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## SONOGRAPHIC EVALUATION OF MALE ANTERIOR URETHRAL STRICTURES: CORRELATION WITH RETROGRADE URETHROGRAPHY – A REVIEW

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### INTRODUCTION

In general, the term urethral stricture refers to a fibrous scarring of the urethra caused by collagen and fibroblast proliferation.<sup>1-3</sup> The scarring process can extend through the tissue of the corpus spongiosum into adjacent structures and this associated scarring in the surrounding corpus spongiosum is known as spongiofibrosis.<sup>1,4</sup> Contraction of this scar reduces the width of the urethral lumen. Bulbar urethral strictures represent the overwhelming majority of cases, while prostatic urethral strictures are rare.<sup>5</sup> The causes of anterior urethral strictures may be inflammatory (e.g., infectious urethritis, balanitis xerotica obliterans), traumatic (straddle injury, iatrogenic instrumentation) or congenital.<sup>1,6</sup> However, most urethral strictures are the result of infection, instrumentation or other iatrogenic causes.<sup>1</sup> The most common external cause of traumatic stricture is straddle injury.<sup>1,7</sup> The male urethra is longer than that of the female and traverses through several anatomical structures such as the prostate, urogenital diaphragm, and corpus spongiosum of the penis, it is therefore more vulnerable to injury and stricture than the female urethra.<sup>1,8</sup> Inflammatory strictures associated with gonococcal urethritis have become less common despite the fact that gonococcus remains the most common sexually transmitted disease.<sup>1</sup> In developing countries, infection is the predominant cause of anterior urethral stricture, unlike in the developed world where trauma is the predominant cause.<sup>9-13</sup> Iatrogenic trauma to the urethra may result from pressure necrosis at fixed points in the urethra from indwelling catheters.<sup>1</sup> Instrumentation-related strictures

usually occur in the bulbomembranous region and, less commonly, at the penoscrotal junction.<sup>1</sup> Congenital hypospadias could be associated with urethral stricture, and following repair of hypospadias, there is an increased likelihood of post-surgical stricturing.<sup>14</sup>

There is currently progressive increase in the incidence of urethral stricture due to the increased number of permanent catheter bearers, the surge of sexually transmitted diseases, and misuse of transurethral diagnostic or therapeutic instrumentation.<sup>1,6</sup>

### EPIDEMIOLOGY OF URETHRAL STRICTURE

Urethral stricture disease increases with age, with a marked increase in persons over the age of 55 years.<sup>5</sup> The peak prevalence of anterior urethral stricture is 40-45 years of age and it is very rare below 9 years.<sup>9-13</sup> The true prevalence of urethral stricture is only estimable. Even with complex analysis of large datasets, in hospitals across the regions of the United States, in a population of older veterans, prevalence was found to be only 0.6%.<sup>5</sup>

Anterior urethral strictures, may present with difficulty in voiding, urinary tract infection, acute urinary retention and high bladder emptying pressures. In the evaluation of patients with urethral abnormalities, clinical evaluation yields limited information and imaging studies are usually indicated.<sup>8</sup> Urethroscopic evaluation may also be limited when a high-grade urethral stricture is present.<sup>8,15</sup>

