles is also controversial. The critical feature is believed to be incompetent valves within the gonadal vein. This valvular incompetence results in retrograde flow through the gonadal vein that becomes exacerbated with standing or increased intra-abdominal pressure (Valsalva maneuver). Venography is the most accurate imaging modality to determine retrograde flow through the gonadal vein, but it is invasive and expensive. Recently, attention has been given to noninvasive imaging modalities for determining retrograde flow in the gonadal veins with color Doppler. Petrov and colleagues considered Doppler sonography to be more accurate than physical examination for detecting a varicocele and recommended its use to avoid more invasive imaging and therapy. Color Doppler scanning provides the urologist with more physiological information because it actually measures retrograde venous flow rather than simply venous diameter. Patients with normal-diameter gonadal veins but abnormal flow can now be identified with a quick, accurate, and noninvasive modality. Petrov and colleagues considered the finding of retrograde flow within the pampiniform plexus by color Doppler sonography to define a varicocele regardless of its diameter. Meacham and associates found 35% of their study population to have retrograde flow through the pampiniform plexus. Among 26 patients with normal semen characteristics, 31% had demonstrable retrograde flow. This result demonstrates the ability of color Doppler studies to detect varicoceles in patients with normal physical examination and a negative gray-scale sonographic examination. Still, only a third of their patients had a positive color Doppler examination. This result may support the view that only a small subset of normally fertile patients will have retrograde flow (Figs. 3 and 4).

**DOPPLER IMAGING FOR EVALUATING VASCULOGENIC IMPOTENCE**

Erectile dysfunction is associated with cavernosal arterial disease or corporeal veno-occlusive dysfunction. Intracavernosal pharmacotherapy and new oral medications have enabled the medical treatment of impotence while facilitating diagnostic evaluation of the arterial inflow or veno-occlusive mechanism. A duplex ultrasound evaluation of the arterial inflow after pharmacotherapy has been used to describe the hemodynamic events with tumescence. Duplex ultrasonography can identify abnormal cavernosal arterial inflow by measuring peak systolic velocity. It also permits indirect measurement of the veno-occlusive mechanism by measuring the cavernosal artery end-diastolic velocity. Color flow duplex ultrasonography permits accurate delineation of the penile arterial and cavernosal anatomy. However, color Doppler analysis does not allow the detection of flow in the distal ramifications of the cavernosal arteries (helicine arterioles). Recently, a new type of color Doppler ultrasonography, called power Doppler, has enabled the determination of flow through the helicine arteries.

Angiography has been considered the standard method for evaluating cavernous arterial disease. However, angiography is invasive and is associated with a complication rate of 2%–4%. Lower-tract imaging, including color Doppler and gray-scale sonography, has been a valuable alternative to angiography.

**FIG. 4.** Color Doppler image demonstrates retrograde (blue; away from transducer) flow with dilated vein. (Reprinted with permission from Meacham RB, Townsend RR, Rademacher D, Rose JA: The incidence of varicoceles in the general population when evaluated by physical examination, gray scale sonography and color Doppler sonography. J Urol 1994;151:1535–1538.)

the determination of vasculogenic impotence amenable to surgical correction. However, only the main tributaries of the dorsal and cavernosal arteries can be delineated.\textsuperscript{37} Pudendal angiography is an invasive imaging method that places the patient at risk of an anaphylactic reaction and is too costly to use for screening.

Power Doppler sonography is founded on the integrated Doppler power spectrum.\textsuperscript{38} The brightness of the Doppler reading is dependent on the number of red blood cells producing the Doppler shift. Power Doppler is angle independent, and background noise is displayed so that it increases the usable dynamic range of the scans, allowing the identification of the small helicine arteries. Sarteschi and coworkers\textsuperscript{38} were able to detect cavernosal arterial inflow in the flaccid state using power Doppler in patients with nonvasculogenic impotence. Helicine arterial inflow was not detected in the flaccid organ, suggesting that the microcirculation is not important during this hemodynamic state. With an intracavernosal al-
prostadil injection, the anatomic detail of the cavernosal arteries became apparent, demonstrating differences between the arteriogenic and nonarteriogenic disorder. The irregularities noted were a decrease in diameter (although it was not statistically significant), irregularities of the arterial wall, and a reduction in pulsatility. These differences were accentuated compared with findings on regular color Doppler scans.

