Original Article

A Comparative Study of Sonourethrography and Retrograde Urethrography in Evaluation of Anterior Male Urethral Strictures

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Abstract

Introduction: The male urethral imaging and pathology is not widespread in the radiology literature because this part of the urinary tract is easily studied by urologists. However urethral obstructive pathologies especially stricture disease is a gray area which needs thorough imaging. Retrograde urethrography has been the standard imaging technique for the evaluation of male anterior urethra, which involves use of radiation and contrast medium. Sonourethrography is a new technique for imaging the male anterior urethra with high-resolution ultrasound while intra-urethral instillation of normal saline.

Aims & Objectives: This study was undertaken to explore the uses of sonourethrography with high-resolution ultrasound in evaluating stricture disease of the male anterior urethra and comparing it with retrograde urethrography.

Materials & Methods: This study was carried out on 60 male patients referred for retrograde urethrography to the department of Radiodiagnosis. These patients underwent retrograde urethrography followed by sonourethrography.

Result: Out of 60 patients, 11 patients were normal, 44 patients had stricture. Rest 5 patients without stricture had Urethrocutaneus fistula, false tract and diverticula. Total 53 strictures were demonstrated in 44 patients, 51 were diagnosed on sonourethrography and 53 on retrograde urethrography. One bulbar and two membranous urethra strictures were missed on sonourethrography and diagnosed on retrograde urethrography. One penile stricture was diagnosed on sonourethrography but missed on retrograde urethrography. Strictures were further characterized as per location, number, length, periurethral fibrosis and other findings.

Conclusion: Compared with retrograde urethrography, sonourethrography is equally efficacious in detecting anterior urethral strictures. The further characterization of strictures in terms of length, periurethral pathologies can be performed with relatively greater sensitivity using the sonourethrography. Thus, ability of sonourethrography to diagnose periurethral pathologies and length of stricture helps in planning proper surgical procedure.

Keywords: Male, Retrograde Urethrography, Stricture, Sonourethrography, Urethra

INTRODUCTION

Urethral pathologies, especially strictures are common problem affecting young adult males and are a major cause of morbidity and discomfort. The male urethral imaging and pathology is not widespread in the radiology literature because this part of the urinary tract is easily studied by urologists with clinical or endoscopic examinations. However, imaging has an important role to play in the study of the stricture diseases of the male urethra since it can detect pathology not visible on urethroscopy.[1]

Retrograde urethrography (RGU) is the standard imaging study for the evaluation of anterior male urethra. Originally, RGU was performed using penile clamps and other devices. McCallum[2] popularized use of Foley's catheter in the distal urethra to help retain contrast material after filling.

Diagnostic imaging of the male urethra has depended on these techniques, which involve the use of radiation and intra-urethral injection of contrast medium to visualize luminal anatomy. Limitations of RGU in accurate evaluation of anterior urethral stricture diseases include variation in the appearance of strictures with position of the patient and the degree of stretch of the penis during the study. It also provides limited information about periurethral structures.

In 1988 McAninch et al.[3] reported a new technique for imaging the male anterior urethra with high-resolution ultrasound (sonourethrography). The initial technique involved the use of a 5 MHz linear array transducer applied to the dorsal surface of the penis. Images were obtained during retrograde instillation of normal saline. As the normal urethral wall and spongiosum are elastic they are compressible on saline injection. When altered by stricture disease the corpus spongiosum loses its elasticity due to higher collagen content and is not compressible, causing a reduction in the inner diameter of the urethra.

An ideal study should be able to indicate the type of surgical procedure suitable for the patient. This includes accurate determination of the site, length and diameter of strictures. Complete preoperative knowledge of complicating conditions like urethral calculi, fistulae, false tracts, diverticula and polyps facilitate favorable urethroplasty outcomes.

As a dynamic, three-dimensional study, which can be repeated without radiation exposure, sonourethrography (SUG) offers important technical advantages compared with RGU. This study was undertaken to explore the uses of high-resolution color Doppler ultrasound in evaluating stricture disease of the male anterior urethra and comparing it with RGU.

MATERIAL AND METHODS

This study was carried out in the Department of Radiology, Indira Gandhi Government Medical College and Mayo Hospital, Nagpur over a period of 3 years from 2002 to 2005.

Sixty male patients referred for retrograde urethrography were selected. Those with symptoms suggestive of acute urethritis were excluded, while patients with recent instrumentation procedure were postponed for a week.