### SONOURETHROGRAPHY VERSUS OTHER URETHRAL IMAGING MODALITIES

Conventional contrast studies such as retrograde urethrography (RUG), voiding

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cystourethrography (VCUG), and double-balloon catheter urethrography are the most commonly used imaging modalities.<sup>1,8</sup> Although these radiographic studies can clearly delineate luminal abnormalities of the urethra, they are limited in demonstrating the abnormalities of the periurethral tissues.<sup>15-18</sup> Recently, advanced cross-sectional imaging techniques such as ultrasound, have been utilized as adjunctive tools in evaluating patients with urethral abnormalities.<sup>1,6,8</sup> The capability of these cross-sectional imaging modalities to evaluate periurethral abnormalities as well as the intrinsic urethral pathology enables more comprehensive delineation of lesions.<sup>8,16,17</sup> Retrograde urethrography is the primary method used to image anterior urethral stricture.<sup>1,8</sup> On RUG, the stricture length is measured as the maximum distance along a tangential straight line touching the edges of the normal urethra adjoining the stricture segment either above or below.<sup>18</sup> The length of urethral stricture may be underestimated if the patient is not placed in a steep oblique position for retrograde urethrography.<sup>6</sup> More than one projection may also be necessary to visualize the stricture.<sup>18-23</sup> Rapid and forceful injection of contrast medium in RUG may lead to rupture of the mucosal barrier with extravasation of contrast into the systemic circulation. This may occasionally lead to systemic complications such as sepsis and anaphylaxis.<sup>24</sup> Reflex contraction of the pelvic muscle due to forceful injection of contrast may also lead to a falsely positive diagnosis of stricture.<sup>1,24</sup> Voiding cystourethrography (VCUG) is preferred for the evaluation of the posterior urethra.<sup>8</sup> Sonourethrography has proven to be precise and effective for evaluating urethral strictures<sup>6,25</sup> and the superficial location of the male anterior urethra makes it ideally suited for sonographic assessment. High frequency transducers produce excellent images and these have become widely available in many centers.<sup>6,8,15</sup> Strictures are located as segments of reduced distensibility on injection of saline.<sup>21</sup> The stricture length and diameter are

determined using electronic calliper measurements.<sup>21</sup> Stricture length is an important criterion for determining therapy. Sonourethrography is best used adjunctively to guide treatment planning in patients with known bulbous urethral strictures and it has been reported to be more accurate than retrograde urethrography for estimating the length of urethral strictures.<sup>17,26-29</sup> Excision and primary anastomosis is appropriate for bulbar urethral strictures under 2.5 cm in length. Re-approximation of longer strictures can result in curvature, pain and tension on the anastomosis. For strictures longer than 2.5cm, the surgeon can use appropriate techniques.<sup>15,22</sup> However, posterior urethral strictures cannot be reliably assessed using sonourethrography.<sup>16</sup>

On SUG, periurethral fibrosis appears as thickened, irregular, non-distensible, echogenic tissue encroaching into the otherwise anechoic urethral lumen. Heavily scarred spongiofibrotic tissue creates a stronger reflective zone that appears echogenic due to high collagen content.<sup>1,6,8,15,21</sup> When SUG demonstrates posterior shadowing, commonly seen in complete or near complete strictures of traumatic origin, and a non-distensible lumen diameter of less than 3 mm during maximum retrograde distention, the changes of periurethral spongiofibrosis are considered to be severe.<sup>21</sup> Spongiofibrosis is best treated with surgical resection.<sup>30,31</sup>

Morey *et al.*<sup>3,2</sup> reported that sonourethrography is a simple technique that provides a dynamic, precise assessment of anterior urethral strictures and it is best suited for staging in men with known symptomatic strictures in whom the need for surgery is clear. As a screening study, SUG does not appear to offer any advantages compared to standard radiographic retrograde urethrography, and the potential additional costs of routine sonographic screening are not warranted.<sup>23,24</sup> The amount of additional information obtained from sonourethrography compared to that provided by contrast imaging is questionable.

Even those clinicians who are most enthusiastic about the efficacy of ultrasonographic urethrography agree that its optimum use is in the evaluation of bulbar urethral strictures.<sup>5,15</sup>

Sonourethrography has also been useful in selecting cases for repeat end-to-end urethroplasty<sup>32</sup> in whom the risk of re-stricture is increased<sup>33</sup>. Preliminary sonographic staging has contributed substantially to greater success than reported in earlier series for this challenging group of patients.<sup>34-36</sup>

Other authors have also demonstrated that associated pathological conditions of the urethra and perineum may be delineated on ultrasound.<sup>35,36</sup> Urethral calculi and periurethral abscesses, diverticulae, fistulas and false passages are well visualized sonographically.<sup>1,6,8,15</sup> Complete preoperative knowledge of such associated conditions facilitates favourable post-urethroplasty outcomes.<sup>37</sup>

Colour Doppler ultrasound has recently been used to detect the position of the urethral artery before optical urethrotomy.<sup>38</sup> Although the clinical importance of sonographic assessment of the urethral vascular anatomy before urethroplasty is not yet well established, colour Doppler may be useful in assessing vascularity before grafting procedures.<sup>38</sup>

