**How to assess the ureters during pelvic ultrasound**

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**ABSTRACT**

**Background**

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Endometriosis, fibroids and gynecological malignancy can all impact the pelvic ureters. Ureteric involvement is likely to be an important factor in determining the extent and timing of surgery in women with these conditions and assessment of the pelvic ureters is now a recommended component of the imaging work-up for women with endometriosis.

The aim of this paper is to provide a step-by-step guide for the identification and assessment of the distal ureters during pelvic ultrasound. We hope that this detailed explanation of the examination technique will help ultrasound examiners to develop this skill and enable them to integrate assessment of the pelvic urinary tract into their routine ultrasound examination.

**Content**

In this paper, we describe a '6 step' detailed approach to ultrasound assessment of the ureters during pelvic ultrasound examination. We discuss tips and common examination findings.

**Conclusion**

The pelvic segments of normal ureters can be identified in almost all women on transvaginal ultrasound examination and the method described is useful in detecting urinary tract abnormalities.

**BACKGROUND**

The main aim of transvaginal ultrasound examination is to assess gynaecological organs in order to plan patient management. Recent advances in the examination technique have facilitated routine assessment of non-gynecological structures in the pelvis, including the ureters[1]. Endometriosis, fibroids and gynecological malignancy can all impact the pelvic ureters. Ureteric involvement is likely to be an important factor in determining the extent and timing of surgery in women with these conditions and assessment of the pelvic ureters is now a recommended component of the imaging work-up for women with endometriosis[2].

Involvement of the urinary tract occurs in approximately 1–2% of patients with endometriosis and involves the bladder in 85% of these cases[3]. Ureteric involvement is found in 4% of patients with rectovaginal endometriosis[4,5]. This can entail direct invasion or compression by endometriotic nodules, ovarian endometriomas or ovarian adhesions[6]. Endometriosis involving the ureters can compromise renal function and in extreme cases necessitate nephrectomy[7]. Mapping of ureteric involvement, including the site of obstruction and presence of hydroureter or hydronephrosis facilitates pre-operative assessment of renal function and improves preoperative counselling. Visualization of the bladder and distal ureters at the time of routine pelvic ultrasound is also useful in the assessment of pelvic pain. A recent study has shown that ureteric calculi can be found in 0.1% of women who are being investigated for pelvic pain due to presumed gynaecological causes[8].

We have previously shown that pelvic segments of normal ureters can be identified in almost all women on transvaginal ultrasound examination. We also suggested that visualization of the ureters could be integrated into the routine pelvic ultrasound examination, particularly in women presenting with pelvic pain or in those with suspected pelvic endometriosis. In a group of 245 consecutive women, the overall visualization rate of ureters was 96% and it was not significantly affected by the experience of the operator. The median time required to

visualize each ureter was between 8 and 9 seconds[1]. Nevertheless, routine visualization of the pelvic ureters during transvaginal scan of has not been widely adopted as yet.

The aim of this paper was to provide a step-by-step guide for the identification and assessment of the distal ureters during pelvic ultrasound. We hope that this detailed explanation of the examination technique will help ultrasound examiners to develop this skill and enable them to integrate assessment of the pelvic urinary tract into their routine ultrasound examination

**ANATOMY**

Anatomically, the ureters are tubular structures that measure approximately 25 cm in length and can be divided into abdominal and pelvic segments of similar length[9]. The ureteric lumen is narrow and is surrounded by transitional epithelium, subepithelial connective tissue, inner longitudinal and outer circular muscle layers and a layer of fibrous tissue. The ureters begin their course from the kidney, posterior to the renal artery, and continue on the anterior edge of the psoas major muscle. At the entrance to the pelvis, the ureters cross the iliac vessels anteriorly. They lie immediately under the peritoneum of the pelvic side wall, behind the lateral attachment of the broad ligaments. Curving medially and forwards, the ureters pass through the base of the broad ligaments below the uterine arteries, approximately 2 cm lateral to the supravaginal part of the cervix a short distance above the lateral fornices of the vagina. Approaching the bladder, the ureters pass medially in front of the upper vagina and enter the bladder base obliquely at the upper angles of the trigone[10]. On ultrasonography, ureteric function can be indirectly assessed by identifying the 'ureteric jet effect'. This was first described by Dubbins et al in a case series of six patients[11]. This effect is caused by the presence of acoustic interfaces between urine of different specific gravities. Ureteric jet can also be assessed by color Doppler ultrasound and can be used to confirm ureteral patency[12]. Peristalsis of ureters is identified by a progressive expulsive wave propelling urine through the

ureteric lumen. The diameter of the ureter is seen to swell and then contract in a progressively more distal fashion, culminating in the production of a ureteric jet at the urethral orifice of the bladder. Video 1 demonstrates the peristaltic wave seen in the distal ureter on transvaginal ultrasound.

**Why ultrasound?**

There are six methods that can be used to evaluate the pelvic ureters: transvaginal ultrasound (TVS), transrectal ultrasound (TRS), abdominal ultrasound, MRI, Computed tomography (CT) and direct visualization at surgery. The benefit of ultrasound and direct visualization are their dynamic nature, which allows an assessment of function in addition to structure. Ultrasound is relatively cheap and easy to perform, whilst avoiding the risks of radiation exposure or surgery. Pelvic ultrasound can also assess the mobility in relation to, and distance from, neighbouring structures.