Informed consent regarding the procedures to be performed was taken from all patients. The patients underwent RGU followed by SUG 3-4 days later, on their subsequent visit to collect the RGU report.

Retrograde urethrography was performed with Siemens klinoskop - H 300 mA x-ray machine. Sonourethrography studies were performed with standard ultrasound scanners 1. ESAOTE color Doppler equipment and 2. GE LOGIC 3 PRO color Doppler equipment with a 5, 7.5, 10 mHz transducers.

The male urethra has been conventionally divided as anterior and posterior. The anterior urethra is further divided into distal long penile part extending from meatus up to penoscrotal junction; and proximal bulbar part up to pelvic diaphragm. The posterior urethra is made up of short fixed membranous part at the pelvic diaphragm and wider prostatic part. The locations of strictures were described as penile, bulbar and membranous as per the involved part.

Term 'Single stricture' implied single location even if there were multiple strictures in that same location. 'Complex stricture' has been used for strictures at multiple locations. Complex and multiple strictures are considered together as per their surgical management as suggested by Chiou R.K. et al.[4]

The stricture length and diameter were determined using electronic caliper measurements. We categorized stricture length as short strictures less than 2.5 cm in length and long strictures, more than 2.5 cm in length. This classification is modification of classification by Chiou R K et al.[4] and Morey A. et al.[5] made as per the type of urethral surgery required.

Periurethral fibrosis was identified as regions of greater echogenicity in corpus spongiosum, and was classified as per the classification by Chiou R.K. et al.[4] as.

i. Minimal spongiosal tissue involvement demonstrates either no identifiable spongy tissue involvement or a minimal abnormality.
ii. Moderate spongiosal tissue involvement shows definite areas of abnormal tissue beneath the urethral surface with sonographically normal tissue in the periphery.
iii. Extensive spongiosal tissue involvement consists of a near full-thickness involvement of the corpus spongiosum.

The sensitivity, specificity, positive and negative predictive value of all parameters was calculated. The strength of agreement between RGU and sonourethrography was calculated using kappa statistics, whereby a kappa value of, 0.2 indicated a poor agreement, 0.21-0.40 indicated a fair agreement; 0.41-0.60, moderate agreement; 0.61-0.80, good agreement; 0.81-1.00, very good agreement.

RESULTS & OBSERVATIONS

Out of 60 patients, the average age was 36.33 year. Maximum number of patients belonged to 2nd and 3rd decade (Table 1, Figure 1). All patients with clinical diagnosis of urethral obstruction were studied with sonourethrography. These findings were compared with retrograde urethrography, which is time proven 'gold standard' (Figure 2). Urethrography ruled out any urethral

obstructive lesion in 11 patients and those were reported to be having normal study (Figure 3). Remaining 49 patients had definite signs of urethral obstruction of varying type.

Out of these 49 patients, 44 patients had stricture and five patients without stricture were as follows, 3 with diverticula including syringocele type-2 (Figure 7), one with false tract (Figure 8) and one with urethrocutaneus fistula (Figure 9).

Total 53 strictures were demonstrated in 44 patients. Total 51 strictures were diagnosed on SUG and 53 on RGU. One bulbar and two membranous urethra strictures were missed on SUG and diagnosed on RGU. One penile stricture was diagnosed on SUG but missed on RGU.