Helicine arterial anatomy was different in the two study groups. Patients with normal power Doppler results all demonstrated three orders of helicine arterioles that originated from the cavernous artery, forming an acute angle. The arteriole wall was regular and pulsatile (Fig. 5). Among patients with vasculogenic impotence and normal cavernous arteries, 50% demonstrated a reduced number of helicine ramifications, usually only

**FIG. 8.** Fluorescence viewing set-up. Blue light filter in cystoscope was used to block most of blue excitation light. (Reprinted with permission from Koenig F, McGovern FJ. Fluorescence detection of bladder carcinoma. Urology 1997;50:778–779.)

one (normal = three) after alprostadil injection, which had a tendency to leave the cavernous artery at right angles and to have an irregular caliber. These patients were unable to reach rigid tumesence and had Doppler features indicative of veno-occlusive disease. Of the patients with cavernous arteries and helicine arteriole disease, none was able to achieve rigid tumesence, and all had veno-occlusive dysfunction.

Those investigators categorize patients into three groups: (1) proximal arterial damage; (2) global arterial and arteriolar damage; and (3) predominantly arteriolar damage. With proximal arterial damage (common iliac, hypogastric, internal pudendal, and common penile arteries), the peak systolic velocity in the cavernous artery is reduced, acceleration time is increased, and acceleration is decreased. Power Doppler scans will illustrate cavernous arteries with uniform caliber and helicine arterioles that are regular in disposition with normal caliber and ramifications. In these patients, the cavernous and helicine arterioles are preserved so that the veno-occlusive mechanism may still be functional in the initial phase, allowing the patient to achieve tumesence. In global arterial and arteriolar damage, all Doppler parameters are abnormal, demonstrating reduced cavernous arterial diameter, irregular caliber, and thinned and irregular-appearing helicine arterioles and first-order ramifications. Penile tumesence is not achieved in these patients. With arteriolar damage, cavernous Doppler parameters are normal. However, the arteriolar component demonstrates irregular caliber, decreased number of ramifications, and branches from the cav- erfous arteries at right angles. This pathology is evident in diabetics.

Power Doppler allows more precise determination of the morphology of the cavernous and helicine arterioles. The arterial and arteriolar morphologic changes discussed may explain the poor results obtained with penile revascularization procedures.

ENDOURODYNAMICS

Flexible cystoscopy was first described by Tsuchida and Sugawara in 1973. This technique of examination has now been utilized by urologists to perform office cystoscopy, bedside cystoscopy in critically ill patients, retrograde pyelography, biopsy and fulguration of tumors, placement of ureteral stents with fluoroscopic guidance, and urodynamic studies.

Loughlin and Yalla in 1986 combined flexible cystoscopy and urodynamics, becoming the first to describe endourody- namics. They recorded urethral pressure profiles (UPP) using flexible cystoscope to aid in determining the urethral location of the pressure sensor during micturition. With their specially designed flexible cystoscope by Olympus, they conducted fluid bridge tests and micturitional total pressure determinations. The standard flexible cystoscope could not be used to measure UPP because the opening of the working port is at the distal end, not on its lateral aspect as needed. Douenias and colleagues demonstrated that endourodynamics gives reliable and accurate results. It allows assessment of the bladder neck during mic- turition (Figs. 6 and 7). This study is particularly useful in patients with detrusor neck dyssynergia, Parkinson’s disease, multiple sclerosis, or Shy-Drager syndrome. It is often difficult to diagnose bladder neck dyssynergia without sophisticated VUDS. Endourodynamics may be the alternative, providing similar information without the need for fluoroscopy.

Chancellor and coworkers have incorporated endourody- namics into the evaluation of patients with spinal cord injury because the examination can be performed easily and accurately without moving the patient from the wheelchair. This saves time and money and reduces patient discomfort. Douenias and associates, who used endourodynamics in lieu of videourody- namics and cystoscopy, showed reduced procedure time, cost, and urethral manipulation. It is recommended to measure cys- tometric pressure initially, as overdistention during cystoscopy may result in an inaccurate measurement. Today, the indications for endourodynamics are incontinence after radical prostatectomy, as stricture commonly coexists, and minimally invasive therapy for prostatitis where the presence of a medium or large middle lobe is a contraindication for microwave thermotherapy or prostate stent therapy.