Assessment of the urinary tract has traditionally been performed using MRI, however it is possible to establish the extent of urinary tract involvement during routine pelvic ultrasound. This provides a complete assessment at the time of a single investigation. Pelvic ultrasound has been shown to be as accurate as MRI in the pre-operative assessment of bladder endometriosis. MRI, although very precise, is less versatile than transvaginal ultrasonography and less accurate in establishing the margins of lesions, probably due to the relatively low haemosiderin content[13]. If complete assessment is performed by a competent skilled ultrasonographer, MRI may become a superfluous investigation in the work-up of women with deep infiltrating endometriosis. Reducing the number of investigations can reduce costs and shorten the patient journey, which is likely to have a positive impact on the patients' experience.

**PRACTICAL POINTS**

**Preparation**

*Both TVS and TRS are performed with the patient in dorsal lithotomy position.*

*The woman's bladder should be empty or contain a small amount of urine.*

It is preferable to ask the patient to empty their bladder prior to any pelvic ultrasound, for their own comfort and to optimize the view of the uterus and adnexa. If the assessment of the urinary tract is the final element of the pelvic scan, some urine may have accumulated over the time that has elapsed to complete the examination of other pelvic organs, which may aid clear demarcation of the mucosal border.

**STEP 1**

*A longitudinal view of the bladder should be obtained.*

Withdraw the vaginal ultrasound probe slightly, keeping the probe in the anterior fornix of the vagina. Adequate magnification and depth should ensure that the entire bladder volume is visualized within the ultrasound field. Move the ultrasound probe laterally in both directions to visualize the entire mucosal and muscular layers of the bladder wall.

**STEP 2**

*A longitudinal view of the urethra should be obtained.*

With the ultrasound probe held in the central plane, it should be possible to view a longitudinal section through the urethra. Where the urethra descends from the bladder is the mid-point of the trigone. (Fig. 1)

**STEP 3**

*The ureteric orifice needs to be identified.*

Having identified the mid-point of the trigone, slowly move the ultrasound probe laterally towards the pelvic side wall in order to identify the ureters. The distal segment of the ureter will usually come into the view once the probe is moved sufficiently far towards the lateral pelvic wall. If the ureter does not come into the view an attempt should be made to identify the ureteric orifice which typically appears as a small pouch protruding into the bladder lumen. Once the ureteric orifice is identified, the probe should be rotated until the whole length of the pelvic ureter comes within view.

**STEP 4**

*Confirm that the structure identified is indeed a ureter.*

Ureters typically appear as long tubular hypoechoic structures with a thick hyperechoic mantle extending from the lateral aspect of the bladder base towards the common iliac vessels. The presence of vermiculation confirms that the structure is indeed a ureter, rather than a vessel. If there is any doubt, apply colour Doppler over the field. Ureters should be free of Doppler signals. Doppler may be useful to identify the uterine artery and to try to visualize the ureter travelling under it as 'water travels under a bridge'.

**STEP 5**

*Follow the length of the ureter to the pelvic brim, at which point it crosses the common iliac vessels.*

Once the distal segment of the ureter has been identified, its course should be followed towards the pelvic sidewall and up to the level of the bifurcation of the common iliac vessels, where the ureter tends to curve upwards and laterally.

**STEP 6**

*Repeat these steps for assessment of the contralateral ureter*

Video 2 demonstrates the step-by-step approach for examining the pelvic ureter.

**TIPS**

Transverse plane: If it is not readily achievable to find the ureters in the longitudinal plane, rotate the ultrasound probe 90 degrees clockwise into the transverse plane. The internal urethral orifice should be identified and the probe should be moved slowly upwards until the ureteric orifices become visible at the lateral aspects of the trigone. A longitudinal view of the distal ureter can then be obtained by keeping the ureteric orifice in the centre of the image whilst rotating the ultrasound probe. In most women this technique will work. Visualization can be difficult in women with large broad ligament fibroids displacing the bladder upwards and in women with procidentia. The ureter is also more difficult to see in women with history of bladder surgery, particularly following ureteric re-implantation when the orifices may not be in their usual anatomical locations.

Transrectal scan: In certain cases, transvaginal approach is not possible or should be avoided e.g. women who have never previously been sexually active, women who suffer from vaginismus or vaginal atrophy. An alternative approach is to use TRS to assess the urethra, bladder and distal ureters. The technique described above is the same for both.

Transabdominal scan: Ideally the patient should have a full bladder to distend the bladder wall. The ureter can usually be seen by scanning the bladder in the oblique plane directed towards the lateral pelvic wall. Alternatively, the ureteric orifices could be identified in the transverse plane and the probe should be rotated keeping the ureteric orifice in the centre of the image as previously described. If that is not possible either, an attempt should be made

to identify the ureteric jet and its origin. Once the origin (the ureteric orifice) is identified, rotate the probe to identify the entire distal course of the ureter.

Measurements: The ureteric diameter can be measured in a longitudinal section at the intersection of the ureter with the uterine artery. (Fig. 2) The measurement can be made at rest and at the peak of dilatation. In our prospective study the median ureteric diameter at rest was 1.9mm, and 2.9mm at the peak of peristalsis[1]. There is no consensus of the cut-off to diagnose abnormal ureteric dilatation. A previous study using CT measurements described 3mm diameter as the upper limit of normal size for non-obstructed ureters on unenhanced helical CT[14]. A recent review of ultrasound literature concluded that any ureter measuring ≥6.0mm at peak peristaltic wave can be considered dilated. In cases of stenosis with evidence of ureteral dilatation, the ureteric diameter should be measured both cranially and caudally to the stenosis at rest and during peristalsis[15]. Common practice in our department is to measure the distance between the stricture and the distal ureteric orifice to aid surgical treatment.

