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Ascending Urethrogram and Sonourethrogram in Evaluation of Male Anterior Urethra

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Authors' contributions

This work was carried out in collaboration between all authors. Author VNSD designed the study, wrote the protocol and the first draft of the manuscript. Authors SK, AA and PM managed the analyses of the study. Authors BS, RR and SR performed the statistical analysis and managed the literature searches. All authors read and approved the final manuscript.

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Letter to the Editor

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ABSTRACT

Aim: To determine the efficacy and accuracy of detection and characterization of anterior urethral strictures by sonourethrogram compared to retrograde urethrogram.
Materials and Methods: A total of 45 patients presented during the 4 months duration of the study. 31 patients qualified for the study; however 2 of these patients were excluded due to technical difficulties encountered during the sonourethrogram. The parameters studied were age, ethnicity, detection of strictures and characterization by length, location and diameter. In the RUG

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tapered segments on either side of the stricture were included. Age distribution, Paired t-test and correlation coefficient were examined.

Results: Age distribution of the study population was between 18-80 years. Among the study population, 58.6% were East Indian origin and 41.4% were African origin. 10 out of 29 patients showed normal anterior urethra by both RUG and SUG. Also, the two techniques correctly identified normal from abnormal study. The presence of a stricture and its location was correctly identified by both methods which were retrospectively confirmed with optical cystourethroscopy. The stricture length and diameter measured by SUG and RUG showed no statistically significant difference. The Pearson correlation coefficient(r) is 0.95 for length measurement ($p<0.01$) and correlation(r) is 0.837 for diameter measurement ($p<0.01$). Periurethral fibrosis and mucosal abnormalities were well shown by sonourethrogram. Among the strictures demonstrated by SUG, 52.6% showed periurethral fibrosis. The presence of periurethral fibrosis varied between the bulbar and penile areas, 77% in bulbar strictures compared to 24% in penile strictures.

Conclusion: Both RUG and SUG proved to be equally efficient in detecting the site of stricture and assessing the length and diameter of the stricture. We noticed that by including the tapered segments on either side of stricture in RUG, the length measurements were comparable to SUG. The periurethral fibrosis and mucosal abnormalities were well demonstrated by the SUG, which was not evident by the RUG.

Keywords: Sonourethrogram; retrograde urethrogram; anterior urethral strictures; periurethral fibrosis.

1. INTRODUCTION

Urethral strictures in males are either anterior or posterior. Generally, the term urethral stricture applies to the stenosis of the urethra caused by fibrous scarring of the anterior urethra secondary to collagen and fibroblast proliferation [1,2]. The scarring process usually starts in the lumen and extends to involve the corpus spongiosum and adjacent structures. The scarring of the corpus spongiosum is called spongiofibrosis. Ultimately, the scarring leads to retraction and contraction resulting in reduced diameter of the urethral lumen.

The etiology of the anterior urethral strictures may be secondary to inflammatory (e.g. infectious urethritis, balanitis xerotica obliterans) and traumatic (straddle injury, iatrogenic instrumentation) or congenital in origin. The infectious strictures from gonococcal urethritis were a major cause in the past. The other infectious causes include Chlamydia urethritis and tuberculosis. In recent years the most common cause of urethral stricture is secondary to trauma, either from instrumentation or accidents (like straddle injury and pelvic fractures) [3]. Management of urethral strictures are aimed at reducing the morbidity and enhancing the quality of life. There are many options like simple dilatation, internal urethrotomy, stenting and various reconstructive surgeries available for the treatment of the urethral strictures [4]. The selection of the appropriate type of treatment is largely dependent on the preoperative evaluation of the strictures. The assessment of the morphology of stricture such as the length of the stricture, diameter of the stricture, site of the stricture and presence or absence of periurethral fibrosis, etc. is a very important determinant for the method of management of the stricture. Hence, imaging forms one of the integral parts in the management of the urethral strictures.

Retrograde urethrography (RUG) and micturatingcystourethrography (MCUG) have long been used as the standard procedures for the evaluation of the anterior urethra and posterior urethra respectively. Strictures are more common in the anterior urethra and RUG is the standard imaging technique used to evaluate the anterior urethra, not only for strictures but also for other diseases like diverticulae, fistula or tumours. However, the RUG has certain disadvantages and limitations such as use of radiation and contrast media [5].

