Ultrasound / White paper

# Assessment of pelvic floor by ultrasound: A useful tool


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## Introduction

The application of ultrasound for the study of pelvic floor disorders is a widely accepted diagnostic tool in clinical practice (as described in the AIUM/IUGA review published in 2019), being useful for managing almost all the pelvic floor dysfunctions. Among the ultrasound methods applicable for pelvic floor examination, we outline perineal pelvic floor ultrasound (4-8 MHz curvilinear transducer), as it reduces patient discomfort and does not modify the anatomy during the examination, opposite to what may occur with the endocavity probes.

The advantage of perineal pelvic floor ultrasound over physical exam lies in reducing possible confounding factors, such as:

- Evaluation of rectal or bladder filling
- Evaluation of levator ani muscle (LAM) coactivation
- Establishment of Valsalva manoeuvre duration

## Pelvic floor ultrasound instrumentation

Perineal pelvic floor ultrasound requires a 4-8 MHz curvilinear transducer and a default configuration of the ultrasound defined by (Fig. 1):

- Maximum width of the image window captured by the transducer (the closest to 90º)
- Optimal depth to visualize all pelvic organs, normally less than 10 cm deep
- One or two focal zones in the centre of the studied structure
- High frequencies
- Optimisation of gain and dynamic range to obtain a high-quality image that carefully discriminates each anatomic structure
- Proper preparation of the probe (abundant ultrasonography gel and a protective cover), avoiding the appearance of air bubbles
- Placement of the transducer to the perineum applying the least possible pressure and without reducing image quality

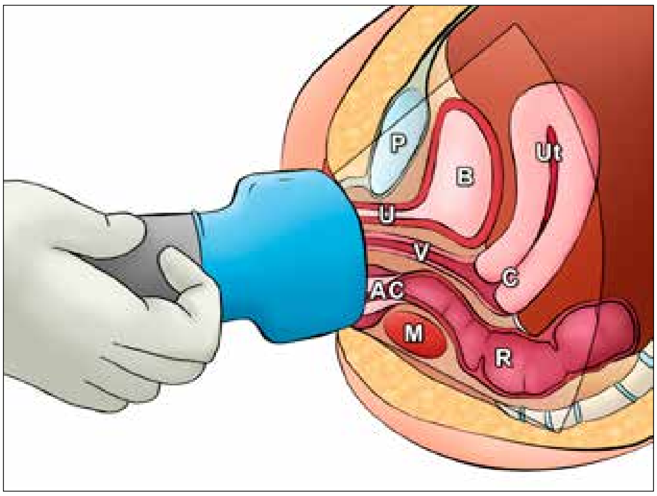


**Figure 1** Schematic drawing of transducer and pelvis. P: Pubis, U: Urethra, B: Bladder, V: Vagina, C: Cervix, Ut: Uterus, AC: Anal Canal, R: Rectum, M: Levator ani muscle

### Two-dimensional pelvic floor ultrasound

The reference plane for the two-dimensional pelvic floor ultrasound examination is the mid-sagittal plane, whose ideal orientation is leaving the cranio-ventral region on the left and the dorso-caudal region on the right (Fig. 2). The anatomic structures included in that plane are, from left to right: the pubic symphysis, the urethra and the urinary bladder, the vagina and deeper the uterus, the rectum, the anal canal and the centre of the LAM (Fig. 2). During contraction, the LAM approximates to the pubis causing the elevation of the pelvic organs, and during Valsalva, the opposite effect triggers the descent of those structures.

### Three-dimensional pelvic floor ultrasound

The axial study of the LAM focuses on the plane of minimal hiatal dimensions, delimited in its anterior part by the region and caudal portion of the pubic symphysis, and on its posterior part by the anorectal angle, accentuated by the central part of the LAM (Fig. 3A). The three-dimensional pelvic floor ultrasound enables the visualization of the axial plane allowing the assessment of the LAM and the urogenital hiatus (Fig. 3B).

The 3D ultrasound is performed with transducers with an image capture-scanning angle of 85° (to acquire the complete volume of the LAM). The volumetric inspection consists of three orthogonal images and a "rendered image" (a semi-transparent representation of the voxels from a definable box). The implementation of the four-dimensional study allows a dynamic assessment of the pelvic floor in real time.


**Figure 2** Midsagittal plane. P: Pubis, U: Urethra, B: Bladder, V: Vagina, C: Cervix, Ut: Uterus, AC: Anal Canal, R: Rectum, M: Levator ani muscle