***Identification of additional significant findings whilst examining the ureters***

*Congenital abnormalities:* The presence of a Mullerian tract abnormality during pelvic ultrasound may be associated with congenital renal tract abnormalities, such as the absence of a single ureter or kidney. Other congenital abnormalities may be detected, such as the presence of a duplex ureter.

*Urinary tract calculi:* Pelvic pain is a common reason for women to be referred for a pelvic ultrasound. However, the origin of their pain is not always gynecological in nature. The ability to identify distal ureteric calculi on pelvic ultrasound enables appropriate and timely referral to urologists. (Fig. 3)

*Ureterocele: In women with a history of recurrent urinary tract infection, it is possible to find structural abnormalities that may be contributing to their symptoms. A ureterocele is the result of congenital dilatation of the distal ureter. This may cause a dilated portion of the ureter to herniate into the bladder due to an abnormal structure of the vesicoureteric junction. Ureteroceles may be unilateral or bilateral and are commonly associated with the presence of duplex ureters.* (Fig. 4)

*Megaureter: Congenital megaureter is an uncommon condition that may be bilateral and is often associated with other congenital anomalies. The diagnosis is made if the resting diameter of the ureter exceeds 6mm. Megaureters may be primary if non-refluxing/non-obstructing or secondary in the presence of an obstruction/reflux of urine. They are often asymptomatic and may be an incidental finding.*

*Urine infection:* Urine usually appears anechoic on grayscale ultrasound. The presence of static echogenic fluid in the bladder, especially if associated with symptoms of urinary frequency, urgency or dysuria, may raise the suspicion of urinary tract infection and warrants further investigation with urine microscopy and culture.

*Endometriotic lesions:* Visualization of the urinary tract is an essential component in the assessment of women with pelvic endometriosis. Figure 5 shows a left ureter that is obstructed at the site of an irregular shaped hypoechoic lesion, which has the typical appearance of an endometriotic nodule. (Fig. 5a)

*Ureteric obstruction: When urinary flow is obstructed, the ureter may appear permanently dilated or show localized dilatation proximal to the site of stenosis. However, in some circumstances, the obstruction may be incomplete and abnormal dilatation may only be visible during the peristaltic wave. In the presence of an obstruction, it may be possible to visualize a rebound wave in the opposite direction to normal peristaltic activity. In the presence of a non-functioning ureter, peristaltic motion will not be visible and the structure is likely to appear fixed in a permanent resting state.*

*The kidneys:* In the presence of any bladder or ureteric abnormalities, it is imperative to assess the kidneys for the presence of hydronephrosis, which may be the result of a partial or complete ureteric obstruction. (Fig. 5b) For examination of the left kidney, the patient lies in a right lateral decubitus position with the probe placed in the lower intercostal space on the posterior axillary line. For examination of the right kidney, the patient lies supine and the probe is placed in the right lower intercostal space in the mid-axillary line. Views are often optimized by asking the patient to lift their arms upwards towards their head with deep inhalation (left kidney) or complete exhalation (right kidney). The entire kidneys should be scanned obtaining longitudinal (long axis) and transverse (short axis) views.

## Conclusion

Pelvic segments of normal ureters can be identified in almost all women on transvaginal ultrasound examination and the method described above is useful in detecting urinary tract abnormalities. We hope that this detailed explanation of the examination technique will help ultrasound examiners to develop this skill and enable them to integrate assessment of the pelvic urinary tract into their routine ultrasound examination.

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**Figure legends**

Video 1: Transvaginal ultrasound video demonstrating a normal peristaltic wave in the distal ureter

Figure 1: Transvaginal ultrasound image of a normal bladder and urethra. The urethra can be seen exiting the bladder at the mid-point of the trigone [T]

Video 2: Video demonstration of the step-by-step technique for examining the distal ureter on pelvic ultrasound

Figure 2: Transvaginal ultrasound measurement of ureteric diameter of the right distal ureter (a) and the left distal ureter (b)

Figure 3: Longitudinal view of the distal ureter demonstrating the presence of a hyperechoic lesion with posterior shadowing an inch above the ureteric bladder orifice. These findings are typical of a ureteric calculus.

Figure 4: A view of the left ureter showing dilatation of the distal part protruding into the bladder and displacing the normal anatomy of the bladder trigone. These findings are typical of a ureterocele [U]

Figure 5a: Ultrasound image of the left ureter in a women with endometriosis. There was evidence of obstruction by an endometriotic nodule [yellow arrow] approximately 3.5cm from the ureteric orifice. Note the dilatation of the proximal ureter above the level of the obstruction [red arrow].

Figure 5b: Transabdominal ultrasound of the ipsilateral kidney showing evidence of moderate hydronephrosis.

