

A variety of vascular changes in the urinary bladder during urodynamic study in women with various types of long-standing urinary symptoms: Preliminary study using three dimensional color and power Doppler sonography

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INTRODUCTION

The urinary bladder undergoes repeated cycles of filling, contraction and emptying during which substantial variations in bladder perfusion and oxygenation may occur. How do bladder blood flow during these cycles of filling, contraction and voiding? The purpose of this study was to investigate the effects of bladder filling as well as spontaneous bladder contractions on regional bladder blood flow. We also aimed to establish a correlation between intravesical pressure and bladder blood flow.

CLINICAL STUDY

The aim of this study is to evaluate color or power Doppler sonography for assessment of urinary bladder blood flow during urodynamic study (UDS) in women with longstanding urologic symptoms. Nineteen women with various urinary symptoms were included in this study. They complained long-standing urinary symptoms (n=15) (including urinary incontinence (n=15), urinary urgency (n=5), frequency (n=8)), loss of voiding sense (n=3), and ESRD (n=1). We obtained multiphasic three-dimensional(3-D) volume data with color/power Doppler of bladder using 4-7MHz 3D-volume curved-array transducer of ACCUVIX XQ (MEDISON, Seoul, Korea) during UDS. 3-D data includes during filling, during voiding sense combined with/without elevation of vesical pressure on UDS and during urgent voiding. We reconstructed continuous multislice axial-images with 1mm-slice thickness by 3D eXtended Imaging™ and evaluated gross blood flow change to the bladder wall. And also we assessed quantitative analysis of blood flow by using of vascular index (VI), flow index (FI), and vascular flow index (VFI) in region of interest (ROI). We created ROI in the urinary bladder wall at entering vesical artery, fitting the individual. This predefined ROI was then used for all intraindividual measurements. The percentage of color pixels was calculated for each ROI (VI). Because the VI value represents the percentage of color pixels in a carefully defined area, differences in size and shape of the individual ROI were not relevant. Quantitative color Doppler US has been used to assess angiogenesis in prostate cancer, breast cancer, and quantify thyroid blood flow, and measure renal blood flow changes induced by vasoactive substances in many reports. This study provides additional evidence for increasing blood flow with increasing distension. Assessing the spatial distribution of blood flow in the microcirculation represents a particularly challenging problem for imaging technologies. The use of VI, FI, VFI as semiquantitative methods enable performance of accurate measurements of the

microvascular density of the urinary bladder. In this study, supplying blood vessels of the bladder were seen in 4/19(21.1%) during filling stage. There were 32times of voiding sense in 16 patients during UDS. We obtained color or power Doppler 3-D volume data at that time and 3-D volume data during void in five patients. Flow signals were seen in 23/32(71.9%) during voiding sense, and 4/5(80%) during void. In conclusion, Blood flow in the bladder tends to increase during urinary urgency. 3-D color/power Doppler sonography is a feasible method for assessing blood flow change in bladder wall during UDS.

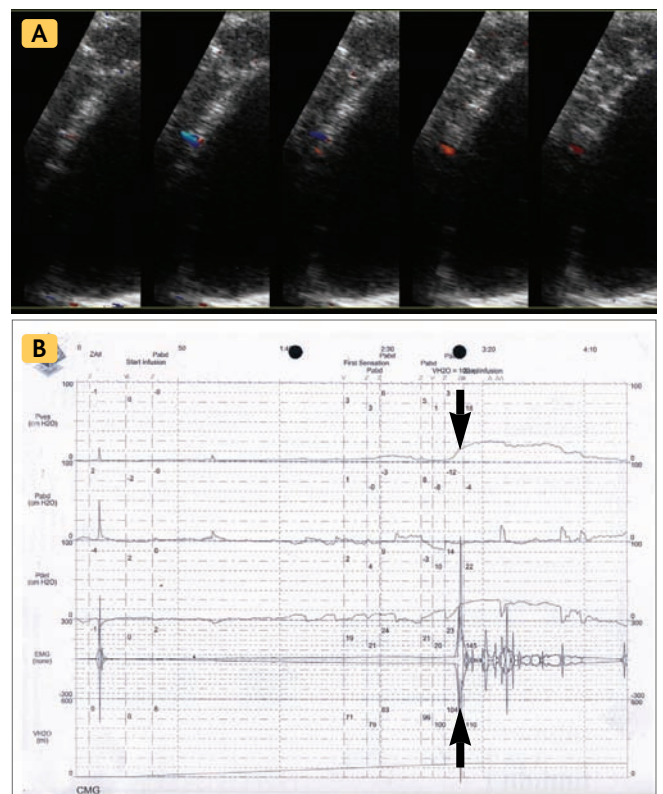


FIGURE 1. Increase of blood flow of the bladder in a patient with detrusor instability that objectively shown to contract spontaneously during filling with 0.9% NaCl.

A. Serial 1mm-reconstructed images show vascular flow signal in right superior vesical artery. These images of multislice view are subtracted from the three-dimensional(3-D) volume data with color Doppler of bladder using 3D eXtended Imaging™. 3D volume data is obtained by using 4-7MHz 3D-volume curved-array transducer when intravesical pressure (Pves) rises up associated with an increase of detrusor pressure (Pdet) during urodynamic study (**B.** arrow).