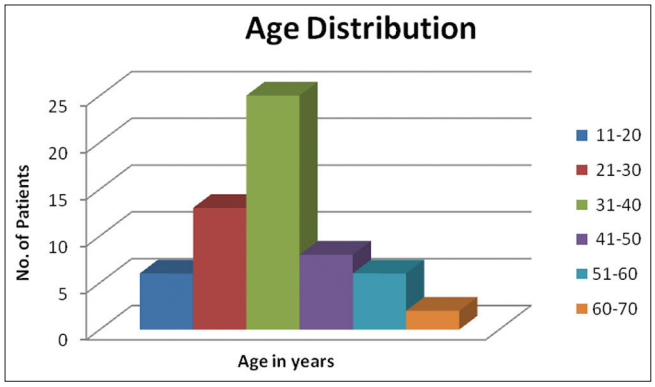

Figure 1: Age distribution of the patients with urethral obstructive complaints

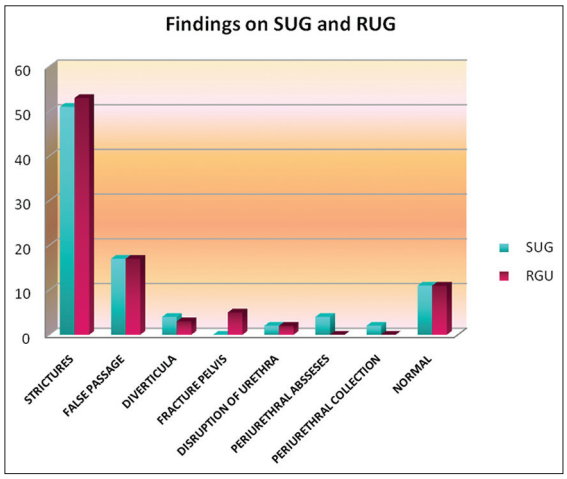

Figure 2: Comparative findings on SUG and RUG

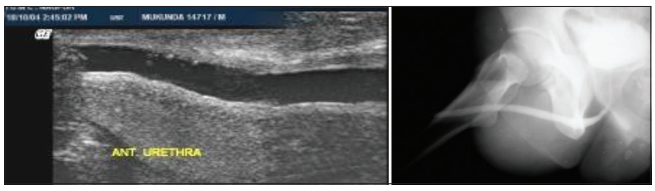

Figure 3: Sonourethrography and retrograde urethrography appearace of normal anterior male urethra

These strictures were further characterized as per location, number, length, periurethral fibrosis and other findings.

Location of Strictures (Table 2)

Bulbar urethral strictures were the commonest found in 26 patients with both the modalities. One extra bulbar stricture was diagnosed on RGU however it was missed on SUG.

Table 1: Distribution of patients according to age

Age (years)	No. of patients	Percentage
11 to 20	06	10.00%
21 to 30	13	21.70%
31 to 40	25	41.70%
41 to 50	08	13.30%
51 to 60	06	10.00%
60 to 70	02	03.30%
Total	60	100%

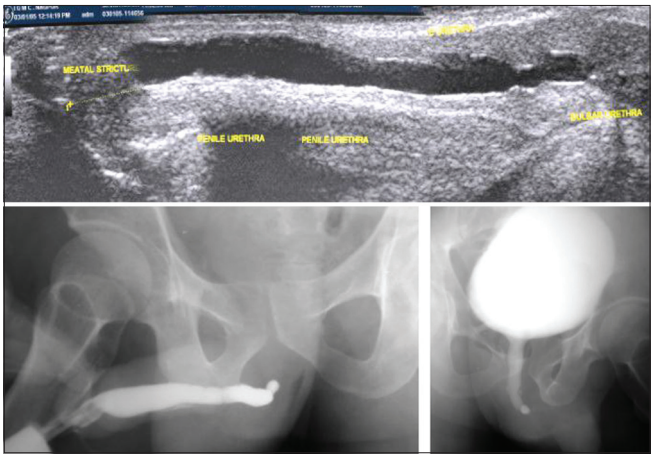

Figure 4: Sonourethrography, retrograde urethrography and voiding cystourethrography appearace of complete short segment stricture bulbar urethra

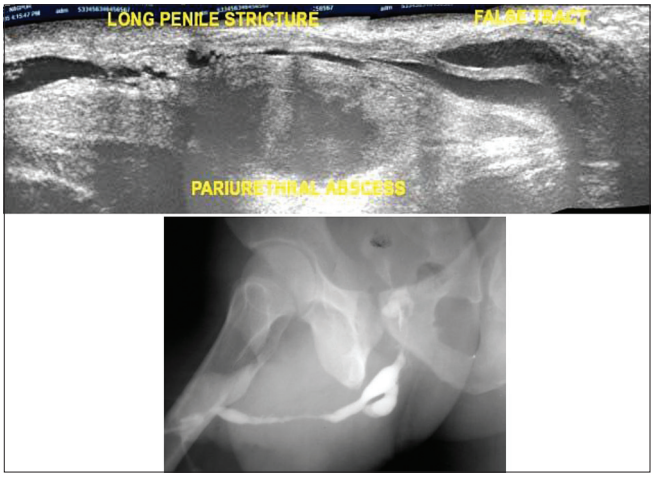

Figure 5: Sonourethrography and retrograde urethrography appearace of long segment stricture penile urethra with periurethral abscess and false tract