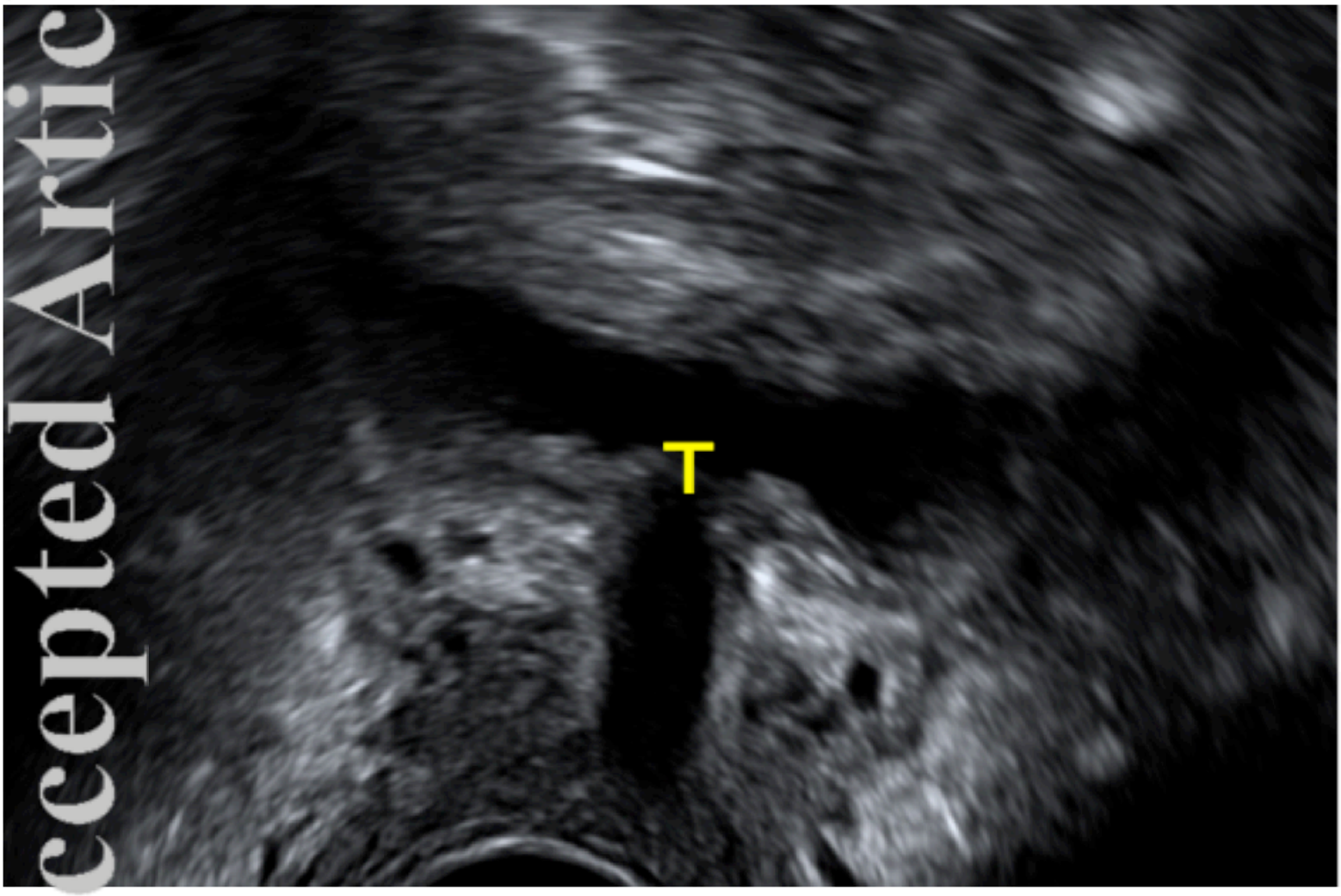



Figure 1 annotated.png