The sonourethrogram (SUG) for the study of anterior urethra is an alternative and safer method of evaluation of the anterior urethra. The SUG has been shown by many studies to be accurate and reliable in measuring the stricture length compared with RUG [6-11]. The use of sonourethrogram for the evaluation of strictures has long been studied and popularized for the last 2-3 decades [6,12,13]. These types of studies are however limited in our knowledge in the Caribbean region and the procedure is not well known. Hereby we undertook the study of

sonourethrogram at the SFGH to evaluate the anterior urethra and compare the results with RUG.

2. MATERIALS AND METHODS

A total number of 45 patients were presented to the department. Among these, 10 patients were known to have posterior urethral strictures, 2 patients had recent history of trauma and 2 patients had urethral fistula and hence were excluded from the study. Furthermore, 2 of the 31 patients were excluded from the study due to the technical difficulties encountered while performing sonourethrogram. The RUG was initially performed by an independent radiologist other than the investigator which was then followed by the SUG performed by the investigator. The results of the retrograde urethrogram were blinded to the investigator performing sonourethrogram. The results obtained by the two methods were compared by two independent radiologists in order to avoid the bias. The various parameters like normal or abnormal study, site of the stricture, length of the stricture, diameter of the stricture, presence or absence of periurethral fibrosis and demographic data were collected for statistical analysis.

The retrograde urethrogram was performed on a fluoroscopy table. A control film was taken before the study. Under aseptic conditions, an 8 F Foley's catheter which was prefilled with contrast to prevent air bubbles was introduced into the glans penis which was stabilised in the navicular fossa by inflating the catheter bulb using 0.5 ml to 1.0 ml sterile water. The patient was then positioned in LAO position with right knee semi flexed and left leg extended. The penis was positioned over the right thigh keeping as horizontal as possible to the table. Under fluoroscopic guidance 10-20 ml of contrast media (Urografin 76%) was introduced and a single spot film was taken. Additional films were taken if necessary.

The sonourethrogram was performed soon after the retrograde urethrogram; 20 to 60 ml of normal saline was introduced in 10 ml increments through the same catheter (8 F Foley) placed for ascending urethrogram in navicular fossa. The patient was positioned supine on the table and the penis was placed over the lower abdomen exposing the ventral side of the penis. The ultrasound gel was applied over the ventral part of the penis, scrotum and perineum. The anterior urethra was imaged with Siemens Acuson X 300 ultrasound machine using high frequency (VF 5-10 MHz) linear array transducer. The saline filled anterior urethra appeared as an echo free dark area on ultrasound. The anterior urethra (penile and bulbar urethra) was scrutinized in both longitudinal and transverse views. The presence of stricture, the site of stricture, length and diameter of stricture was assessed thoroughly. The presence or absence of periurethral fibrosis was evaluated, which appeared as increased periurethral echogenicity with or without posterior acoustic shadowing.

The measurement of stricture length and diameter was done with the aid of an electronic calliper available on the imaging monitor. The length of the stricture was measured in sonourethrogram from the transition of normal to abnormal urethral mucosa on either end of stricture as shown in Fig. 1. In measuring the stricture on retrograde urethrogram, we followed the technique that includes the tapered ends of the stricture. The imaginary lines drawn connecting the normal urethra outlined in RUG on either side of the stricture was taken as the length measurement as shown in Figs. 2 and 3.

The presence and site of the strictures was confirmed retrospectively by cystourethroscopy in all patients. Unfortunately, we do not have the operative findings for length measurements for comparison as most of our study population either underwent internal urethrotomy or awaiting for urethroplasty.

The study was conducted at San Fernando General Hospital (SFGH) in the radiology department. The study was planned and conducted strictly in accordance with Helsinki principles and good clinical practice. Ethics committee approval for the study was obtained from the University of the West Indies. Patients referred from urology outpatient department for urethrogram with clinical diagnosis of urethral strictures were considered for the study. Young patients aged less than 18 years of age, patients with recent (less than 3 months) history of traumatic injury to the urethra and patients with known posterior urethral strictures were excluded from the study. Informed consent was taken from all patients.