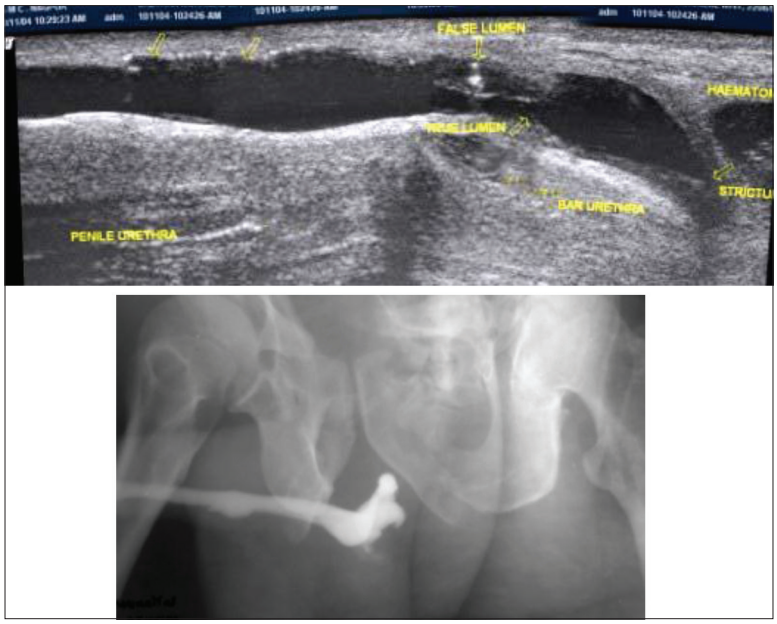

Figure 6: Sonourethrography and retrograde urethrography appearace of post-traumatic disruption of bulbar urethra with periurethral haematoma and false tract

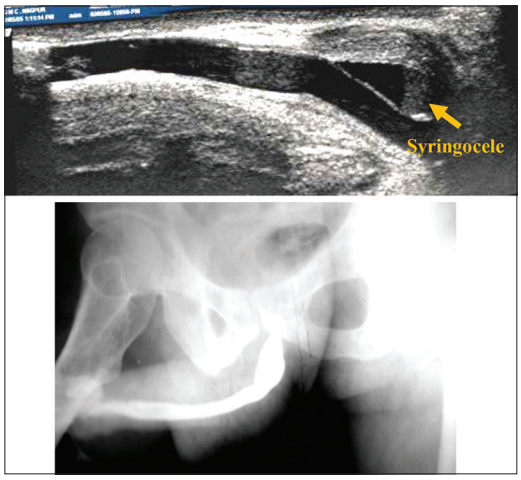

Figure 7: Sonourethrography and retrograde urethrography appearace of unruptured syringocele

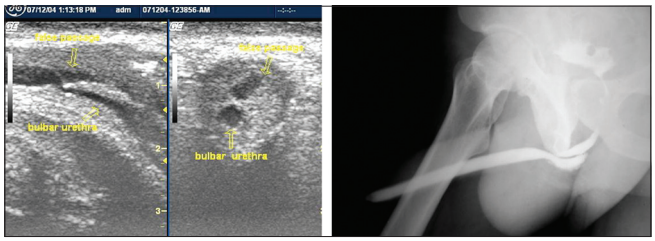

Figure 8: Sonourethrography and retrograde urethrography appearace of post-instrumentation false Passage

Total eight penile strictures were diagnosed on both the modalities. One extra penile stricture diagnosed on SUG was not seen on RGU. Two penile strictures categorized as pure penile were actually complex strictures involving penile and membranous urethra as membranous strictures were not visualized on SUG.

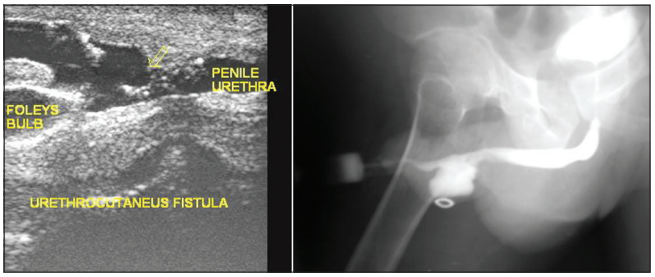

Figure 9: Sonourethrography and retrograde urethrography appearance of urethrocutaneus fistula

Seven complex strictures visualized on both the modalities all were penile and bulbar urethral complex strictures; however two complex strictures involving penile and membranous urethra were visualized only on RGU.

