Sonourethrography in the Evaluation of Anterior Urethral Strictures

Jong Chul Kim, M.D., Jin Geun Kwag, M.D.

Purpose: To determine the reliability of sonourethrography (SUG) in the evaluation of male anterior urethral strictures.

Materials and Methods: Both SUG with retrograde saline infusion and retrograde urethrography (RUG) were performed in 5 young normal volunteers and 20 patients with symptoms of impaired urine flow. Those findings were compared with urethrocystoscopic and operative findings in all patients.

Results: SUG was more accurate in the evaluation of the stricture length and degree than RUG in 7 patients with anterior urethral strictures, when compared with their subsequent open urethroplasty findings. Only SUG could classify the degree of spongiform fibrosis surrounding the strictures in 15 patients. So, SUG was diagnostically as efficacious as or, superior to, RUG in all 20 patients.

Conclusion: SUG can be used as one of complementary and reliable tools for diagnosis, evaluation and follow-up of anterior urethral strictures.

Index Words: Male urethra, ultrasonography

INTRODUCTION

Retrograde urethrography (RUG) and voiding cystourethrography (VCU) have been used in evaluating the male urethra. But these methods have disadvantages such as radiation exposure to the gonads, variable definition of stricture length or degree depending on the degree of urethral distension, and inability to visualize the periurethral pathology. Recently sonourethrography (SUG) with saline infusion has been used to visualize the anterior urethra (1-7).

We analyzed SUG findings in normal volunteers and patients with anterior urethral strictures to determine the reliability of SUG in the evaluation of urethral strictures.

MATERIALS and METHODS

During recent 5 years we performed both RUG and SUG in 5 normal young male volunteers and 20 male patients with symptoms of impaired urine flow (including hesitancy, nocturia, hematuria, split stream, and postvoiding dribbling). The age ranged from 18 to 43 years (mean 34).

RUG was done by injection of 20-30 cc of Angiographin®-310 (Megglumine amidotrizoate, Schering AG, Berlin, Germany) through a 7-12F Nelaton catheter located at the distal penile urethra with the Eschmann penile clamp (England) affixed to the glans. Radiographs were taken on both oblique positions, and reviewed by one radiologist (J. G. K.).

SUG of the anterior urethra was performed in each patient on supine position using a 12-F Foley balloon catheter (the balloon filled with saline was located at the fossa navicularis) by another radiologist (J. C. K.) without prior knowledge of the patient’s history or radiologic studies. After application of the ultrasonic gel to the ventral surface of the penis (pendulous urethra), scrotum (distal bulbous urethra) and perineum (proximal bulbous urethra), an 5, 7.5 or 10 MHz linear array or curved convex transducer of Diasonic DRF-400 (Milpitas, California, USA) or Siemens Sonoline SL-2 (Erlangen, Germany) was applied. Transverse and longitudinal scanning of the entire anterior urethra was done with cranial extension of the penis toward the abdomen and slow, constant retrograde infusion of 0.9% sterile saline (about 20-30 cc)
via an irrigation syringe. The study was recorded with a multiformat camera and videotapes. Urethral stricture was categorized as focal if it was less than 1 cm in length, and diffuse if the length was more than 1 cm. The degree of urethral stricture was classified as mild (encroachment upon less than one third of the urethral luminal diameter), moderate (encroachment upon one third to a half of the urethral lumen), and severe (encroachment upon if more than a half of the diameter of the urethral lumen), according to the classification of McAninch et al. based on sonographic appearance (1). The length of urethral stricture was determined by direct measurement from RUG, and by the electronic caliper measurement from SUG.

Urethroscopy and subsequent operation were done in all patients, and these findings were compared with those of both SUG and RUG. In 7 patients who underwent open urethroplasty (one patient with recurrent focal severe stricture after previous urethrotomy and 6 patients with diffuse severe stricture), the precise length of the stricture and the extent of scarring in the wall of the urethra and spongiofibrosis of surrounding corpus spongiosum were measured during surgery with full depth biopsy and compared with the measurements obtained during RUG and SUG. The degree of spongiofibrosis was also classified as mild (encroachment upon less than a third of the diameter of the surrounding corpus spongiosum), moderate (encroachment upon a third to a half of the corpus spongiosum), and severe (encroachment upon if more than a half of the diameter of the corpus spongiosum).

In another 13 patients who received internal optical urethrosopic urethrotomy, the approximate length and severity of the stricture were estimated during that procedure and compared with those of both RUG and SUG.