2.1 Statistical Analysis

Analysis was performed using IBM SPSS v 21.0 software. The paired t- test and correlation coefficients were calculated. In all tests, p values of ≤0.05 were considered significant and P values >0.05 was considered as a trend.

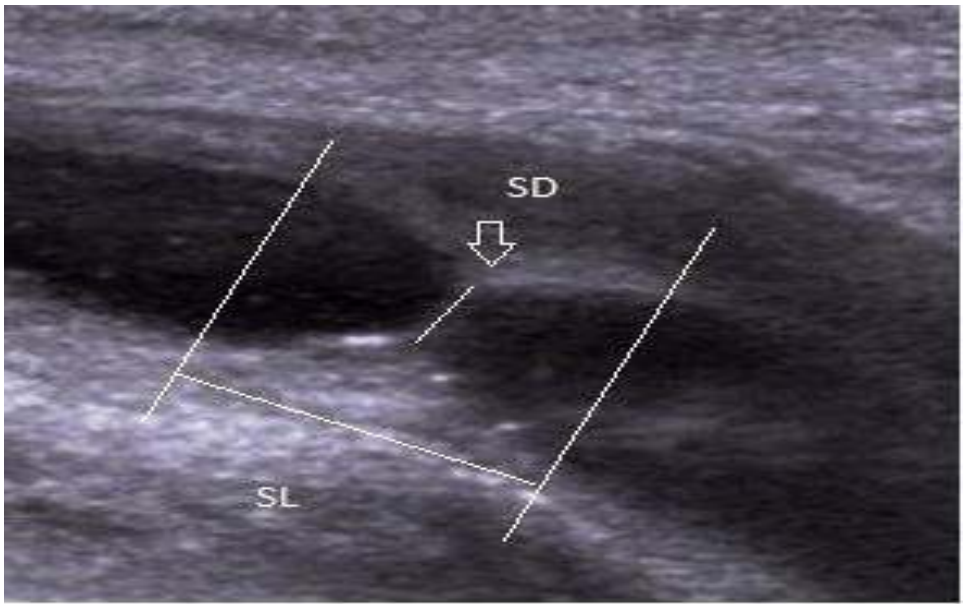

Fig. 1. Saline sonourethrogram showing the method of measurements

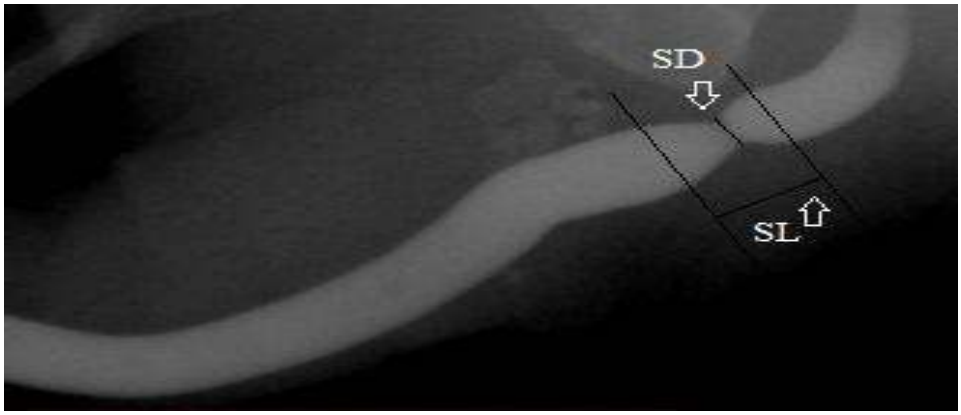

Fig. 2. RUG showing the method of measurements

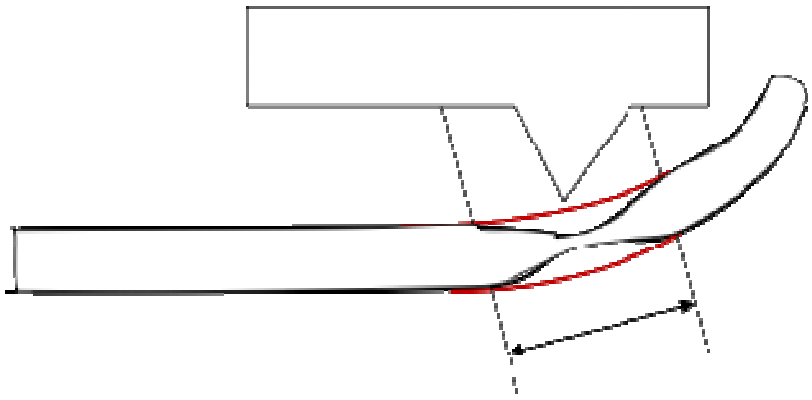

Fig. 3. Line diagram showing the stricture measurement method in RUG

3. RESULTS

A total of 29 patients were examined by both RUG and SUG. Various parameters like age, ethnicity, presence of stricture, site of the stricture, length of the stricture, diameter of the stricture and periurethral fibrosis were studied by both RUG and SUG and statistically compared.

3.1 Age

The mean age of the patients presented for the study was 56.21±15.65. The minimum age is 18 years and maximum age is 80 years (Table 1).

3.2 Ethnicity

Among the study population, 17 patients were of East Indian origin and 12 were of African origin.

3.3 Stricture Detection by SUG and RUG

Among 29 patients, 10 patients showed normal anterior urethra by retrograde urethrogram and same patients also showed normal anterior urethra in sonourethrogram. The strictures detected by retrograde urethrogram in 19 patients were also detected by sonourethrogram in similar anatomical location which were confirmed retrospectively by cystourethroscopy.

3.4 Stricture Location

The stricture location was divided into 5 categories into penile, penobulbar junction (Penoscrotal), bulbar, bulbomembranous and long stricture (stricture measured more than 4 cm). Both investigations showed strictures in similar anatomical categories. The total of 3 penile, 5 penobulbar, 9 bulbar, 1 bulbomembranous and 1 long stricture (>4 cm) were recognized.

3.5 Stricture Length