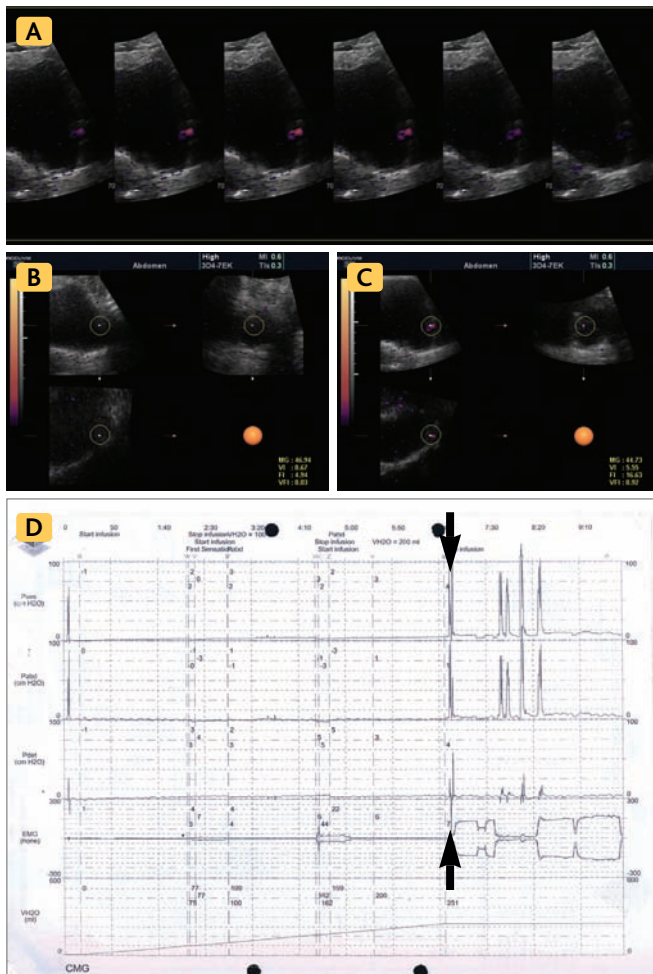


FIGURE 2. Blood flow change of the bladder in patients with stress incontinence during filling stage and during Valsalva maneuver. **A.** Serial 1mm-reconstructed images those are subtracted from the multiphasic three-dimensional(3-D) volume data during Valsalva maneuver with power Doppler of bladder shows increased blood supply through the left inferior vesical artery. ROIs are created in the point of inserting the bladder of left inferior vesical artery at time of early bladder filling with NaCl (**B**) and first voiding sense (**C**). **B.** There is a faint vascular signal in the left lateral wall of the bladder, that is measured in VI 0.67, FI 4.94, VFI 0.03 during early filling stage. **C.** There is a high flow signal in the bladder wall, that is measured in VI 5.55, FI 16.63, and VFI 0.92 during void sense. All parameters are significantly higher in void sense than filling stage. **D.** Graph of urodynamic study shows no involuntary response of the detrusor. After Valsalva maneuver graph shows that all of vesical pressure, abdominal pressure, and detrusor pressure increase. At Valsalva maneuver, blood flow can be detected at the inserting site of the left inferior vesical artery, that is not seen during filling stage.

CHANGES OF BLOOD FLOW TO THE BLADDER DURING UDS

Video urodynamics displaying simultaneous urodynamic data with radiographic images of the bladder and urethra were originally described. Pressure flow study combined with fluoroscopy is generally referred to as video urodynamics, which is currently the gold standard to diagnose and localize lower urinary tract dysfunction. There have been some preliminary attempts with ultrasonography instead of fluoroscopy as the imaging modality in video urodynamics using catheters to measure bladder pressure. We believed that a totally noninvasive pressure flow-like urodynamic system could be invented based on the concept of Doppler ultrasonography, which has been widely used for evaluating blood flow velocity. [1] Recent studies showed that bladder blood flow is altered in patients suffering from lower urinary tract symptoms, or urinary stress incontinence. One study showed that alpha blockers, administered to male patients suffering from bladder outlet obstruction, increase urinary bladder and prostate perfusion. Some authors have reported that hormone replacement therapy increases bladder neck blood flow in postmenopausal women with urinary stress incontinence. Furthermore, in a recently published study, the importance of bladder perfusion was described in young women suffering from recurrent urinary tract infections. After a short therapy regimen with topical estrogens, a notable increase in vascular perfusion was observed. [2] Some investigators have reported that bladder wall perfusion decreases during passive distention of the bladder. But a recent report found an increase in blood flow during distention. To investigate this problem, we measured blood flow to the bladder during urodynamic study using 3-D volume data of color and power Doppler ultrasound with simultaneous measurement of intravesical pressure during UDS. The flow spectra deduced from the bladder wall vessels showed evidence of low resistance. Further evidence for the increase in vesical blood flow was that there was an increase, although not quantifiable, in the perfused vessels of the bladder wall. As a result of the blurring of the color Doppler signals, measuring the diameter of the individual vessel yields no precise information about the corresponding flow rate. [3]

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