We opacified the corpus spongiosum in two patients with anterior urethral strictures by injecting 15–18 cc nonionic contrast medium lopamiro® (Iopamidol, Industria Chimica s. p. a., Milano, Italy) through a 22-gauge butterfly needle placed into the glans penis close to the frenulum. We got spongiosograms to evaluate the degree of fibrosis of the corpora spongiosa in these patients with symptoms of recurrent urethral strictures after internal urethrotomy and to compare these findings with those of SUG and RUG.

We also evaluated the results of operations and postoperative follow-up status in all patients.

**RESULTS**

Both RUG and SUG were performed and reviewed in 5 normal volunteers of young males (Fig. 1). In nonerect state, ultrasonography revealed the two corpora cavernosa (dorsolateral) and the corpus spongiosum (ventral, in the midline) of homogenous medium echogenecity (Fig. 1b), without visualization of collapsed anterior urethra. After retrograde saline distension of the lumen, SUG identified the normal distal urethra as an anechoic tubular structure of 4–9 mm (mean 6.5 mm) diameter in the center of the moderately echogenic corpus spongiosum (Fig. 1c and 1d).

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![Fig. 1. Normal urethrography.](image)

a. Oblique view of normal retrograde urethrography (RUG) shows the whole urethra distended with contrast media demonstrating urethral contour and caliber. The posterior urethra is usually not well distended compared to the anterior urethra.

b. Dorsal transverse sonogram of a normal penis shows the two dorsolateral corpora cavernosa (CC) and a ventral corpus spongiosum (CS) of similar size and homogenous echo texture surrounded by subcutaneous tissue and fascial layers (SQ).

c. Normal sonourethrography (SUG) of ventral longitudinal scan reveals the easily distensible anterior urethra (U), the corpus spongiosum (CS) and the corpus cavernosum (CC). Region of the external urinary sphincter (arrow) is seen as a gray mass proximal to flame-shaped portion of the bulbous urethra. Bulbospongiosum (BS) is seen ventral to the external sphincter area. D, Distal; P, Proximal; V, ventral; Dor, Dorsal

d. Normal SUG of mid portion of the penile urethra (U). Some echogenic curvilinear air bubbles are seen in the urethral lumen. (The same abbreviations as in c)
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* Scarring in periurethral corpus spongiosum surrounding the urethral stricture: +/- equivocal; + mild; ++, moderate; ++++, severe
The wall of the urethra appeared as smooth, thin hyperechoic line between the fluid-filled lumen and the spongy tissue of the corpus spongiosum. The region of the external urinary sphincter was seen as gray mass proximal to the flame-shaped portion of the bulbous urethra in the bulbospongiosum (i.e., the corpus spongiosum surrounding the bulbous urethra) (Fig. 1c).

The findings of RUG, SUG, urethroscopy or operation, operation result and follow-up were summarized in Table 1.

The causes of the stricture were as follows: iatrogenic infections after long-term catheterization due to nonurological reasons in 10 patients, urethral injury after trauma in 8 patients, and previous internal urethrotomy in 2 patients.

Twenty urethral strictures were diagnosed by SUG: 9 strictures were focal (Fig. 2), and 11 were diffuse (Fig. 3). SUG could classify urethral strictures: 5 strictures as mild, 9 as moderate (Fig. 4) and 6 as severe (Fig. 2). SUG demonstrated a urethral stricture as a narrow segment of the urethral lumen typically with irregularity and thickening of the inelastic nondistensible wall (Fig. 2b). Dilated lumen proximal to the stricture could be identified (Fig. 2b and 3b) in 13 patients. Whereas in RUG only the narrowing of the urethra was shown, SUG clearly identified spongiofibrosis (collagen fibrotic tissue replacing the normal spongiosal tissue) as solid thick hyperechoic soft tissue with stronger reflection zone that appeared brighter than the surrounding distorted corpus spongiosum (Fig. 2b and 3b) in 15 patients (except patients of No. 1-5). The degree of the spongiofibrosis on SUG correctly corresponded with that on biopsy in all 7 patients (of No. 14-20) who underwent open urethroplasty.

Among 13 patients of urethrotomy, 7 patients (of No. 1-7) of mild and moderate spongiofibrosis required no further treatment during a 5-year follow-up period due to the relief of stricture symptoms and maintenance of normal urinary stream.

The criteria for recurrence of the urethral stricture were as follows: recurrent symptoms of impaired urine flow, progressive deterioration of the urinary stream, and recurrent narrowing in the previous stricture site on urethrography, etc. Seven patients (No. 8-14) of...

Moderate to severe scarring on SUG had recurrent stricture during the following 3.6—8.4 months (mean 6 months). The result of operation was categorized as ‘good’ when the patient resumed normal urinary stream, or ‘fair’ when the urinary stream improved initially then slightly diminished with the maximum urinary flow rate of more than 10 ml/sec but not so as to require further treatment.