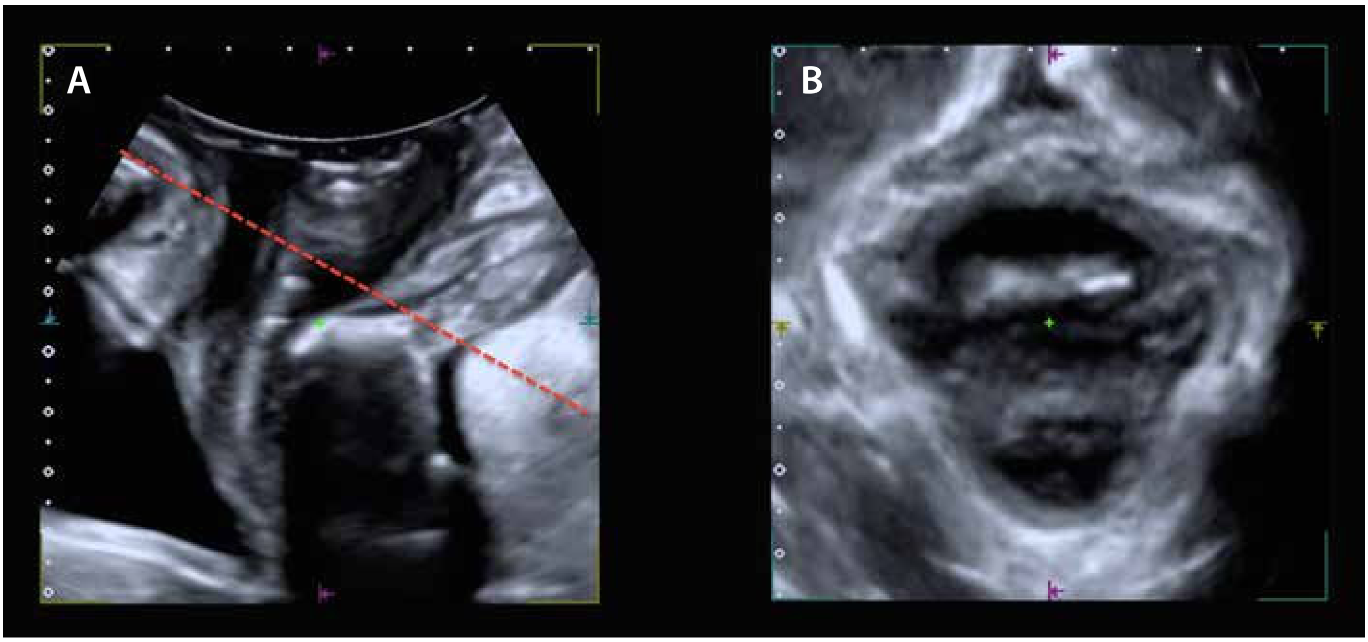


**Figure 3** It displays the references of the plane of minimal hiatal dimensions (red line), which is defined by the caudal portion of the pubic symphysis and the anorectal angle (A). Plane of minimal hiatal dimensions (B).

## Ultrasound evaluation of stress urinary incontinence

Stress urinary incontinence (SUI) appears whenever there is an imbalance between the abdominal pressure and the contraction strength of the detrusor muscle, produced by an insufficient support at the base of the bladder, causing the urethra-bladder junction to move during Valsalva manoeuvre. The main measures used to evaluate urethral hypermobility are:

- Bladder neck-pubic symphysis distance: vertical distance (dashed red line in Fig. 4) between the bladder neck and an imaginary horizontal line (green line in Fig. 4) passing by the posteroinferior edge of the pubic symphysis (Fig. 4). This constitutes the most analysed and reproducible parameter for the evaluation of the urethra mobility in patients with SUI. Nevertheless, it is difficult to establish a definable cut-off point to diagnose SUI; therefore, it must be studied considering the clinical context of the patient.

**Figure 4** It includes the bladder neck-pubic symphysis distance (red) and the retrovesical angle (yellow).

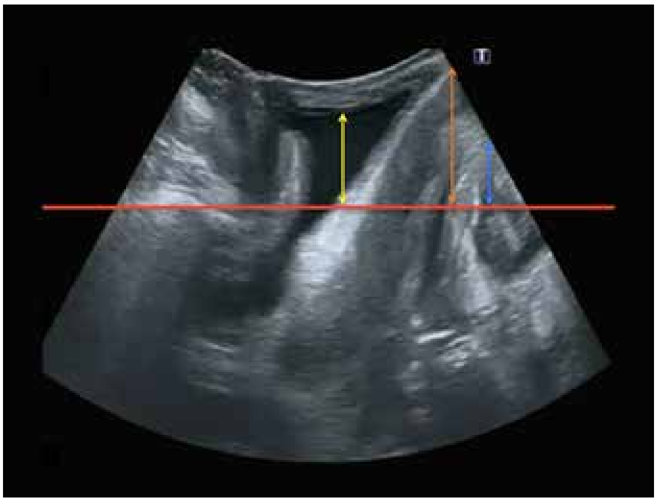

**Figure 5** Baseline that passes by the posteroinferior edge pf the pubic symphysis (red line). Pelvic Organ Prolapse (POP) of the anterior (yellow arrow), middle (orange arrow) and posterior compartments.

- Retrovesical or posterior urethrovesical angle: angle defined in between the proximal axis of the urethra and the closest portion to the urethra of the posterior bladder wall (yellow lines in Fig. 4). This parameter does not have a definable cut-off point either to determine SUI. However, it is useful in the diagnosis of pelvic organ prolapse (POP) of the anterior compartment.

Other criterion used to diagnose SUI:

- Bladder neck funnelling: consists in the opening of the bladder neck during stress. It may suggest a possible intrinsic aetiology: the urethral sphincter as the cause of SUI.

## Pelvic floor ultrasound applied to Pelvic Organ Prolapse (POP)

POP is defined as the descent of the pelvic organs from the pelvic cavity, which can involve the anterior wall of the vagina or bladder, posterior or rectal vaginal wall, uterus or vaginal arch. For ultrasound assessment of POP, measurements are taken from a reference point established by the imaginary line (red line in Fig. 5) passing by the posteroinferior edge of the pubic symphysis. A POP is significantly symptomatic when it surpasses that reference line by 10 mm in the anterior compartment (yellow line in Fig. 5) or by 15 mm in the middle (orange line in Fig. 5) and posterior compartment (blue line in Fig. 5).