Rifkin<sup>39</sup> was the first to describe the use of sonourethrography in evaluation of the prostatic urethra and McAninch *et al*<sup>40</sup> subsequently reported its usefulness in evaluating stricture disease of the anterior urethra. Typically in SUG, a high frequency (7.5-10 MHz) linear transducer is applied on the ventral or dorsal surface of the penis. Ultrasound images are obtained with retrograde injection of normal saline or sterile lidocaine jelly via a catheter tip syringe in the urethral meatus while simultaneous real-time images of the urethra are obtained sequentially from the penile urethra proximally towards the deep bulbar area.<sup>41,42</sup>

After the urinary bladder has been filled with normal saline by several syringes, firm suprapubic pressure is applied by an assistant,

thus producing a pseudo-antegrade study of the proximal bulb. With proximal and distal distention, stricture length is precisely delineated. The sensitivity of sonourethrography performed in this manner has been corroborated by many authors.<sup>28,43,44</sup>

Transverse images are particularly welcomed by urologists who are able to relate the images to the view obtained at urethroscopy.<sup>6</sup> Some of the limitations associated with retrograde urethrography also apply to ascending urethral ultrasonography. The technique remains relatively invasive, with insertion of a catheter distally, and requires two operators (one to instill fluid to distend the urethra and ensure no displacement of the catheter, and the second to perform the ultrasound).<sup>6</sup> Furthermore despite trimming of the distal catheter beyond the balloon to allow visualization of the penile urethra, pathology in the fossa navicularis may not be identified due to the presence of the balloon. The procedure also requires a sterile technique.<sup>6</sup>

A descending ultrasound technique can also be used.<sup>6</sup> With this method the same range of pathologies seen using the ascending method can be identified, such as strictures, intraluminal structures such as papillomas and periurethral fibrotic cuffing. In addition the ability to visualize the navicular fossa allows pathology such as strictures in this region to be visualised.<sup>6</sup> A further area in which descending urethral ultrasound technique is found to be invaluable is in those patients who have had or are planning to undergo hypospadias repair as the condition is associated with urethral strictures and post-surgical stricturing. The ventral position of the urethral meatus and the absence of a navicular fossa make it difficult to anchor a urethral catheter or achieve a satisfactory seal during ascending contrast urethrography. Depending on the severity of the disease, it may be completely impossible to employ either contrast urethrography or ascending ultrasound technique due to an inability to catheterize the meatus, or undesirable in terms of requiring bladder catheterization prior to acquiring a micturating urethrogram.<sup>2,3</sup>

The advantages of the descending ultrasound technique over the alternative imaging methods are that it is non-invasive, well-tolerated by the patient, can be performed by a single operator and provide excellent views of the distal urethra, which is especially important in hypospadias assessment.<sup>6</sup> However, under-distension of the urethra by an inadequate stream of urine can mimic a long stricture. A further potential pitfall to be aware of is the fact that care needs to be taken to avoid missing very proximal bulbar strictures. It may be necessary in such cases to perform further voiding views via a perineal approach.<sup>6</sup>

Limitations of SUG include small field-of-view provided by the transducer and operator dependency which limited the widespread clinical use of this technique in the past. However, recent advances in ultrasonographic techniques, such as extended 'field-of-view' imaging, have further added to the utility of the technique, and are particularly useful in demonstrating pathology to non-radiologists.<sup>6</sup>

A review of the initial experience of McAninch *et al* in 1988 revealed poor correlation between retrograde urethrography and sonourethrography.<sup>40</sup> Radiographic urethrography consistently underestimated stricture length compared to intraoperative measurements, while sonourethrography correlated well. Although the depth of periurethral fibrosis could not be accurately distinguished ultrasonically, stricture areas remained rigid during retrograde instillation of saline while normal urethra distended easily. With repeat fillings and multiple views of questionable areas, the technique produced detailed real-time functional information that could be tailored to the needs of the surgeon. However, the posterior urethra could not be satisfactorily evaluated.<sup>40</sup>