The statistical comparison of stricture length measurements by retrograde urethrogram and sonourethrogram showed no significant difference ($r=0.951$, $P<0.01$). The mean length of strictures according to anatomical location was also compared. Mean length of stricture by sonourethrogram is slightly greater than the retrograde urethrogram in penile and bulbar strictures. The strictures involving the bulbomembranous junction showed greater length measurement on retrograde urethrogram than SUG which could be secondary to poor visualization of the proximal end of stricture in sonourethrogram.

3.6 Stricture Diameter

The stricture diameter also showed high correlation between both methods with no significant statistical difference ($r= 0.837$, $p<0.01$).

3.7 Periurethral Fibrosis

The periurethral fibrosis was seen in 10 out of 19 (52.6%) patients. When it was seen, greater percentage was present around the bulbar strictures (77%) compared to penile strictures (24%).

4. DISCUSSION

The ascending urethrogram and micturating cysto-urethrogram are the standard radiological investigations to assess the male urethra. Strictures may be caused by infection, prolonged urinary catheterization, instrumentation, previous internal urethrotomy, trauma, and neoplasm.

Albers P et al. [13] concluded that due to a high rate of recurrence of strictures secondary to internal urethrotomy, urethroplasty should be considered as an effective treatment in patientswith more than one treatment failure after internal urethrotomy. In general strictures less than 1 cm long are treated with urethral dilatation and/or internal urethrotomy. Strictures no more then 1-2 cm in length are treated by urethroplasty with end to end anastomosis in bulbar region, where the cause of the stricture is trauma or congenital. Strictures longer than 2 cm and penile strictures greater than 1 cm are treated with substitution urethroplasty [9]. Hence, when reconstructing urethral strictures, the length and diameter of the stricture and degree of periurethral fibrosis are the main factors that will decide the choice of surgical procedure.