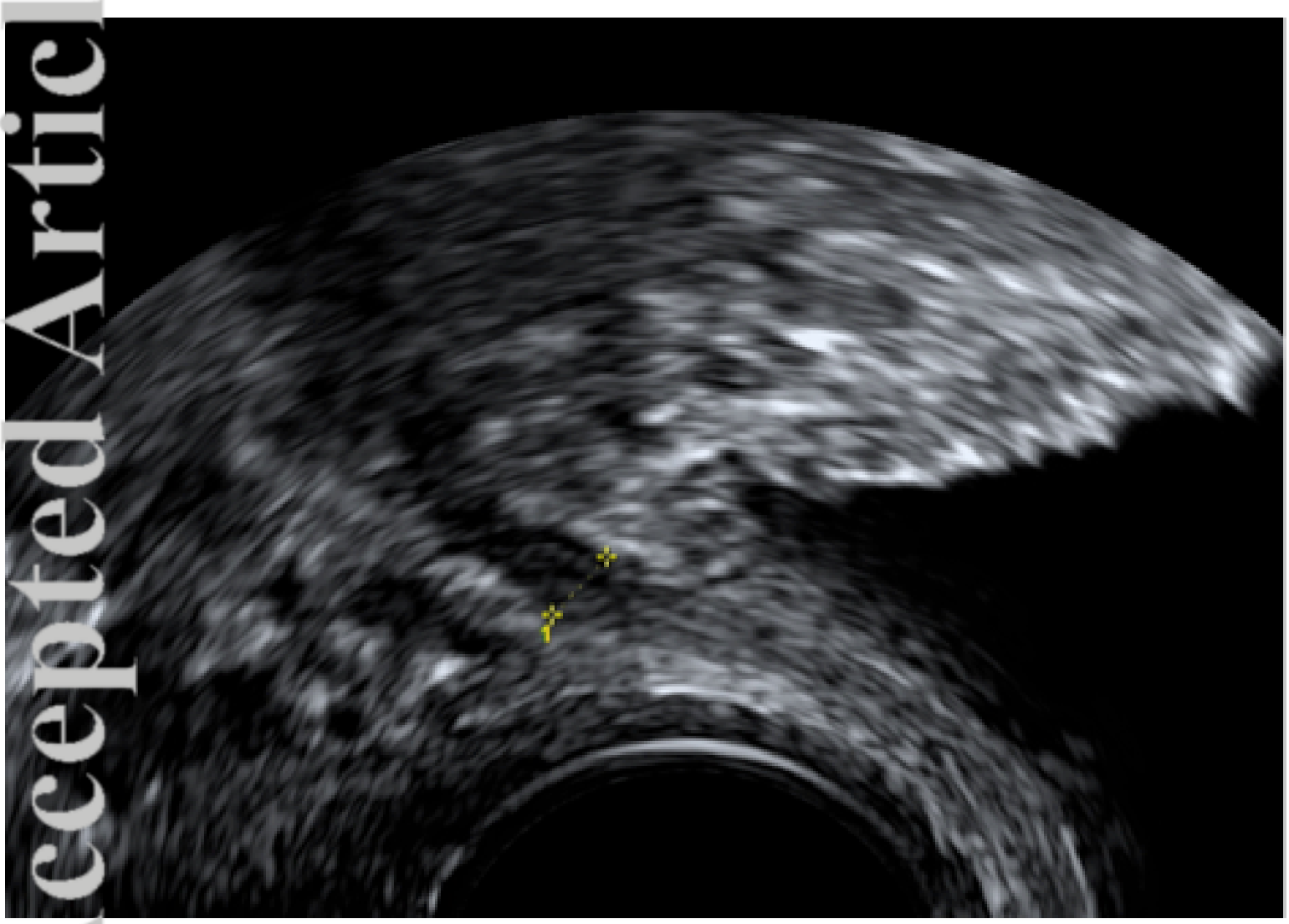
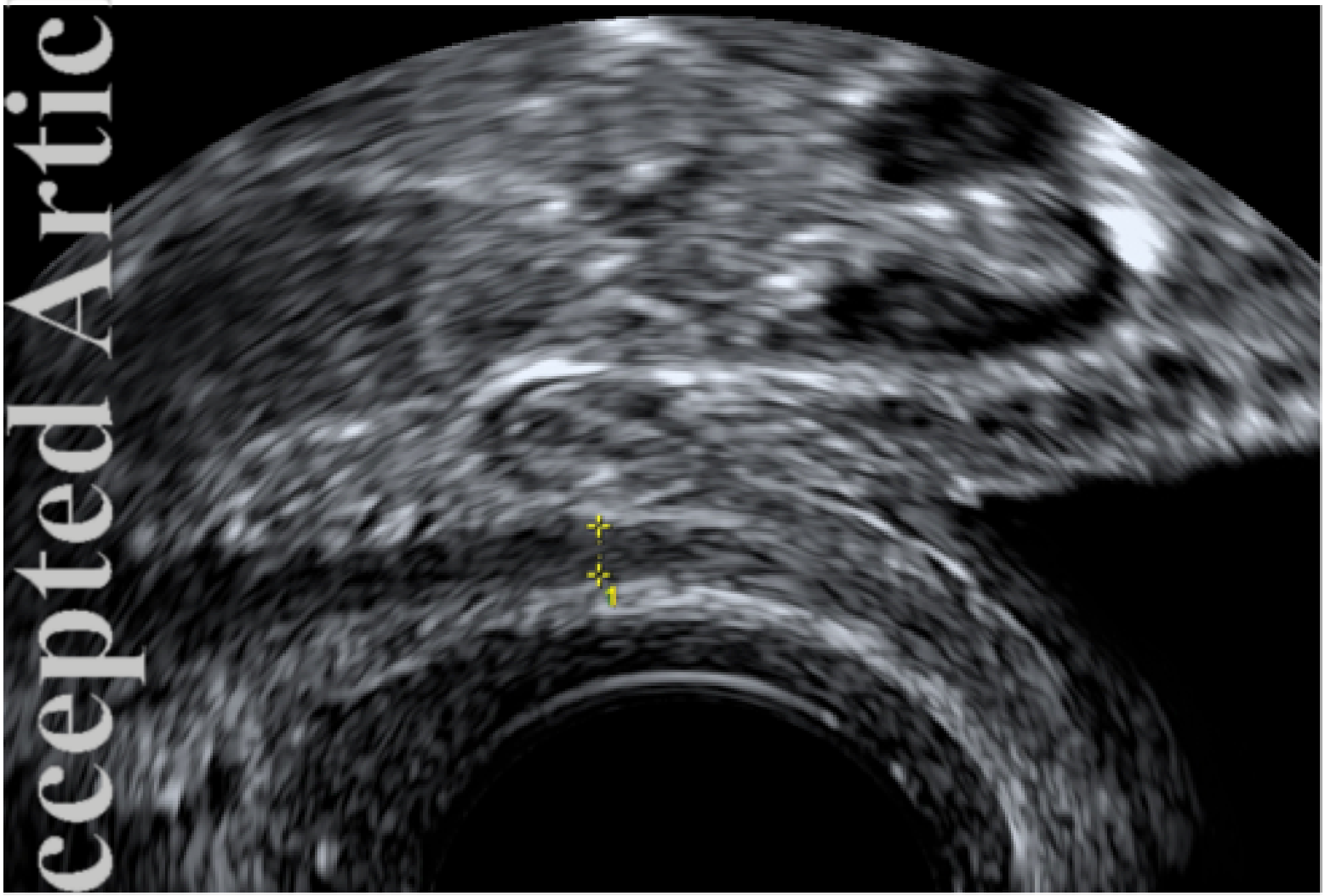