Two other small series in the urological literature in late 1988, described preliminary experience with sonographic imaging of the anterior male urethra.<sup>45,46</sup> Urethral ultrasound was reported to have a higher sensitivity in detecting strictures, while being well tolerated. Merkle and Wagner<sup>45</sup> predicted the

outcome of internal urethrotomy on the basis of sonographic assessment of periurethral scarring. More than 80% of patients with ultrasonic evidence of periurethral fibrosis had recurrent stricture within 6 months.<sup>45,47</sup>

Bearcroft *et al.*<sup>37</sup> in a study in which sonography of the anterior urethra was prospectively performed in 24 consecutive men referred for conventional urethrography found out that in 11 of the patients, both the sonographic and the contrast urethrograms were considered normal. Both studies demonstrated one or more strictures in nine patients but ultrasound also demonstrated periurethral cuffing in three of these. Sonography demonstrated a mucosal flap missed on the contrast study and also showed that suspected air bubbles seen on the contrast study were true urethral filling defects. Diverticula were seen in three contrast studies, two of which were demonstrated sonographically, but the third, a shallow diverticulum in a patient with a complex stricture, was not seen on the SUG. Both studies demonstrated mucosal irregularity in five patients, and lack of urethral distensibility in five patients. Reflux into prostatic and Cowper's ducts shown on RUG, was not detected by ultrasound. They however concluded that SUG still offered advantages over RUG both in terms of the additional abnormalities detected and convenience of the study.

Ultrasound serves different purposes in different areas of the urethra. For the reconstructive urologist, it is not as helpful in guiding procedure selection in the pendulous urethra as in the bulbar urethra.<sup>48</sup> Pendulous strictures are usually diffuse and post-inflammatory, and not focal or post-traumatic. As a result, most distal strictures are not amenable to excision and will generally require some form of onlay urethroplasty, regardless of length.<sup>48</sup> Furthermore, because the pendulous urethra is in a lateral, dependent position during retrograde urethrography, radiographic and ultrasonic images provide roughly equivalent information.<sup>48,49</sup>

It is now well established that radiographic

retrograde urethrography often underestimates stricture length in the bulbar urethra.<sup>1,6,8,15</sup> It was proposed that urethral ultrasound is more accurate because the handheld transducer is positioned in the mid-sagittal plane, directly perpendicular to the diseased urethral segment.<sup>6,15,21</sup> During standard retrograde urethrography the pelvis is aligned obliquely with respect to the anteroposterior x-ray beam and the bulbar portion of the urethra is fixed in the same axis as the pelvis. As a result the radiographic image is an “end on” view, which apparently reduces stricture length.<sup>15,21,50</sup>

Choudhary *et al.*<sup>21</sup> did a prospective comparison of sonourethrography and retrograde urethrography in evaluation of anterior urethral strictures and found out that sonourethrography had an overall greater sensitivity in estimating stricture length and correlated better with operative findings. When strictures were grouped according to anatomical sites, both techniques were equally sensitive in length estimation in the penile urethra. However, RUG correlated poorly with the intra-operative length of strictures in the bulbar urethra, underestimating the length in spite of radiographic magnification. Most previous studies show consistently poor correlation between RUG and sonourethrography in estimating stricture length, especially for bulbar urethral strictures.<sup>1,6,8,15,40</sup>

Akano<sup>51</sup> in a study of thirteen male adult patients diagnosed with anterior urethral strictures in Abuja, Nigeria, documented abnormalities of the anterior urethra in all patients and eleven of them had strictures. Ten of the eleven strictures were detected on both SUG and RUG. One patient who was negative on RUG showed a 2.3mm thick stricture on SUG. The urethral mucosa, thickness of the urethral wall at the stricture level and the lengths of the strictures were well assessed on sonourethrography. He concluded that SUG is as efficacious as retrograde urethrography in the assessment of the male anterior urethra in patients with urethral stricture and may be recommended in the evaluation of this disease, in view of its

efficacy, non-invasiveness, ready-availability and lack of exposure to radiation. Gupta *et al.*<sup>27</sup> in a study of 30 patients reported poor correlation between the two techniques in estimation of stricture length found at surgery, with RUG underestimating the length in most cases.