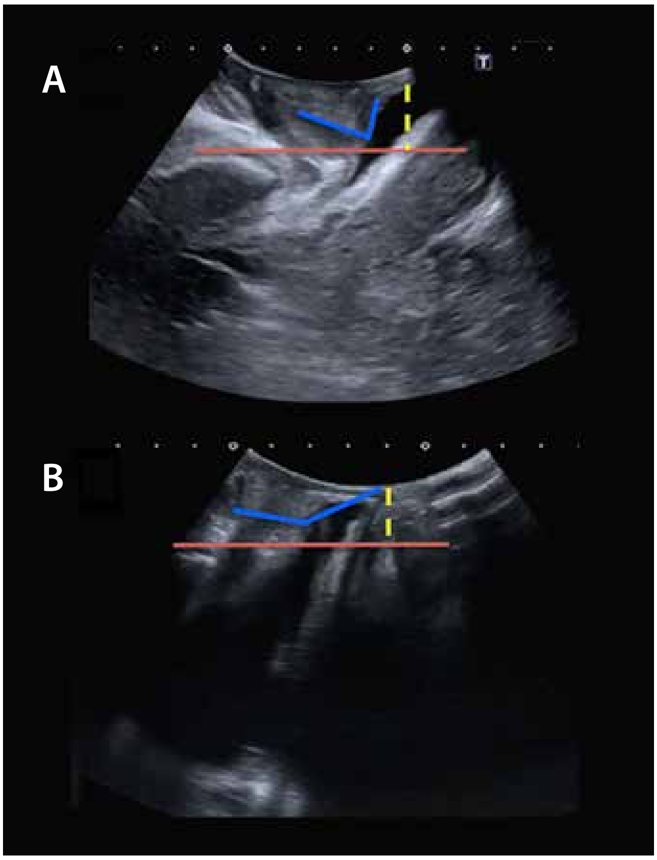


**Figure 6** Midsagittal image during Valsalva manoeuvre of a single cystocele (A) and a cystourethrocele (B).

## Anterior compartment assessment

The urethral mobility is the main variable used in the ultrasound differential diagnosis of anterior compartment pathology:

- Single cystocele (Green Type III): vertical descent ≥10 mm (dashed yellow line in Fig. 6A) and retrovesical angle < 140º (blue line in Fig. 6A).
- Cystourethrocele (Green Type II): vertical descent ≥10 mm (dashed yellow line in Fig. 6B) and retrovesical angle ≥ 140º (blue line in Fig. 6B).

## Middle compartment assessment

In the ultrasound evaluation of the middle compartment, it is crucial to assess uterine mobility to differ between uterine prolapse and cervical elongation without uterine prolapse. The parameter that best allows the diagnosis of uterine prolapse is the difference, between the resting condition and the Valsalva manoeuvre, of the pubic-uterine fundus distance (red line in Fig. 7) of more than 15 mm.

## Posterior compartment assessment

The ultrasound differential diagnosis of the posterior compartment pathology should be performed with checking for the following:

- Rectocele: anterior rectal wall herniation towards the vagina (Fig. 8A).
- Rectoenterocele: rectocele herniation combined with small bowel herniation or other abdominal content towards the vagina (Fig. 8B).
- Enterocele: protrusion of the anterior abdominal content towards the anorectal angle separating the vagina from the rectal ampulla (Fig. 8C).
- Rectal intussusception: invagination of the rectal anterior wall in the anal canal at the level of the anorectal canal angulation (Fig. 8D).

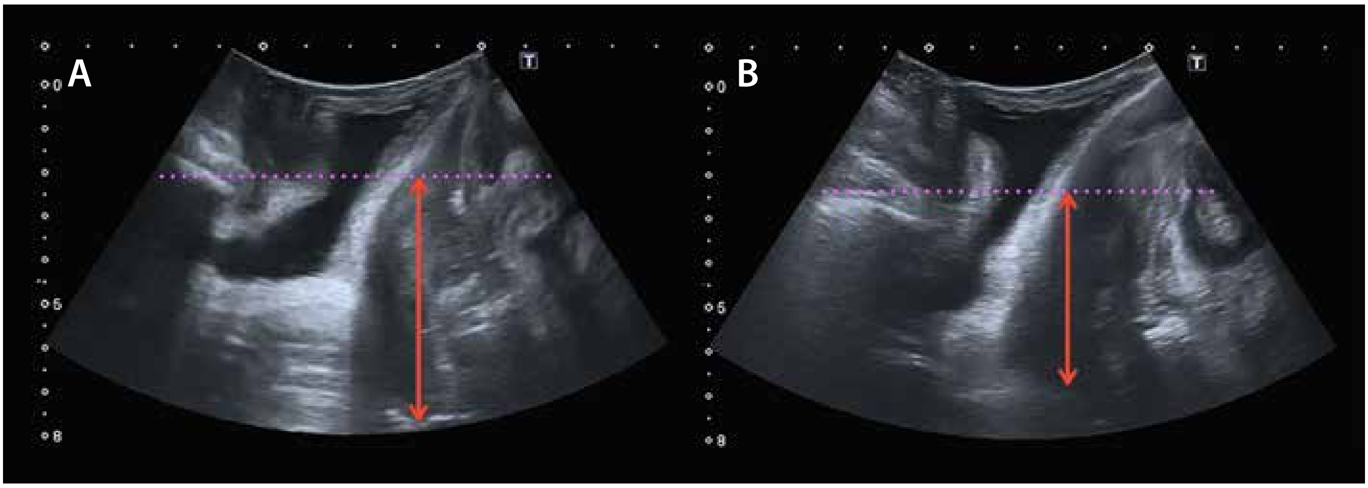


**Figure 7** Diagnosis of uterine prolapse with a difference between rest position (A) and Valsalva (B), of the pubic-uterine fundus distance > 15 mm.