Figure 2a.png



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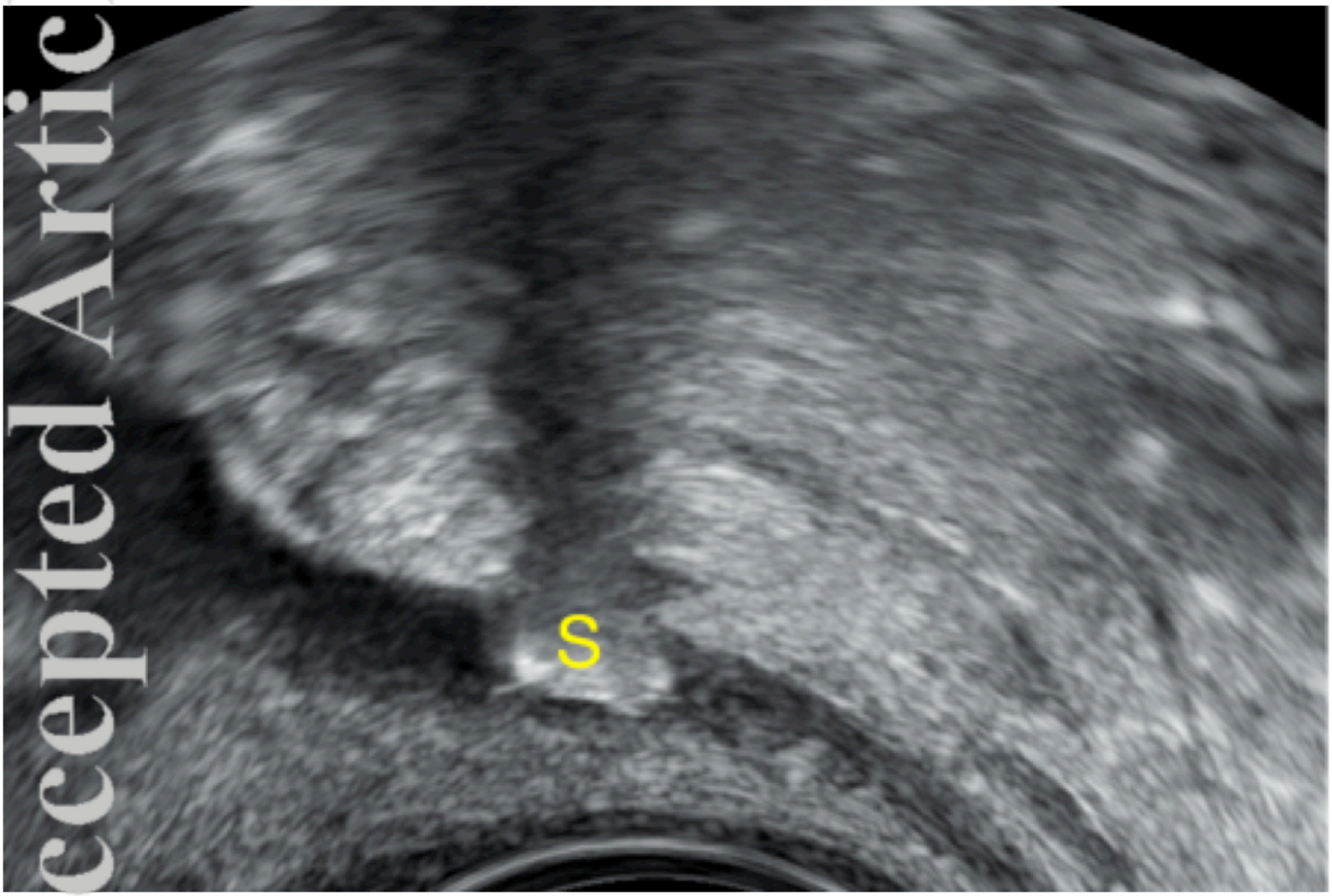
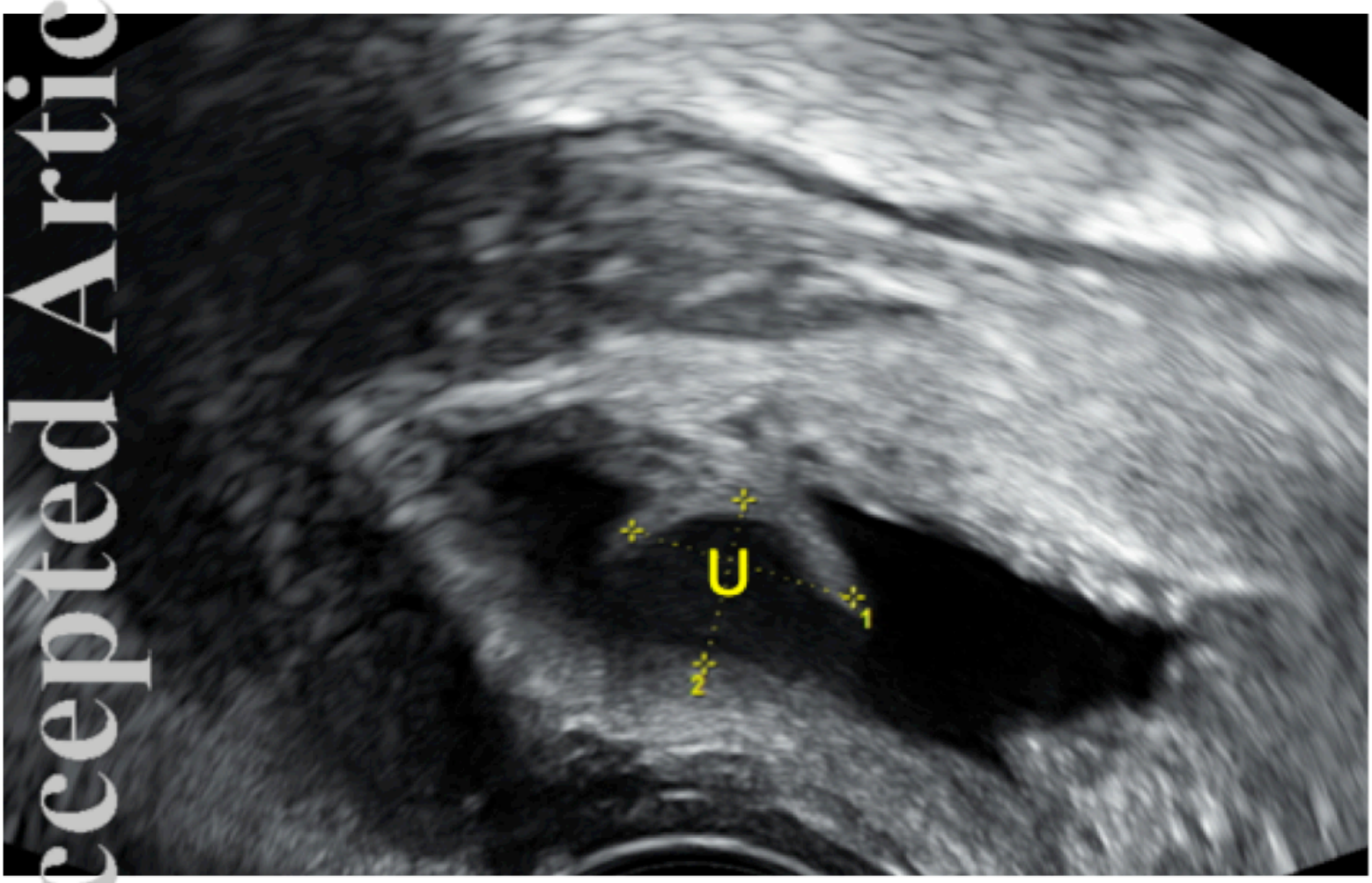