Gluck *et al.*<sup>46</sup> estimated that in 16% of strictures, the reconstructive procedure indicated by sonourethrography differed from that indicated by RUG. The estimation of stricture diameter is also important for assessing the severity of narrowing when compared with the normal lumen.<sup>15,29</sup>

Choudhary *et al.*<sup>21</sup> found out in a study that RUG showed a lower sensitivity and overall accuracy with the sensitivity being lowest for severe strictures of diameter <4 mm. In their study, sonourethrography correlated better with operative findings while accurate determination of diameter by RUG was difficult due to overlapping segments on radiographs taken, especially with improper positioning and poor opacification of severe strictures. Previous studies had also documented poor correlation between luminal diameter measured by RUG and operative findings.<sup>15,29,46</sup>

Choudhary *et al.*<sup>21</sup> in the same study also showed that all false tracts confirmed at surgery were detected at sonourethrography as areas of urethral wall disruption with linear hypoechoic tracts within the grey corpus spongiosum. Three false tracts were missed at RUG, possibly due to temporary occlusion of the tract and overlap of segments due to obliquity in one case. Gluck *et al.*<sup>46</sup> in a previous study of 22 patients, found that sonography was not able to pick up bulbar sinus tracts detected on RUG. All cases of urethral calculi were detected by sonourethrography, but most were missed on RUG. Retrospectively, it was thought that most calculi were too small to produce any contour change or visible filling defects in the contrast radiographs. The calculi could also not be detected on the standard penetration pilot radiographs taken before the study.<sup>15,21,40,46</sup>

Nash *et al*<sup>29</sup> reported that sonourethrography identifies periurethral fibrosis, but it was unreliable in predicting the depth. In 36 patients with full-depth biopsies, when the greatest depth on histopathological study was compared with that measured by sonography, the difference was significant. Nevertheless, in spite of the underestimation of the depth of spongiofibrosis on SUG, sufficient information was provided for classification of the degree of spongiofibrosis.<sup>8,21,52</sup>

Gluck *et al*<sup>4,6</sup> suggested that sonourethrography could also be used intra-operatively to monitor the extent and depth of urethrotomy, which could lead to a more adequate incision of scar tissue during direct-vision internal urethrotomy (DVIU). The most extensive scarring may not always be at the 12 o'clock position, which is the position typically incised during an internal urethrotomy. And an inadequate incision into the scar may lead to recurrence.<sup>52</sup> In a retrospective review, all strictures that recurred after DVIU were found in patients with "significant, prominent" scars indicative of severe spongiofibrosis.<sup>46</sup> If the degree of stricture disease is more accurately staged, the surgeon can tailor the type of repair to the specific case.<sup>21</sup>

The complications frequently encountered in RUG and SUG include pain, urethral bleeding and contrast medium intravasation, with significantly more patients complaining of pain during RUG.<sup>21</sup> Gluck *et al*.<sup>46</sup> reported bleeding after sonourethrography in 1(5%) patient with no discomfort or fever reported during or after the procedure respectively. Twenty of their 22 patients studied, preferred the SUG technique to the RUG procedure. Sonourethrography is comfortable without rapid over-distention of the urethra, as it is performed in real-time compared with RUG where spot films are taken during rapid contrast injection. Hence in sonourethrography, the risk of contrast extravasation is obviated.<sup>50</sup> Heidenreich *et al.*, in a prospective study of 175 patients, reported no complications of dysuria, haematuria, urinary infection or systemic

reactions on SUG.<sup>44</sup>

## BENEFITS OF SONOURETHROGRAPHY OVER OTHER URETHRAL IMAGING MODALITIES

Overall, Sonourethrography is a simple and effective technique for evaluating the male anterior urethra. The normal saline used as a negative contrast agent is well tolerated by patients.<sup>8</sup> The study can be safely repeated as it does not expose gonads to ionizing radiation. This advantage of SUG is particularly beneficial in the pediatric population, whether in evaluating stricture disease in the adolescent child<sup>53</sup> or in the context of hypospadias. However, marked operator dependency limit the widespread clinical use of sonourethrography.<sup>1,6,8,15</sup> The main limitations relate to proximal strictures, the requirement for a cooperative and coordinated patient and the need to be aware of the potential for false-positives due to under-distension of the urethra.<sup>1,6,8,15,21</sup> Urethral ultrasound is an inexpensive and effective technique for imaging the anterior urethra, and indeed in some cases may be the only method of doing so.<sup>6</sup>

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