Number of Strictures (Table 3)

Both the modalities diagnosed 30 single strictures. One additional single bulbar and single penile stricture diagnosed by SUG and RGU respectively. 13 complex strictures were diagnosed with equal accuracy on both the modalities.

Length of Strictures (Table 4)

Out of 44 patients, 28 patients had short segment strictures, 3 patients had long segment strictures and 13 patients had complex strictures. Out of the 28 short segment strictures, 22 were bulbar (Figure 4) while six were penile short segment strictures. In long segment strictures total three patients were identified, two were penile (Figure 5) and one was bulbar stricture found on SUG which were categorized in short segment category on RGU.

Table 2: Distribution of patients according to location of strictures

RGU / SUG	Penile	Bulbar	Complex	Normal	Total
Penile	8	0	2	1	11
Bulbar	0	26	0	0	26
Complex	0	0	7	0	7
Normal	0	1	0	15	16
Total	8	27	9	16	60

Table 3: Distribution of patients according to number of strictures

RGU / SUG	Single	Multiple	Normal	Total
Single	30	0	1	31
Multiple	0	13	0	13
Normal	1	0	15	16
Total	31	13	16	60

Table 4: Distribution of patients according to length of strictures

RGU / SUG	Short	Long	Complex	Normal	Total
Short	27	0	0	1	28
Long	1	2	0	0	3
Complex	0	0	13	0	13
Normal	1	0	0	15	16
Total	29	2	13	16	60

Periurethral Fibrosis (Table 5)

Out of 44 patients with diagnosis of urethral stricture diseases, sonourethrography revealed periurethral fibrosis in 34 (56.7%) patients.

Other Periurethral Findings (Table 6)

Other findings such as periurethral hematoma, periurethral abscesses, diverticula and false passages were well seen on sonourethrography. Four patients had periurethral abscesses two of them were opening in the urethra and one opening outside. Two patients with trauma had associated periurethral hematoma and collection. However these periurethral hematoma and periurethral abscesses were missed on RGU.

Total 4 cases of diverticula diagnosed on sonography. Out of these two were wide-mouthed diverticula and one shallow penile urethra diverticulum. Case of Syringocele type-2 (Figure 7) also considered under the heading of diverticula as it is described under same heading, suppose to be congenital and have tendency to open in the urethral lumen to give appearance as diverticulum.[6,7] False passages were seen in 16 patients with one patient having urethrocutaneus fistula (Figures 5 & 6).

Table 5: Grades of periurethral fibrosis in relation to stricture on SUG

Grade of fibrosis	Number of patients	Percentage
Minimal	07	11.70%
Moderate	13	21.70%
Extensive/severe	14	23.30%
No fibrosis	26	43.30%
Total	60	100%

Table 6: Distribution according to periurethral findings

Periurethral findings	No. of cases
Hematoma/collections	2
Periurethral abscesses	4
Diverticula	4
False passages	16
Urethrocutaneous fistula	1

DISCUSSION

Retrograde urethrography has been the standard imaging technique for the evaluation of male anterior urethra, which involves the use of radiation and contrast medium. It gives very limited information about periurethral structures. Radiation is harmful especially to the gonads which are frequently exposed during these examinations.

An ideal study should be able to indicate the type of surgical procedure suitable for the patient. This includes accurate determination of the site, length and diameter of strictures. Complete preoperative knowledge of complicating conditions like urethral calculi, fistulae, false tracts, diverticula and polyps facilitate favorable urethroplasty outcomes.

For this study, the sonourethrographic imaging was performed with the urethra distended by normal saline as a negative contrast agent. Bearcroft P.W.P. and Berman L.H[8] used radiographic contrast medium immediately after the contrast study. If no contrast study is to be performed it was replaced by normal saline.

Initial studies described dorsal scanning approach to the penile urethra[3,9,10] moving ventrally for subscrotal and perineal views of the bulbar urethra. These studies however used 5 MHz transducer and near-field artifact was a problem. Despite the penile urethra appearing in the extreme near field, we found that ventral approach was preferable with the penis extended along the lower abdomen. This enabled the longitudinal scans to be accomplished in a single rapid sweep. Near field artifact was abolished by using a high frequency probe (10 MHz).