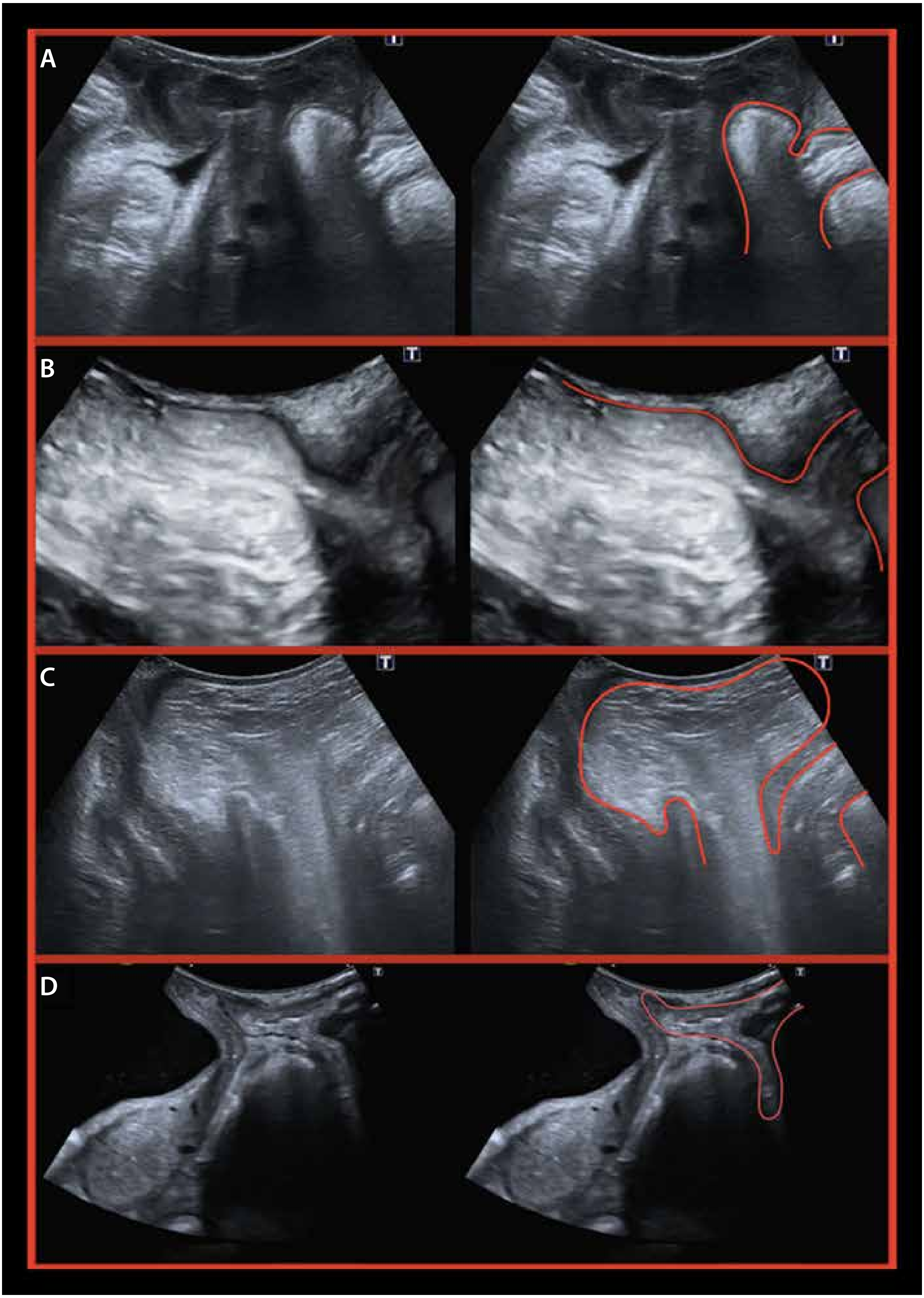


**Figure 8** Ultrasound differential diagnosis of the posterior compartment: Rectocele (A), Rectoenterocele (B), Enterocele (C), Intussusception rectal (D).

## Surgical pelvic floor implants

Stress urinary incontinence (SUI) affects a large number of patients, causing a severe impact on their quality of life. This has led to an increase, over the past decades, in the appearance of surgical procedures for its correction. Anterior compartment meshes are located between the urinary bladder and the vagina. Different forms of mesh failure in this compartment have been described, such as mesh migration, apical failure, and the association of apical and lateral failure. In the ultrasound evaluation of anti-incontinence meshes, a study of different parameters should be carried out, being the most studied the positioning of the mesh with respect to the urethra and the measure of urethral mesh compression:

- Location of the sling in relation to the urethra: It is carried out measuring the length of the proximal urethra, divided by the total length of the urethra. This parameter ranges from 0% to 100%. A 0-percentile value indicates that the sling is close to the neck bladder and a 100-percentile value indicates that it is close to the external meatus of the urethra. The optimal positioning of the sling is in between 40th and 70th percentile (Fig. 9A).
- Measure of urethral mesh compression: the most important parameter is the sling-pubis gap. It is defined as the distance between the centre of the sling and the posterior edge of the pubic symphysis. The bigger the sling-pubis distance, the lesser the mid-urethral compression and the sling tension (Fig. 9B).

