Ultrasonic Assessment of the Internal Urethral Sphincter in Stress Urinary Incontinence

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Abstract

A new concept was described in 1996 explaining micturition and urinary continence. Continence depends on a strong, sound and intact internal sphincter, and on an acquired behaviour of keeping a high alpha sympathetic tone. Weakness of the internal sphincter causes Stress Urinary Incontinence (SUI). Weakness is mostly due to rupture and or split of the wall. Ultrasound (U/S) assessment of the internal sphincter is utilised to demonstrate the defect of the internal sphincter wall.

Three dimensional U/S assessment of the internal sphincter is done in 2 groups of women. The first group consists of 20 continent women. The second group consists of 60 patients with SUI who had clinical, radiological and urodynamic evaluation.

Continent women have a linear internal sphincter that extends from the bladder neck down for almost the entire length of the urethral length. The internal sphincter has a thick symmetrical wall with 3 different echoes. In SUI patients, there is irregularity in the wall with areas of echolucency denoting the defect and rupture.

Three dimensional U/S assessment of the internal urethral sphincter is very sensitive and specific for the diagnosis of SUI.

SYNOPSIS

Defects of the internal urethral sphincter which cause SUI can be clearly demonstrated by 3D ultrasound examination.

INTRODUCTION

Ultrasonic imaging of the lower urinary tract is a safe, non invasive, and patient acceptable technique that provides adequate resolution of the anatomical features and shape of the bladder neck. It can be done through abdominal, vaginal, perineal and rectal routes (1,2,3,4). The application of transvaginal ultrasound (TVS) allows the evaluation of the relation of the bladder neck and the symphysis pubis. Several investigations indicated that sinking of the bladder neck below the lower edge of the symphysis pubis is indicative of stress urinary incontinence (5,6,7). On the other hand, urge incontinence is characterized by funneling of the bladder neck and enlargement of the urethrovesical angle (8).

Perineal ultrasonography can provide information about the bladder neck similar to the findings obtained with radiologic cystourethrography (9). It has the advantage that it does not displace the bladder neck by an intravaginal probe, and as it visualizes only thin “slice” of pelvic tissues, it permits obtaining accurate measurements (10).

Realtime ultrasonography using 2-dimensional scanning of the lower urinary tract can thus provide valuable information in cases of stress urinary incontinence. The shape of the bladder neck, its anatomical relations and urethrovesical angles can be assessed. However, the length and shape of the urethra and the structure of the internal urethral sphincter cannot be obtained.

OBJECTIVES

Assessing the value of imaging of the internal urethral sphincter using three dimensional ultrasonic examination. To evaluate the value of scanning the bladder neck, urethra and the internal urethral sphincter in both normal women and women suffering SUI using 3D ultrasonic machine and the results will be evaluated.

PATIENTS AND METHODS

All the patients and the controls in this study gave an informed consent and the study was approved by the local ethics committee.

Three dimensional ultrasonic assessment of the bladder neck, the urethra and the internal urethral sphincter was done...
using vaginal and rectal probes, multifrequent, 5-7.5 MHz kretyz 530-3D in two groups of women.

Twenty women not suffering from leakage of urine on sudden increase of abdominal pressure e.g., on coughing, sneezing, laughing or jumping, were examined clinically and by 3D U/S.

Also sixty patients with stress urinary incontinence, second and third degrees, as proved from the history, were examined clinically, with urinalysis performed, and urodynamic studies measuring urethral pressure performed for each of them.

Then they were examined by 3 dimension U/S using vaginal and rectal probes which gives 360 degrees visualization of the bladder neck and the urethra. In addition, different views, multiplanes-e.g., cross section view, lateral section view and coronal section view- were obtained and evaluated. Also the entire length of the urethra was measured and the length of the internal urethral sphincter measured and evaluated.

RESULTS

Three dimension ultrasonic assessment of the bladder neck and the urethra proved that the internal urethral sphincter extends from the bladder neck for almost the entire urethral length. The internal sphincter had a thick wall with 3 echogenic characters, mucous membrane followed by a sheet of compact fibers with superimposed fibers in its middle part.

In normal women the internal urethral sphincter had a linear thick wall with mucous membrane coaptation. The muscle layer extended longitudinally with connection to the detrusor muscle above. The sheet of collagenous tissue fibers extends beyond both sides of the muscle layer, more on the outer side this is best shown in cross section.

In addition the collagen fibers were compact, close to each other, with no echolucent areas Fig. 1,2 and Diagram 1.

Figure 1
Fig 1: 3D ultrasonogram showing normal urethra. The internal sphincter has a thick wall with 3 sono echogenic characters. It extends from the bladder neck downwards for 70% of the urethral length.
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**Figure 3**
Fig. 2: Cross section of the normal internal sphincter showing mucous membrane, collagenous tissue and muscle layer overlying the middle part of collagenous tissue. Notice the compactness of the fibers with no rupture or defects in the wall.

On the other hand, in patients with SUI, the internal urethral sphincter was torn with irregular wall shape and thickness. No coaptation of mucous membrane was seen, and in the lateral view the wall thickness varied along the whole length. Fig. 3

**Figure 4**
Fig. 3: 3D ultrasonic picture of a patient with SUI grade III. The urethra is dilated with irregular outline. The sphincter wall is thin and torn.

Also there was shortening of the urethra with irregularity in its course.