PHOTODYNAMIC THERAPY WITH AMINOLEVULINIC ACID FOR SUPERFICIAL BLADDER TRANSITIONAL-CELL CARCINOMA

Integral photodynamic therapy (PDT) is an investigational treatment for cancer that works by generating a reactive oxygen molecule through the interaction of light and a photosen- sitizing chemical. Aminolevulinic acid has received attention as a possible photosensitizing agent and is currently undergo- ing clinical trials for both superficial bladder and skin can- cers. This chemical is an initial substrate of heme biosyn- thesis, and when it is administered, epithelial tissues accumulate endogenous protoporphyrin IX. It is hoped by administering this medication intravesically instead of intravenously, as with prior photosensitizing agents, that photosensitization of the skin and the risk of damaging bladder muscle leading to bladder shrinkage can be avoided.

Kriegmair and colleagues reported the use of PDT with in- travesical ALA for recurrent superficial bladder cancer. Their experience encompassed 10 patients, all of whom had received multiple transurethral resections, intravesical mitomycin C, and subsequent BCG. Radical cystectomy was indicated in all pa- tients because of extensive superficial cancer covering the blad- der wall, which could not be resected safely. Four patients had concomitant carcinoma in situ. The PDT was performed after intravesical instillation of ALA in an attempt at bladder sav- age. The average functional bladder capacity was 335 mL, and clinical staging by CT scan of the abdomen and pelvis, along with a bone scans, suggested that all patients had organ-confined disease.

The bladder cancers were photosensitized by the intravesic- al instillation of 5 g of ALA hydrochloride (Merck, Darmstadt, Germany) dissolved in 30 mL of sodium bicarbonate. The du- ration of instillation ranged from 4.7 to 8.3 hours (mean 5.1 hours). Light was applied from an argon-pumped dye laser with red and green continuous-wave light with a wavelength of 635 nm (Figs. 8, 9). Isotonic saline was used as cystoscopic irrigant during the photosensitization. The response was evaluated at 10 to 12 weeks after the procedure with cystoscopy, random biopsies, and urine cytology.
In the months following PDT, a total of five patients had disease advancement and underwent radical cystectomy. The rate of positive biopsy before and after PDT was 62.5% and 18.8%, respectively. In three of four patients with moderately or poorly differentiated papillary tumors and concomitant carcinoma in situ, there was either a complete or a partial response, whereas only three of the six patients with well- or moderately differentiated tumors and concomitant carcinoma in situ had an adequate response. Although there was no protection by the patients against exposure to light, there were no phototoxic skin reactions. After PDT, all 10 patients complained of dysuria, which persisted for as long as 4 weeks in some patients. Six patients complained of gross hematuria and passing of desquamated tissue. There was no decrease in bladder capacity and no erosion of the submucosa or bladder muscle in all repeated biopsy or cystectomy specimens. It is also to be noted that in vivo spectral measurements demonstrated a 10-fold greater fluorescence of papillary tumors than of normal urothelium. It appears that PDT with ALA has a promising future as an alternative therapy for bladder cancer with few side effects.

DYNAMIC FAST MRI FOR PELVIC PROLAPSE

Pelvic prolapse is a common malady in multiparous women between the ages of 45 and 56 years, often after hysterectomy, with a reported prevalence approaching 16%. The symptoms of pelvic floor prolapse include pain, urinary or fecal incontinence, hemorrhoids, and constipation. The major risk factors for pelvic floor relaxation are age, obesity, chronic cough, and multiparity, obviously conditions that may lead to consistently elevated intra-abdominal pressure. Along with understanding the symptoms and causes of pelvic relaxation, the surgeon will need to appreciate and document the severity and pelvic compartment involved because the type and anatomic approach for surgical intervention can differ widely. The physical examination of the anterior, middle, and posterior compartments may be difficult, especially in obese women or severe prolapse, and may not be reliable or even reproducible between examiners. There are numerous radiologic evaluations possible, including bead-chain cystometrography, videourodynamics, sonography, vaginography, and

![](https://example.com/image.png)