Figure 3 annotated.png

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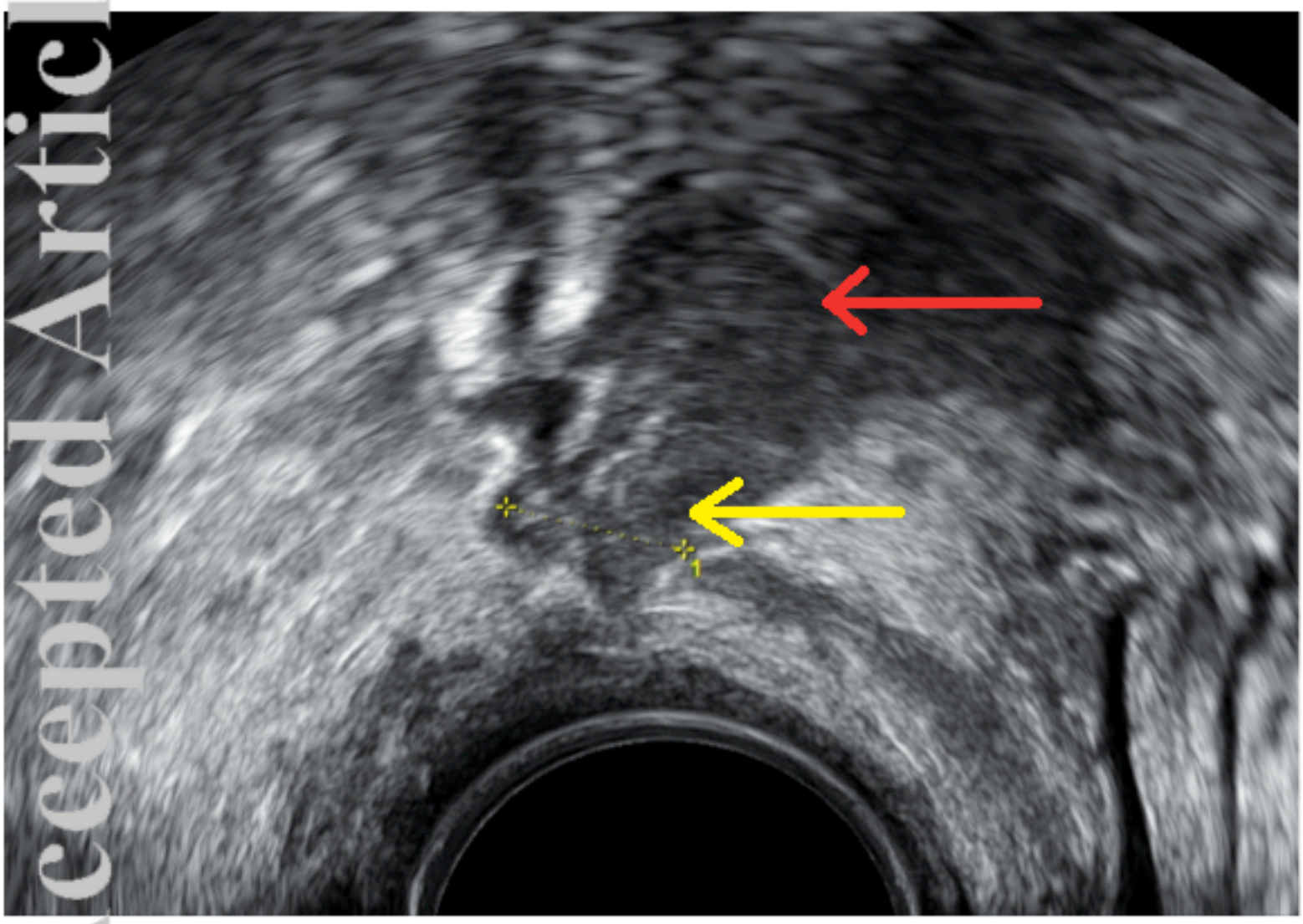