Table 7: Statistical evaluation of study

Sr. no.	Character	SEN (%)	SPE (%)	PPV (%)	NPPV (%)	K value	Agreement
1	Location of stricture	97.73	93.75	97.73	93.75	0.90	Very good
2	Number of strictures	97.73	93.75	97.73	93.75	0.94	Very good
3	Length of strictures	97.73	93.75	97.73	93.75	0.92	Very good
5	Diverticula	100	98.20	75.00	100	0.85	Very good
7	False passages	100	100	100	100	1.00	Very good
8	For all urethral pathologies	98.96	96.21	78.88	98.87	0.88	Very good

Sen- Sensitivity, Spe- Specificity, PPV- Positive predictive value, NPV- Negative predictive value, K value- kappa value

We used digital panoramic reconstruction of the ultrasound images to facilitate comparison of SUG with RGU.

Out of 60 patients studied most patients belonged to 3rd decade with average age of the patients being 36.33 year (Table 1, Figure 1). Chiou R.K. et al., Bearcroft P.W.P. et al., Gluck C.D. et al., Gupta S. et al., Samaiyar S.S. et al.[4,8,9,11,12] also had mean age of patients around 3rd decade.

Location of Strictures

Locations of the strictures were categorized as penile, bulbar and membranous. One patient with penile stricture was diagnosed only on SUG and missed on RGU while another patient with bulbar stricture was diagnosed only on RGU. Rest of the stricture locations matched perfectly in both the studies.

The two complex penile and membranous strictures which were visualized on RGU and missed on SUG in patients were considered as false negative. McAninch JW et al., Bearcroft P.W.P. et al. and Gupta S. et al.[3,8,11] had similar problem regarding the posterior urethra (membranous and prostatic), which is difficult to evaluate with SUG owing to its inability to scan the urethra in a perpendicular fashion.

One penile partial stricture missed on RGU was seen on SUG with periurethral fibrosis. Patient had stricture demonstrated at same site before the urethral dilatation on RGU. This stricture was considered false positive. Pushkarna R. et al.[13] reported similar finding, one patient had normal RGU showed 2 mm stricture on SUG.

One bulbar stricture, which was demonstrated on RGU, was missed on SUG. Patient had bilateral large scrotal pyocele; this pyocele interfered with proper visualization of bulbar urethra. This stricture was considered false negative. In the rest of the patients location of stricture perfectly matches on both the modalities.

Strength of agreement between these two methods by kappa statistic for location of strictures was found to be 0.90, which means very good agreement. Sensitivity and specificity of sonourethrography for location of stricture was 97.73% and 93.75% respectively. Positive and negative predictive values were 97.73% and 93.75% respectively (Table 7).

Number of Strictures

Out of 44 patients, 'single stricture' were found in 31 patients and 'complex' strictures in 13 patients. The 'single stricture' included three bulbar and three penile strictures which were multiple in numbers however they were at single location. The penile strictures included two strictures with associated membranous urethral strictures visualized on RGU missed on SUG.

Kappa value for number of stricture was 0.94 meaning very good agreement between SUG & RGU. Sensitivity and positive predictive value of SUG was 97.73% and specificity and negative predictive value was 93.75% (Table 7). There was good correlation of the complex strictures in both the techniques. All the previous studies showed good correlation of both the modalities regarding stricture number or multiplicity. [4,5,9,12]

Length of Stricture

SUG diagnosed length of stricture with sensitivity of 97.73% and specificity of 93.75%. Positive and negative predictive values were 97.73% and 93.75% respectively. Kappa value for length of stricture was 0.92, which signifies very good agreement between SUG and RGU (Table 7).

When strictures were grouped according to anatomical sites, both techniques were equally sensitive in length estimation in the penile urethra. However, RGU correlated poorly with length of strictures in the bulbar urethra, underestimating the length in spite of radiographic magnification. Most previous studies show consistently poor correlation between RGU and SUG in estimating stricture length, especially for bulbar urethral strictures.[14] This information gained using SUG in the penile urethra was not as helpful in clinical decision making as it was in the bulbar region because conventional radiographic RGU correlated closely with sonourethrographic and intraoperative findings in this area.[5] Gupta et al.[11] in the study including 30 patients reported poor correlation between the two techniques in estimation of stricture length, RGU underestimating the length in most cases. S. Choudhary, P. Singh et al.[15] in their study of

70 patients reported similar findings. Samaiyar S.S. et al.[12] found that contrast urethrography underestimated the length by 50% or by 0.6 mm, mainly in the bulbar region.