The SUG was discussed for the past 3 decades by many authors as an effective and alternative method to RUG in evaluating anterior urethral strictures. Heidenreich A. et al. [14] reported that sonourethrography showed 98% sensitivity and 96% specificity in detecting urethral strictures. However, Babnik Peskar et al. [10] found SUG detected 98.4% of the strictures shown by RUG. SS Samaiyar et al. [15] reported that the diagnostic accuracy of RUG was 85% compared

Table 1. Age distribution in the study population

	N	Minimum	Maximum	Mean	Std. deviation
Age	29	18	80	56.21	15.651

Table 2. Represents the summary of the data collected

Patient code	Age	Ethnicity	Length of stricture (cms)		Site of stricture		Diameter of stricture		Periurethral fibrosis
			US	RUG	US	RUG	US	RUG	
2	29	EI	2.7	4.0	BMJ	BMJ	0	0	Present
4	65	AF	0.8	0.5	P	P	0.1	0.1	Absent
4	65	AF	0.5	0.4	PBJ	PBJ	0.1	0.1	Absent
5	18	EI	1.9	1.7	PBJ	PBJ	0.1	0.1	Absent
6	62	AF	2.5	2.4	B	B	0.1	0.2	Present
7	73	AF	0.8	0.7	B	B	0.1	0.1	Absent
8	63	AF	1.6	1.1	B	B	0.1	0.1	Absent
10	67	EI	>4	>4	P+B	P+B	0.2	0.2	Present
14	45	EI	0.9	0.6	P	P	0.3	0.2	Absent
16	62	EI	1.1	1.1	B	B	0.3	0.2	Absent
19	50	EI	1.0	1.0	PB	PB	0.5	0.5	Present
20	50	AF	1.2	1.2	B	B	0.1	0.1	Present
21	45	EI	0.4	0.4	P	P	0.1	0.1	Absent
22	32	AF	2.9	2.6	B	B	0.2	0.2	Present
23	72	AF	3.2	2.7	PB	PB	0.1	0.3	Present
24	63	EI	0.5	0.4	B	B	0.3	0.3	Absent
26	73	EI	2.5	2.0	PB	PB	0.3	0.2	Present
29	57	EI	2.0	0.9	B	B	0.1	0.1	Present
31	31	EI	2.0	2.0	B	B	0.1	0.1	Present

EI= East Indian origin, AF= Caribbean African origin, P= Penile, PB= Penobulbar, B= Bulbar, BM= Bulbomembranous

to 96% of SUG. Nash et al. [16] showed in their study both SUG and RUG correctly identified stricture and anatomical location. Likewise, S Choudhary et al. [7] in his study did not find any difference between the RUG and SUG in identifying the stricture and anatomical location. In our study also we found that RUG and SUG correctly indentified the presence of stricture and their anatomical location therefore the results coincided with the previous studies.

The choice of the surgical procedure is based upon the stricture length, location, and severity of periurethral fibrosis, so the accurate characterization of these parameters while assessing the urethra should be considered. Several previous studies [17-19,11,20,8,21]. in the literature showed underestimation of stricture length by radiographic examination. Nash et al. [16] published in their study that there was a significant difference between stricture length as measured by urethrography compared to sonourethrography ($p<0.003$). However when he grouped them into penile and bulbar, penile strictures showed good correlation (correlation coefficient=0.94), while bulbar strictures showed poor correlation (correlation coefficient=0.64, $p<0.007$). Samaiyar SS et al. [15], Babar Khan M et al. [19] found similar findings in their studies. S Choudhary et al. [7] found in the estimation of stricture length, RUG showed a lower sensitivity (60-80%) for lengths 1-4 cm, compared with sonourethrogram (73.3-100%). Also they observed that spongiofibrosis was detected by sonourethrography with a sensitivity of 77.3 - 83.3%. Gluck et al. [22] and Gong EM et al. [23] both suggested that sonourethrography is effective for evaluating the urethral stricture disease and it may also provide more accurate measurement and improve preoperative planning. Morey et al. [21] concluded in their study that the preoperative SUG did not change the management in strictures measuring <10 mm in RUG.