Figure 5a annotated.png

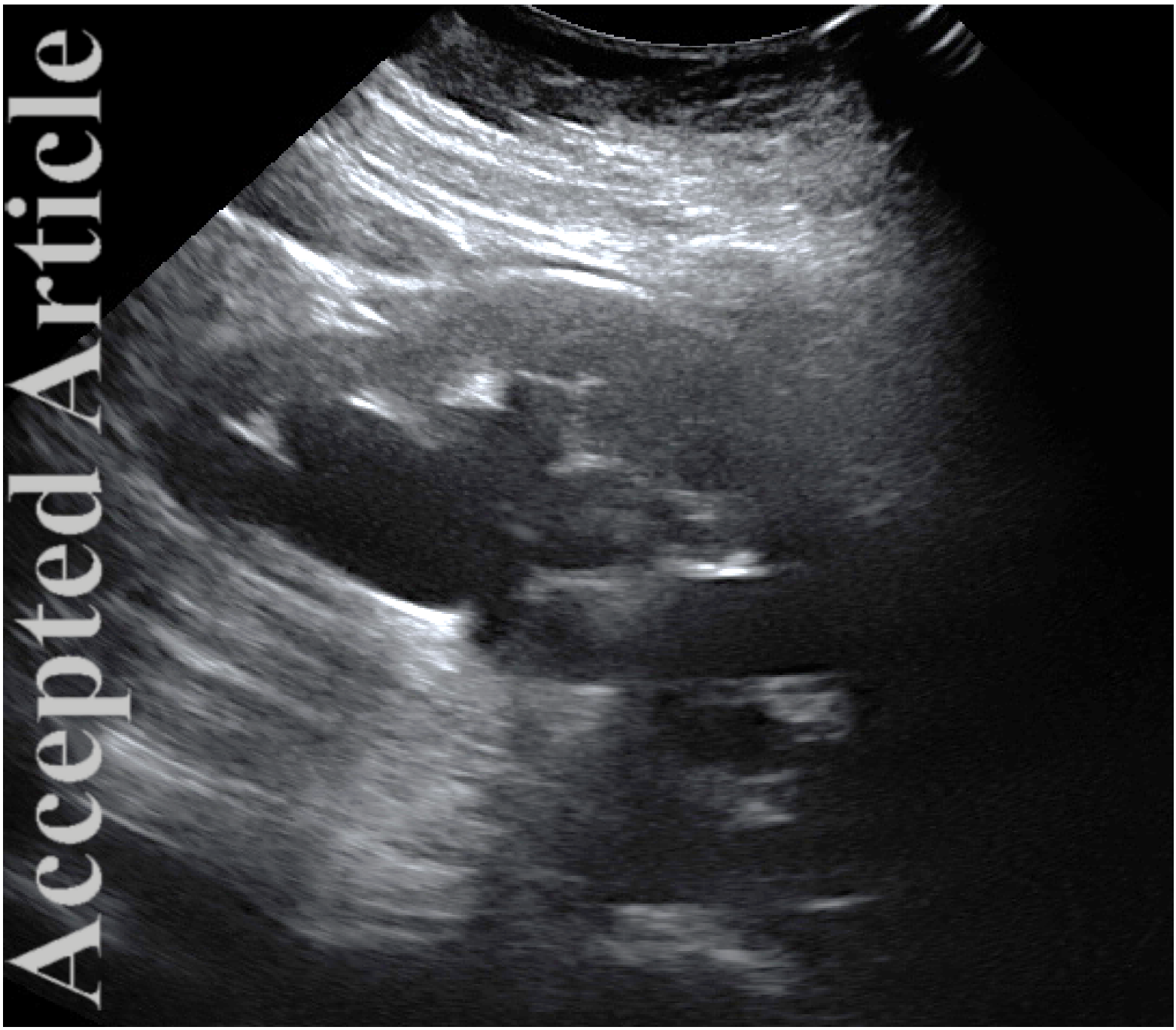

Figure 5b.bmp