In the patient of No. 13, SUG was more precise than RUG in the evaluation of length and degree of the urethral stricture (Fig. 2). He refused open urethroplasty and received optical urethrotomy at another hospital. The second RUG and SUG after 11 months in our hospital showed recurrent urethral stricture at the previous incision site. We also performed spongiosography to compare the findings of this spongiosography with SUG findings. That spongiosography demonstrated complete disruption of contrast medium in the bulbous portion of the corpus spongiosum, and this finding was compatible with severe periurethral scarring in the corpus spongiosum on SUG (Fig. 2c). In another postoperative patient (No. 4) of recurrent stricture symptoms, SUG showed recurrent mild focal urethral stricture at the previous operation site without significant spongiosfibrosis which was compatible with normal spongiosogram (Fig. 2d), so he received repeated internal urethrotomy and has been doing well until now.

In 7 patients (of No. 14-20) who underwent open urethroplasty with full depth biopsy, SUG was correct to determine the degree of the anterior urethral stricture in all patients (100%), and RUG was correct in 6 patients (86%). The stricture length was correctly evaluated in one patient (of No. 17) by SUG and in another patient (of No. 18) by RUG. But, in each case of the remaining 6 patients, the measurement difference of the stricture length between SUG and open urethroplasty was much less (ranged from +1 to −2 mm : mean difference = +0.2 mm) than that between RUG and open urethroplasty (from +7 to −9 mm : mean difference = −3.4 mm). The measurement error of the stricture length between SUG and open urethroplasty was negligible, but RUG tended to underestimate the stricture length with a larger numerical difference (e.g. −9 mm in No. 19 and −8 mm in No. 20) from that on open urethroplasty.

In the remaining 13 patients who underwent internal urethrotomy, SUG was correct to determine the severity of the stricture in all patients (100%), but RUG was correct only in 8 patients (62%).

Both SUG and RUG were well tolerated by all volunteers and patients without significant complications.
DISCUSSION

The anterior urethra has been studied with conventional roentgenographic techniques such as RUG and VCU. Recently SUG with retrograde saline infusion or antegrade (voiding) SUG of the anterior urethral stricture applying 5–7 MHz linear array transducers on the dorsal surface of the penis and on the ventral surface of the scrotum has been reported (1–7). They applied 5–7 MHz linear array transducers on the dorsal surface of the penis without using a 10 MHz probe to get the images of penile urethra through the window of corpora cavernosa, and then they rearranged the transducers on the ventral surface of the scrotum to visualize the bulbous urethra. However, due to the ventral location of the male distal urethra in the corpus spongiosum, it was considered that the ventral scanning of the penis and scrotum would be easier and get more detailed image of distal urethra with higher MHz superficial ultrasonic probes without switching the scan orientation during the examination of both penis and scrotum. So we used transducers on the ventral surface of the penis and scrotum, and could get good real-time dynamic images of normal male distal urethrae and urethral strictures within shorter times (less than 10 minutes).

In 5 normal volunteers, the normal distended urethral diameter showed a range of 4–9 mm (mean 6.5 mm), and this value was similar to the measurement (i.e., more than 4 mm) by Benson et al (6,8).

In our study, SUG of the anterior urethral strictures well corresponded to the urethroscopic or operative findings in the location, length, and degree of the stricture and spongiosfibrosis. SUG correctly estimated the stricture length with a standard deviation of 2 mm in all 7 cases of excisional urethroplasty, but RUG underestimated the stricture length in 5 cases among them, so the correlation between SUG and RUG was not good. SUG correctly evaluated the degree of stricture in all cases, but RUG underestimated it in 3 cases and overestimated it in two cases. To get good quality of RUG, multiple radiographs with additional radiation exposure were required in 4 cases in which the stricture varied with the position of the patient and the degree of penile stretch. SUG provided sufficient information to classify the degree of spongiosfibrosis in 15 cases, but RUG could not define the periurethral structures or the extent of spongiosfibrosis in all cases.

There were postoperative recurrent urethral strictures in 7 patients (35%) in our study. The recurrent rate of urethral strictures in patients treated by internal urethrotomy was reported as 15% (9,10) 37% (11), etc. Our higher recurrence rate after internal urethrotomy (6/20 = 30%) is considered to be related to many cases of moderate and severe strictures (14/20 = 70%) and their long duration of stricture symptoms (3 months to 4 years, mean = 3.5 years). Jakse et al (10) reported recurrent strictures after excision urethroplasty in 5 of 90 patients (7%) during the follow-up period of one to eight years, which were due to abscess formation, perineal hematoma, and excessive length of stricture. Novak (11) reported 14% recurrence in patients of urethral strictures undergoing an open operation. So the recurrence rate of 5% (1/20) after open urethroplasty in our study is comparable to those of others.