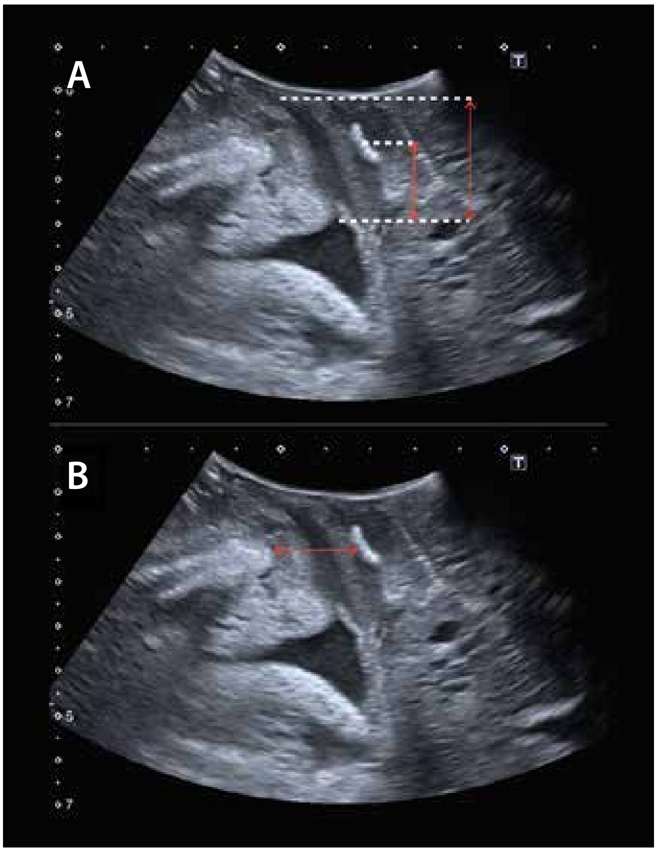


**Figure 9** Positioning of the sling in relation to the urethra (Figure A, up). Sling-pubis gap (Figure B down).

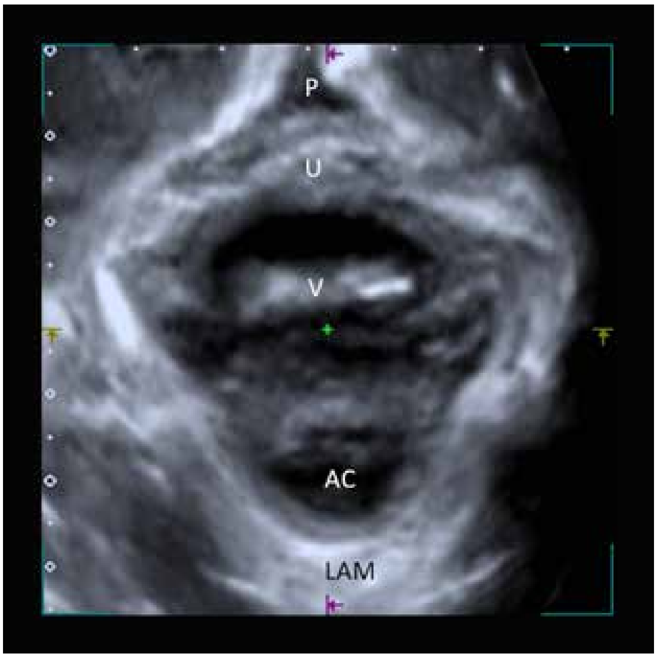


**Figure 10** Plane of minimal hiatal dimensions. P: Pubis, U: Urethra, V: Vagina, AC: Anal Canal, LAM: Levator ani muscle

## Levator ani muscle (LAM)

The multiplanar reconstruction from the plane of minimal hiatal dimensions (Fig. 10) is the standardised and reference mode of evaluating LAM avulsion. The axial planes are obtained with 2.5 mm intervals (5 mm caudal and 12.5 mm cranial), evaluating a total of 8 planes (Fig. 11). The exact location of the 8 planes is established from the three central planes (yellow dashed line in Fig. 11):

- 1st plane (on the left): the pubic symphysis arches are separated.
- 2nd plane (central): the pubic symphysis arches are closed.
- 3rd plane (on the right): the pubis should not be displayed, being replaced by an acoustic shadow.

LAM avulsion is defined as the disinsertion of the muscle from the pubic area. It is complete when it is present in the three central planes, and partial when there is muscle damage in other planes without meeting the criteria for complete avulsion. It has also been defined as LAM avulsion type I (Fig. 12A) when there are well inserted muscle fibres in the most lateral regions of the pubovisceral muscle, and LAM avulsion type II (Fig. 12B) when there is a complete detachment of the pubovisceral muscle from its insertion in the pubis.

Vaginal delivery constitutes the main risk factor for LAM avulsion. However, the association of different factors may influence in the trigger of avulsion, such as, maternal age, body mass index, duration of second stage of labour, fetal head circumference, neonatal weight, obstetric perineal injuries, Kristeller manoeuvre, episiotomy or epidural analgesia. Operative vaginal delivery represents the main risk factor: a recent meta-analysis has determined that the estimated joint odds ratio for vacuum delivery vs. normal vaginal delivery was 1.93 (95% CI: 1.31-2.86), for forceps delivery vs. normal vaginal delivery was 5.33 (95% CI: 3.78-8.11), and for forceps delivery vs. vacuum delivery was 2.36 (95% CI: 1.46-3.84).