5. CONCLUSION

However, they concluded that in the management of intermediate length strictures (measuring on RUG 11-25 mm) sonourethrogram has a major influence on selection of therapy. SUG enables the selection of patients by identifying the stricture too long for resection and end to end anastomosis, which may be appropriately treated by flap or graft procedure. Based on their findings they recommended excisional therapy for strictures less than 25 mm measured by SUG.

The study published by Babnik Peskar et al. [10] observed no major differences between RUG and SUG in carefully conducted RUG with accurate length measurement i.e. including the tapered ends of stricture on either side. We followed the recommendations made by Babnikpeskar et al. [10] and conducted the RUG in the recommended left anterior oblique position, keeping the penis as much as possible parallel to the fluoroscopy table. In our study the length of the strictures measured by SUG and RUG showed no statistically significant difference. However, when the stricture lengths were grouped into penile and bulbar sites, there was more correlation observed in the penile area than in the bulbar. This could be explained by the fact that the bulbar urethra is in a deeper location in the pelvis and it may not be positioned completely parallel to the fluoroscopic table, causing foreshortening of the stricture. S Choudhary et al. [7] found lower sensitivity and accuracy in the estimation of stricture diameter and lowest for severe degree strictures of diameter <4 mm. Babnik Peskar et al. [10] found similar percentage of lumen reduction in RUG and SUG suggesting good correlation between the two methods. In our study the stricture diameter showed high correlation (correlation coefficient=0.837) between the RUG and SUG.

One of the advantages of SUG over RUG is the ability to show the periurethral soft tissues and periurethral scarring or fibrosis. The strictures with significant fibrosis are shown to have higher rates of recurrence after treatment [8,12,24]. The extent, location and depth of the periurethral scarring are relevant factors to consider during internal urethrotomy. Gluck et al. [22] suggested that SUG when used intraoperatively can detect the extent and location of scar accurately leading to more adequate incision of the scar [25]. Furthermore, considerable scarring may not always be at the 12 o'clock position, which is the typical incision site generally used during urethrotomy. Hence, using SUG to evaluate periurethral scarring guides the treatment and reduces the rate of recurrence [22]. The detection of periurethral fibrosis is therefore one of the key findings in selection of appropriate therapy and prognosis [23]. In our study we found 52.6% of strictures were associated with significant periurethral fibrosis which was not identified by RUG. Also we observed that when periurethral fibrosis was present it showed in a greater percentage (77%) in bulbar strictures than in penile strictures (24%).

In addition SUG was shown to be superior in detecting other urethral abnormalities like small urethral calculi, urethral mucosal abnormalities and false tracts [7]. In our study we observed mucosal detachment in one case by sonourethrogram which was not demonstrated by RUG. The sonourethrogram provides dynamic 3D real time imaging of urethral abnormalities which was not possible by conventional RUG.

Sonourethrogram is a simple and well tolerated procedure which can be safely repeated without exposing to radiation. Sonourethrogram is done without using radiographic contrast material, alleviating the contrast related adverse reactions. Similar to other studies, we observed that in all our study subjects SUG was better tolerated than RUG [7,14]. In our study most of the patients expressed that they preferred the sonourethrogram over retrograde urethrogram as it was a more comfortable and less painful procedure.