The accurate estimation of stricture length is important, as it is one of the factors that determine the suitable operative procedure. Earlier investigators, using standard radiographic imaging alone, proposed that only strictures 1 cm or less be selected for excision therapy.[16] Because sonographic measurements are often longer, new ultrasonic criteria proposed indicate resection and end-to-end anastomosis for adult bulbar stricture measuring up to 25 mm.

The overall sensitivity of ultrasound in evaluation of stricture was found to be 97.73% and specificity was 93.75%. The predictive value of positive diagnosis in the present study was 97.73% and that of negative diagnosis was 93.75% (Table 7). Comparing this with the study by Heidenreich A. et al.[17] showed sensitivity of 98% and specificity of 96% with positive and negative predictive values 98% and 96% respectively. Samaiyar S.S. et al.[12] had sonourethrographic accuracy of 96.44%.

Additional information was available about the periurethral region on sonourethrography like periurethral fibrosis.

Periurethral Fibrosis

There was no correlation between the presence of periurethral fibrosis and the severity of strictures. Periurethral fibrosis is a critical determinant of appropriate therapy and ultimate prognosis.[16] Excessive fibrosis is said to be responsible for high recurrence rates.[10]

Other Periurethral Findings

Other findings such as periurethral hematoma, periurethral abscesses, diverticula and false passages were well seen on sonourethrography. However periurethral hematoma and periurethral abscesses were missed on RGU.

Diverticula were diagnosed by sonourethrography with 100% sensitivity and 98.2% specificity. Positive predictive value was 75% and negative predictive value was 100%. Degree of agreement calculated between SUG and RGU found to be Kappa value = 0.85 means very good agreement (Table 7).

Bearcroft P.W.P. et al.[8] studied 24 patients of which 11 were normal. Three cases demonstrated diverticula however only two of these were seen on SUG. A shallow diverticulum was found in case of complex strictures only on contrast study. Alanen A, Nurmi M[18] studied 16 male patients out of which one had diverticulum. Most of the previous studies underestimated these findings.

False passages were seen in 16 patients and one had urethrocutaneus fistula. False passages were seen equally with both the methods, however careful evaluation of the periurethral structures and proper transverse scanning was needed.

Chiou RK et al.[4] patients had inadequate evaluation in eight patients out of 35. Among 27 patients one had no stricture, another had urethrocutaneus fistula without stricture and a case of false passage with short stricture. RGU were unable to demonstrate the origin of fistula however SUG identified the origin of fistula and delineated the extent of urethral and periurethral extent. Gupta s. et al.[11] were able to pick up 10 false tracts on retrograde urethrography and eight false tracts out of 10 on sonourethrography. Sonourethrography definitely have upper hand in evaluation of periurethral pathologies.

The complications encountered during RGU were contrast intravasation in one (1.6%) patient, pain during the procedure in one (1.6%), and urethral bleeding in one (1.6%) patient. One (1.6%) patient had chills during the procedure. No patients with contrast intravasation had adverse systemic reactions. Local burning pain occurred during retrograde injection of contrast medium. This subsided in all cases a few hours after the procedure. During sonourethrography, pain was experienced by one (1.6%) patient during inflation of the Foley bulb in the fossa navicularis and bleeding per urethra in one patient (1.6%). Sonourethrography certainly have added advantage of lesser degree of complications.

CONCLUSIONS

In the present study we have found sonourethrography to be a multiplanner, easily available and cost effective technique for evaluating the male anterior urethra without radiation exposure. It is an effective combination of high-resolution sonography and normal saline as a negative contrast agent.

When compared with conventional RGU, sonourethrography is equally efficacious in detecting anterior urethral stricture diseases. However, further characterization of strictures in terms of length, periurethral pathologies like periurethral fibrosis, diverticula, abscesses, fistulas and false tracts can be performed with relatively greater sensitivity using the sonourethrography.

Ability of sonourethrography to diagnose periurethral pathologies and length of stricture especially in bulbar urethra helps surgeon to plan proper surgical procedure. In conclusion, sonourethrography in experienced hand

can prove to be highly effective modality for diagnosis of anterior urethral obstructive pathologies like strictures.

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