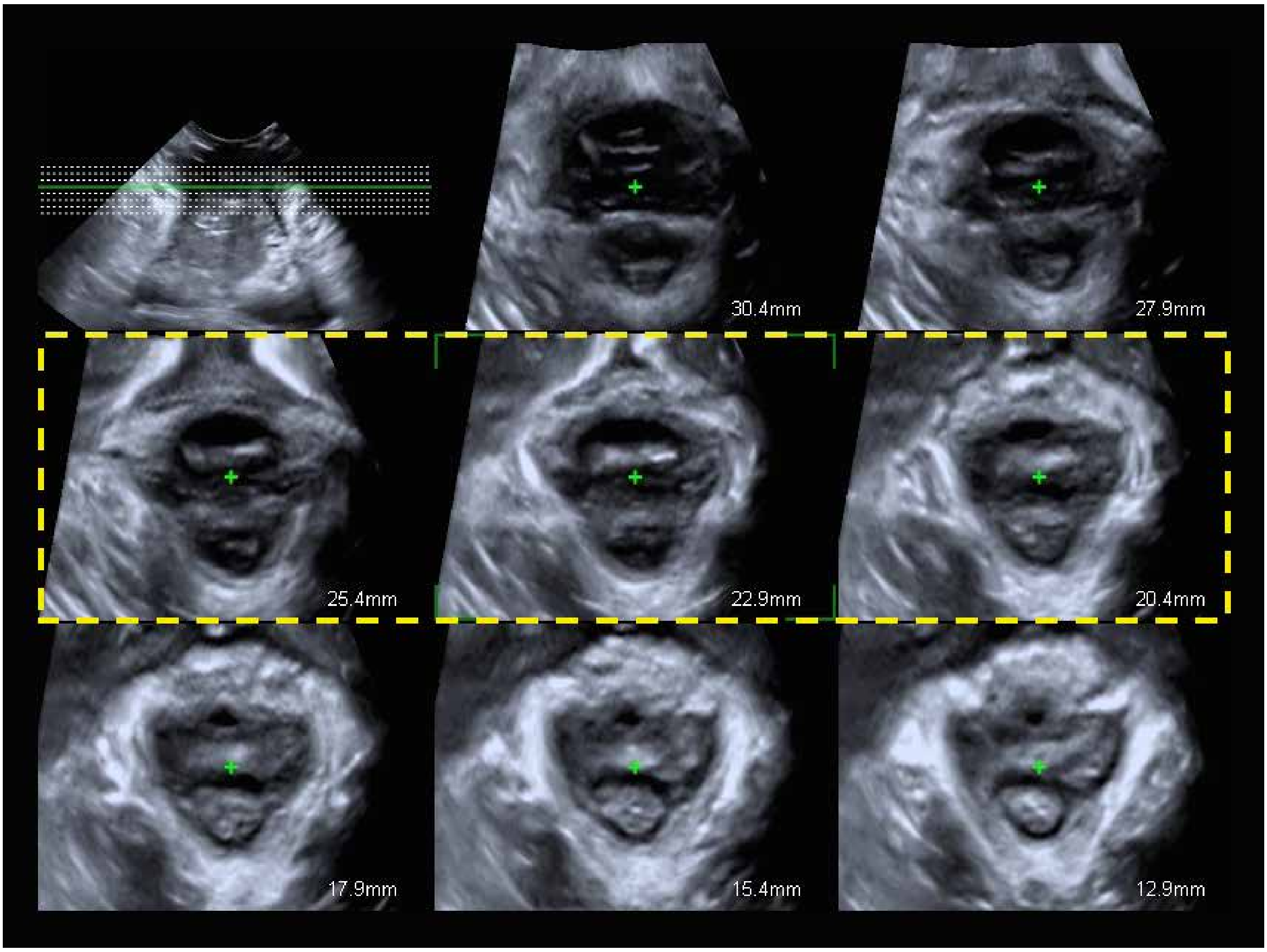


**Figure 11** Multiplanar levator ani muscle (LAM) reconstruction with the three central planes highlighted in yellow.

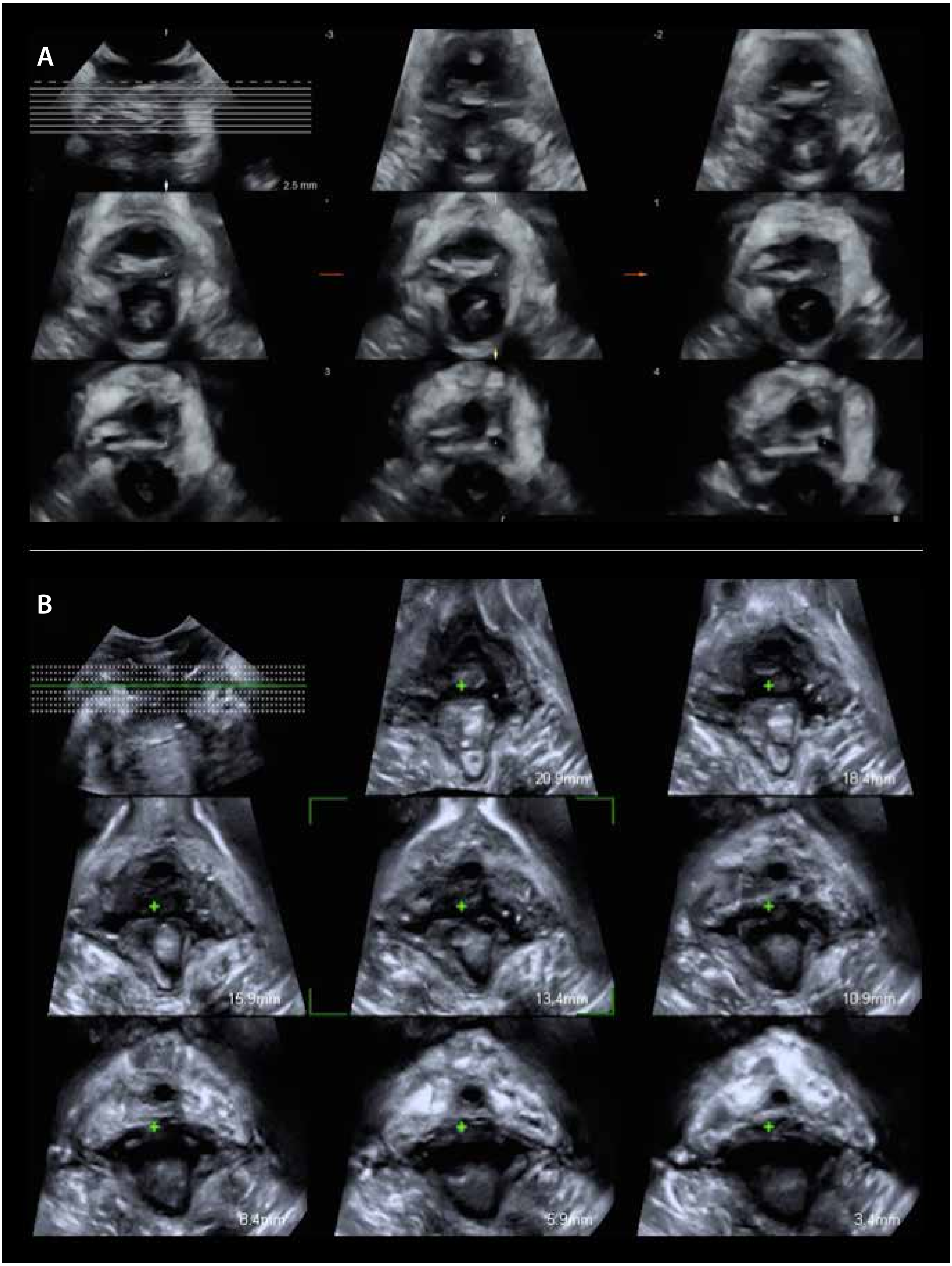


**Figure 12** Right levator ani muscle (LAM) avulsion type I (A), and bilateral LAM avulsion type II (B).

## Anal sphincter

For the evaluation of the anal sphincter, the transducer should be placed transversally over the perineum with the probe tilted towards the anal canal (Fig. 13). It is advisable to capture the volume in contraction to enable a better tissue discrimination. The multiplanar assessment allows the