6. LIMITATIONS

One major limitation of sonourethrogram is its inability to visualize the posterior urethra by transperineal approach. The transrectal approach has been studied by different authors for the evaluation of posterior urethra [26,27]. However, this approach is not well tolerated by the patients. Another limitation found in our study was that the long penile and bulbar strictures were unable to be distended adequately, causing the restricting proper visualisation. Also, in subjects with perineal scars and previous perineal surgeries the bulbar urethra was inadequately visualised.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Gallentine ML, Morey AF. Imaging of the male urethra for stricture disease. Urol Clin North Am. 2002;29:361–372.
2. Bircan MK, Sahin H, Korkmaz K. Diagnosis of urethral strictures: Is retrograde urethrography still necessary? Int Urol Nephrol. 1996;28:801–804.
3. Blandy JP. Urethral stricture. Postgrad Med J. 1980;56:383-418.
4. Peterson AC, Webster GD. Management of urethral stricture disease: Developing options for surgical inter- vention. BJU Int. 2004;94:971–976.
5. Edward M, Mullin Lloyd J, Paterson and David, Paulson F. Retrograde urethrogram: Diagnostic aid and hazard. J. Urol. 1973;110:464-466.
6. McAninch JW, Laing FC, Jeffery B, Jr. Sonourethrography in the evaluation of urethral stricture: A preliminary report. J Urol. 1988;139:294-297.
7. Choudhary S, Singh P, Sundar E, Kumar S, Sahai A. A comparision of sonourethrography and retrograde urethrography in evaluation of anterior urethral strictures. Clin Radiol. 2004;59: 736-742.
8. Merkle W, Wagner W. Sonourethrography of the distal male urethra: A new diagnostic procedure for urethral strictures. Results of retrospective study. J Urol. 1988;140: 1409–1411.
9. Mundy AR. Management of urethral strictures. Postgrad Med J. 2006;82:489-493.
10. Babnik Peskar D, Visnarperovac A. Comparison of radiographic and sonographic urethrography for assessing urethral strictures. Eur Radiol. 2004;14: 137-144.
11. Sakti D. Ultrasonographic evaluation of the urethral stricture disease. Urology. 1992; 40:237–242.
12. Jordan GH, Schlossberg SM, Devine CJ. Surgery of the penis and urethra. In: Walsh FC, Retik AB, Vaughan ED Jr., et al., editors. Campbell's urology, 7th ed. Philadelphia: WB Saunders. 1998;3318-94.
13. Albers P, Fichtner J, Bruhl P, Muller SC. Long-term results of internal urethrotomy. J Urol. 1996;156:1611-4.
14. Heindenrreich A, Derschum W, Bonfig R, Wilbert DM. Ultrasound in the evaluation of urethral stricture disease: A prospective study in 175 patients. Br J Urol. 1994; 74:93–98.
15. Samaiyer SS, Shukla RC, Dwivedi US, Singh PB. Role of sonourethrography in anterior urethral stricture. Indian J Urol. 1999;15:146-151.
16. Nash PA, McAninch JW, Bruce JE, Hanks DK. Sonourethrography in the evaluation of anterior urethral strictures. J Urol. 1995;154:72—6.
17. Gupta S, Manibrata B, Tiwari A, Gupta RK, Kumar A, Gujral RB. Sonourethrography in the evaluation of anterior urethral strictures: Correlation with radiographic urethrography. J Clin Ultrasound. 1993; 21:231–239.
18. Pushkarna R, Bhargava SK, Jain M. Ultrasonographic evaluation of abnormalities of the male anterior urethra. Indian J Radiol Imaging. 2000;10:89-91.
19. Babar Khan M, Mahamood R, Ghaffar A, Mahmood T. Role of sonourethrography in evaluation of anterior urethral stricture and comparison with retrograde urethrography; 2006.
20. Alam AKMK, et al. Sono-urethrography in the evaluation of male anterior urethral strictures.BJU. 2010;13(2):51-56.
21. Morey AF, McAninch JW. Role of preoperative sonourethrography in bulbar urethral reconstruction. J Urol. 1997; 158:1376–1379.
22. Gluck CD, Bundy AL, Fine C, Loughlin KR, Ritchie JP. Sonographic urethrogram: comparison to roentgenographic techniques in 22 patients. J Urol. 1988; 140:1404–1408.
23. Gong EM, Arellano CM, Chow JS, Lee RS. Sonourethrogram to manage adolescent anterior urethral stricture. J Urol. 2010; 184(4 Suppl):1699-1702.
24. Merkle W, Wagner W. Risk of recurrent stricture following internal urethrotomy. Prospective ultrasound study of distal male urethra. Br J Urol. 1990;65:618–620.

25. Klosterman PW, Laing FC, McAninch JW. Sonourethrography in the evaluation of urethral stricture disease. Urol Clin N Am. 1989;16.
26. Matthew D. Rifkin MD. Sonourethrography: Technique for evaluation of prostatic urethra. Radiology. 1984;153:791-792.
27. Shapeero LG, Friedland GW, Perkash I. Transrectal sonographic voiding cystourethrography: Studied in neuromuscular bladder dysfunction. AJR. 1983;141:83-90.

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