In cross section view there were areas of echolucency indicating ruptured deficient areas. Fig. 4

**Figure 5**
In coronal section view, funnelling of the bladder neck was seen. Fig. 5

**Figure 6**
Fig. 5: 3D ultrasonogram of the internal sphincter of a patient with SUI with rupture of the upper part giving funnel shape appearance.

Sometimes weakness of the internal urethral sphincter was in the lower part, and rupture and widening of the urethral lumen was seen in the lower part, giving a “flask shape” appearance. Fig. 6 & Diagram 2.
DISCUSSION
A new concept was described in 1996 explaining micturition and urinary continence (11). Urinary continence depends on a strong and intact internal urethral sphincter; and on an acquired behavior, gained by learning in early childhood how to keep a high alpha sympathetic tone. This high alpha sympathetic tone. This high alpha sympathetic tone keeps the internal sphincter closed all the time until a “need” or a desire arises. Weakness of the internal sphincter causes SUI (12). Weakness is mostly due to a rupture and a defect in the wall of the internal urethral sphincter. Mechanism of micturition in human beings can be divided into two stages:

I- STAGE ONE:
In infancy, micturition occurs spontaneously as a spinal cord reflex. As the urinary bladder fills, afferent impulses reach the spinal cord, and when it is full, efferent impulses, through the pelvic parasympathetic (S 2, 3, 4) stimulate detrusor muscle contraction thus emptying the bladder irrespective of time and place.

II- STAGE TWO:
In humans (this is also applicable to some domestic animals), the mother starts to teach her infant (age 18-24 months) how to hold himself. This is achieved by gaining an acquired behaviour, learning how to keep a high alpha sympathetic tone (T10-L2), thus keeping the internal urethral sphincter closed all the time till the appropriate time and place are available. On desire to void and/or in need the person, first through the high centers, inhibits this acquired high alpha sympathetic tone, thus allowing the internal sphincter to relax and open allowing voiding to occur.

Urinary continence depends on three main factors: (11, 12, 13)

I- The presence of an intact, sound, and strong internal sphincter.

II- The internal sphincter is composed mainly of collagenous and elastic tissues extending concentrically outwards from an inner mucosa which lies on the “lamina propria” followed by the collagenous bundles extending beyond the muscle layer. The muscle fibers lie on and intermingle with the collagen fibers; and they are connected with the detrusor muscle above and the urethral muscle fibers below.

The collagenous and elastic tissues give the high wall tension to the internal sphincter and hence the high closure pressure. The muscle layer is responsible for closure and opening of the internal sphincter controlled by the alpha sympathetic activity (T10-L2).

III- An acquired behaviour gained by learning in early childhood is how to keep a high alpha sympathetic tone thus keeping the internal sphincter closed.

Weakness of the internal sphincter would reduce the wall tension and subsequently the urethral closure pressure, so that sudden increase of the intra-abdominal, intravesical pressure would overcome it leading to leakage of urine. This initiates a quick reactive sympathetic response that increases the internal sphincter tone preventing further leakage. Weakness of the sphincter is due to a defect of the collagenous tissue layer. The most common cause is rupture and split of the collagenous fibers. Other causes include atrophy, and degeneration caused by several factors, e.g., trauma, infection and hormone deficiency.

Three-dimension ultrasound gives a stereoscopic picture of the organ assessed.

Three-dimension U/S examination of the bladder neck and the urethra by 2-D does not give a proper assessment, but with 3-D ultrasound, the picture is quite clear due to the multiplane views of the bladder neck and the entire urethra allowing better visualization and evaluation. The lateral section view in normal women shows 3 echogenic
constituents of a thick wall of the internal urethral sphincter consistent with the histological picture described. It shows mucous membrane followed by a continuous compact sheet of collagen fibers with muscle fibers overlying and intermingling with the collagen fibers in the middle part. The wall is thick, linear with mucous membrane coaptation closing the lumen. The urethra is almost straight and linear, the internal urethral sphincter extends from the bladder neck for almost the entire urethral length.

In patients with SUI, the wall of the internal urethral sphincter is torn as proved by areas of echolucency. As a result of the wall rupture, the internal urethral sphincter is irregular in shape and contour. The urethra is apparently short with irregular course. The rupture in the wall may affect only the upper part, the lower part or the entire length of the internal urethral sphincter. When the rupture affects only the upper part, it causes funneling of the bladder neck Fig 5.

When the rupture affects only the lower part it causes dilatation of the lower part leaving the upper part narrow giving a “flask-shape” appearance. Fig 6.

The rupture may affect the entire length giving irregularity of the shape and the lumen. Fig 6.

There is apparent shortening of the urethra in all cases of ruptured wall. The posterior wall of the urethra is intimately related to the anterior vaginal wall. The vagina is markedly distended during labor, the contact area in the posterior wall of the urethra would either stretch simultaneously or rupture and be torn. Repeated distension of the vagina would repeat the insult on the posterior wall of the urethra and the damage inflicted Fig 7.

**Figure 8**

Fig. 7: Trans-rectal 3D ultrasonogram of the internal sphincter of a patient with SUI. It illustrates the relation of the internal urethral sphincter with the vagina. The ant. Wall of the sphincter is intact. The post wall of the sphincter and the ant. Wall of the vagina are torn and irregular.

In conclusion, three dimension vaginal ultrasonic assessment of the internal urethral sphincter is an additional informative, non-invasive tool in the evaluation of cases of SUI as it is both sensitive and specific in the diagnosis of SUI.

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**References**


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