**FIG. 10.** Sagittal dynamic MR images of woman with urinary and fecal incontinence. (A) Relaxed. (B) During maximum strain. Vertical distance from pubococcygeal line to rectal air column is 5.5 cm, demonstrating rectocele. (Reprinted with permission from Yang A, Mostwin JL, Rosenshein NB, et al. Pelvic floor descent in women: Dynamic evaluation with fast MR imaging and cinematic display. Radiology 1991;179:25–33.)
barium defecography.\textsuperscript{56–58} Unfortunately, none of these provides a representation of all three compartments. These studies are also uncomfortable and expose the patient to high radiation exposure from both fluoroscopy and radiography.\textsuperscript{55} The relatively high failure rate of surgical therapy in creating symptomatic improvement and preventing recurrent prolapse suggests that these preoperative imaging modalities are inaccurate or inadequate.\textsuperscript{59}

Recently, fast-sequence dynamic MRI has shown promise of delivering accurate images of these three compartments without ionizing radiation (Figs. 10 and 11).\textsuperscript{55} Yang and associates\textsuperscript{55} examined 26 patients with dynamic MRI for pelvic prolapse and 16 control patients without pelvic relaxation for other gynecologic reasons such as endometriosis. They used the imaginary pubococcygeal line (PCL) as their frame of reference to discern the features of the prolapsed component. The limits of descent with maximal strain were defined as 1 cm below the PCL for the bladder base, 1 cm above for the vaginal cuff or end of the cervix, and 2.5 cm below for the rectal air column. The dynamic MRI study enhanced the information from two patients in regard to the anterior compartment, two the middle, and four the posterior compartment. There was no statistical difference in the resting position between the control, clinically negative, and clinically positive patients in any compartment, suggesting that static images without dynamic imaging may be inadequate to aid in diagnosis. Yang and coworkers felt that another advantage of dynamic MRI was in the detection of enteroceles. A defect in Denovilliers’ fascia or in the rectovaginal

\textbf{FIG. 11.} Sagittal dynamic MR images of postmenopausal woman with stress urinary incontinence. (A) Bladder (B) and vaginal (V) positions without strain. (B) Positions during mild strain. Note small cystocele and vaginal prolapse. (C) Positions during strong abdominal straining. Note pronounced cystocele and vaginal vault prolapse (VP). (D) Prolapsed organs are completely reduced. (Reprinted with permission from Yang A, Mostwin JL, Rosenshein NB, et al. Pelvic floor descent in women: Dynamic evaluation with fast MR imaging and cinematic display. Radiology 1991;179:25–33.)
septum may become more readily apparent on dynamic MRI because of the mesenteric or retroperitoneal fat in these defects. The authors commented on how important it is to give precise instructions to the patient in regard to the stepwise pelvic strain (mild, moderate, and maximum) and perineal contraction. This improves the reproducibility of each examination. These graded steps allow cinematic display of resting and dynamic images of the temporal and spatial positions of the prolapsed organs.

It appears that dynamic MRI has few disadvantages. The ones noted are cost, inability to obtain urodynamic parameters such as detrusor instability simultaneously, and the variability of the rectal air column, leading to underestimation of the posterior compartment defect. However, with the use of gadolinium dimeglumine pentetate, this problem can be avoided.

Dynamic MRI is a fast and accurate but costly imaging modality, so questions about when to use it are becoming apparent. Yang and coworkers\(^5^5\) suggest its utilization when: (1) patients with incontinence or other symptoms of prolapse have equivocal urodynamic or physical examination results; (2) there is recurrent prolapse or incontinence; (3) for follow-up examinations in patients followed conservatively; (4) for suspected enterocoele or multicompartiment prolapse; (5) in patients unable to tolerate contrast or radiographic procedures; (6) in children with imperforate anus prior to reconstruction; and (7) as a research tool to define the biomechanics of prolapse. We can foresee the urologist, urogynecologist, and pelvic surgeon utilizing dynamic MRI as an adjunct to the physical examination and radiologic studies when clinical questions have not been answered.

**CONCLUSIONS**

Imaging of the lower urinary tract is now multidimensional, including videourodynamics; gray-scale/color Doppler ultrasonography of the urethra, penile, and testicular vasculature; videourodynamics; and dynamic MRI. These modalities are in some instances becoming office based and being utilized with more frequency. They facilitate a quick, accurate, and reproducible diagnosis. Cost can be prohibitive and a limiting factor, but the proper instances for their utilization are now becoming apparent.

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Address reprint requests to:
Gopal H. Badlani, M.D.
Dept. of Urology
Northshore-Long Island Jewish Health Systems
New Hyde Park, NY 11040
This article has been cited by:

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