It is important to identify the spongiosfibrosis in determining whether the stricture can be treated successfully by internal urethrotomy alone or will require open surgical correction, because simple incision of the scar in the stricture site cannot remove the damaged periurethral tissue in the corpora spongiosum. This scarring cannot be assessed by the premedical history of the patient, uroflowmetry, urethroscopy, antegrade and retrograde urethrography, etc. The extent of scarring was completely independent of the clinical symptoms and urethrogram findings. We can expect high recurrence rate of urethral stricture after simple cold-knife internal urethrotomy in those patients with severe spongiosfibrosis and diffuse stricture (especially of more than 3 cm in length) on SUG. Intraoperative guidance of stricture dilatation may be performed with real-time sonography (2). SUG may be used to calibrate the urethra for the assessment of adequacy of optic urethrotomic incision. The most extensive scarring may not always be at the 12 o'clock position, which is the position typically incised during direct vision internal urethrotomy, and inadequate incision into the scar may lead to recurrence (2). SUG may be ideal for evaluating patients who require repeated studies to follow a stricture over time, because ultrasound does not use ionizing radiation. So we recommend (a) internal urethrotomy for the patients of focal urethral strictures with no, minimal or mild spongiosfibrosis, and (b) open urethroplasty when the stricture is more than 3 cm long, or the patient has severe spongiosfibrosis on SUG and/or a history of repeated failed endoscopic procedures. This recommendation will decrease the recurrence rate of postoperative strictures.

Beckert et al described the spongiosography as a valuable adjunct to the diagnosis of urethral strictures (12). Normal spongiosogram reveals the shape of the glans penis and the corpus spongiosum up to the membranous portion of the urethra, the deep dorsal vein of the penis and its circumflex branches, as well as Santorini's plexus. So the radiologic findings of attenuation or even interruption of the contrast medium within the corpus spongiosum can suggest fibrotic destruction of the surrounding corpus spongiosum in urethral strictures. Depending on our experiences of spongiosography in two patients, however, this rather invasive spongiosography does not seem to be very
advantageous to SUG in the evaluation of sponge-)
ofibrosis in urethral strictures.
SUG has disadvantages such as dependency to the
operators, difficulty to evaluate urethral fistula and the
posterior urethra (membranous and prostatic
urethrae), etc. Fortunately, most strictures occur in the
anterior urethra (13, 14).
SUG is a simple, repeatable, dynamic, and reliable
procedure in the evaluation of male anterior urethral
strictures without radiation hazard, risk of reactions or
extravasation of contrast media, or any significant
complications. SUG may be used as a complementary
or primary evaluation tool in the male anterior urethral
strictures.

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초음파 요도 촬영술의 전방 요도 협착 평가

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목적: 남성의 전방 요도 협착 질환 진단에 있어서 초음파 요도 촬영술의 유용성에 대해 연구하고자 함.

대상 및 방법: 정상 남성 자원자 5명과 배뇨 장애를 호소하는 전방 요도 협착 환자 20명을 대상으로, 요도 개구부를 통해 역행적으로 생리적 식염수를 주입하면서 요도와 그 주변부의 병변을 초음파로 검사하였다. 음경, 음낭과 회음부의 복측(腹側)에 초음파 탐촉자를 접촉시켜 전방 요도를 검사한 후, 그 결과를 역행성 요도 촬영술, 방광요도경 및 수술 소견과 비교 분석하였다.

결과: 요도 성형술을 받은 7명의 전방 요도 협착 환자 모두에서 초음파 요도 촬영술은 역행성 요도 촬영술에 비해 협착 길이, 두께, 요도벽 변형 등을 더 정확하게 진단할 수 있었다. 수술 방법 결정에 큰 영향을 미치는 협착 주위 음경 해면체의 섬유화는 초음파 요도 촬영술로만 진단이 가능하였고, 15명의 환자에서 그 정도를 정확하게 분류할 수 있었다. 나머지 13명의 전방 요도 협착에서도 초음파 요도 촬영술이 역행성 요도 촬영술과 비슷하거나 더 좋은 진단 성적을 보였다.

결론: 초음파 요도 촬영술은, 방사선 위생을 위반한 합병증을 동반하지 않고, 전방 요도의 해부학적 구조와 요도 협착을 역동적으로 영상화하여 요도 협착의 수술 방법 결정에 도움을 주는 등 전방 요도 협착 질환의 평가 및 추적 검사에 유용하다고 사료되므로, 조영제를 사용하는 종래의 고식적 요도 촬영술과 함께 향후 그 사망이 더욱 기대된다.