analysis of the whole sphincter complex, locating the first plane on the puborectalis muscle, and the last plane on the anal verge (8 planes in total) (Fig. 14). The distance between the planes depends on the length of the anal canal and permits the study of the sphincter complex continuity (red arrow in Fig. 15), as well as its thickness, discontinuity, the location of the defect and the anal mucosa changes.

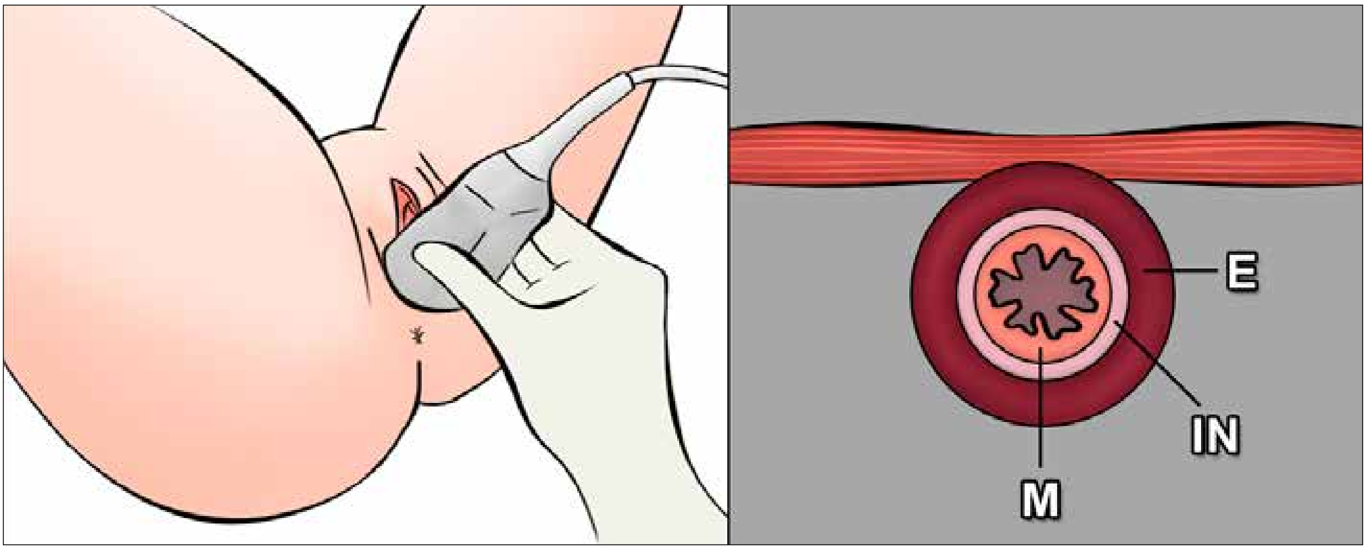


**Figure 13** Adding an additional schematic drawing how to place the transducer. LAM: levator ani muscle, IN: internal sphincter, E: external sphincter, M: rectal mucosa

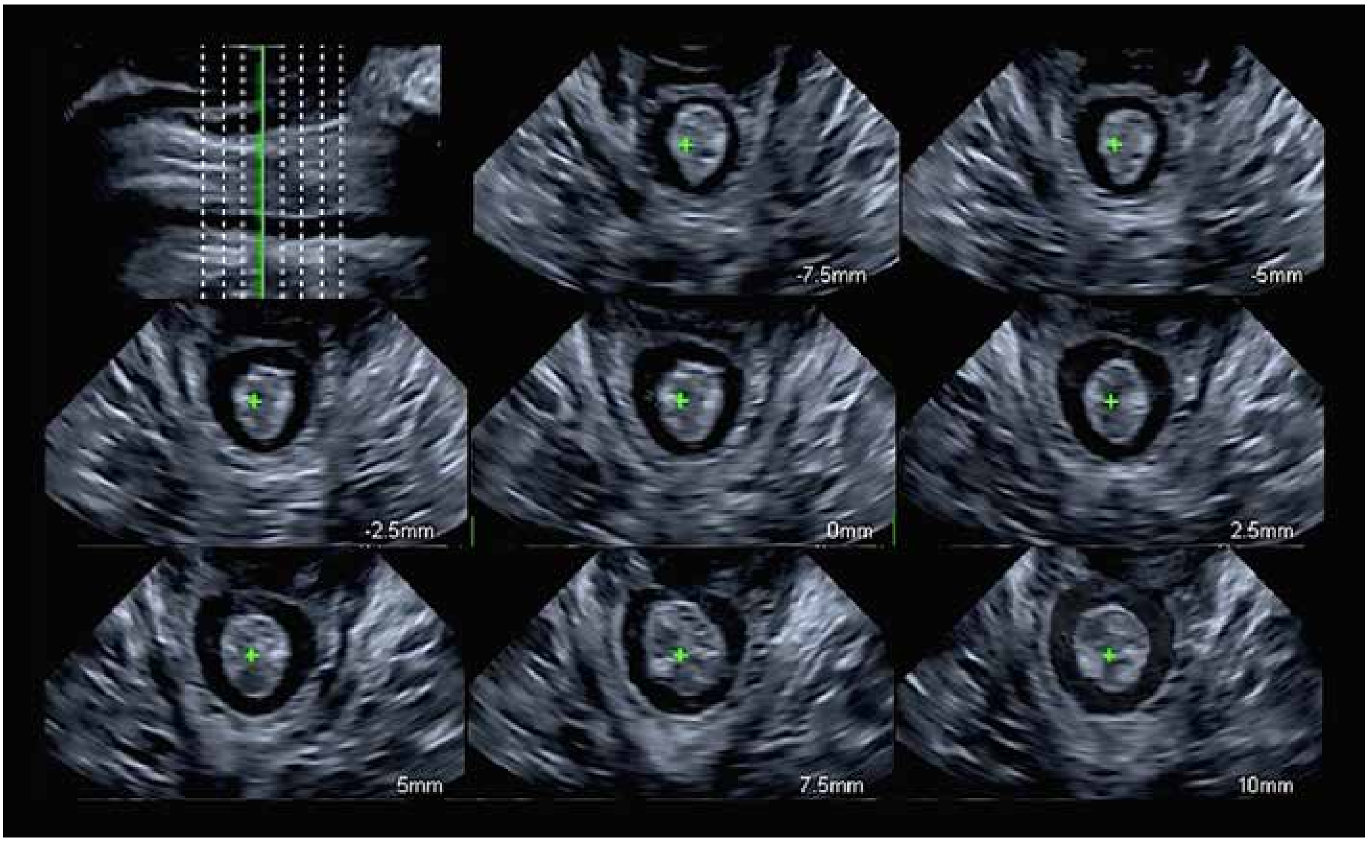


**Figure 14** It shows a multiplanar study to analyze the sphincter complex.

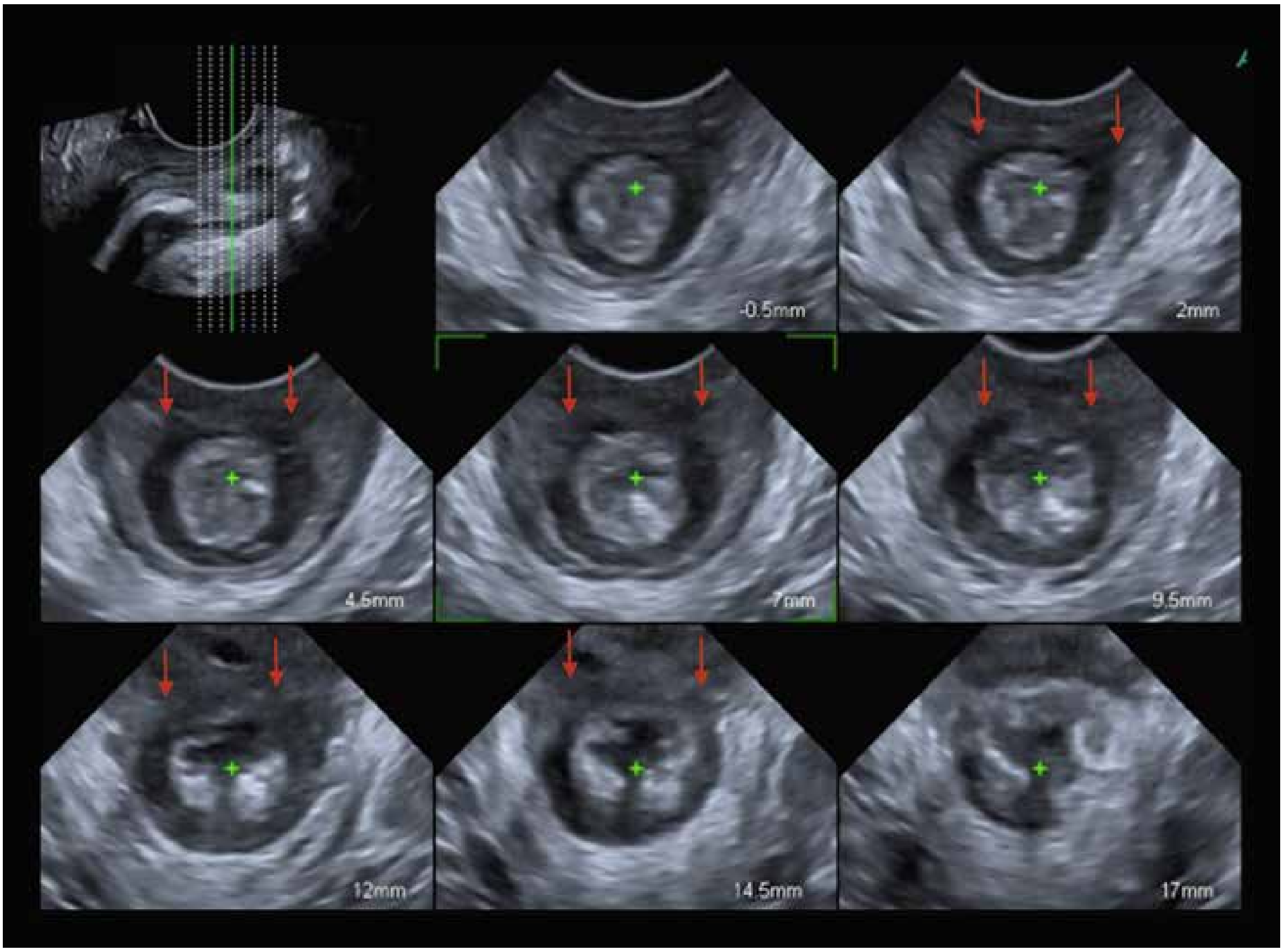


**Figure 15** Internal and external anal sphincter injury at 12 o'clock (Red arrow).

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