Is MRI the gold standard imaging technique to diagnose levator ani muscle avulsion?

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Aims and objectives

The levator ani muscle (LAM) is a broad muscular sheet of variable thickness attached to the internal surface of the bony pelvis. There is significant controversy about the sub-divisions of the muscle, however, it is broadly accepted that it is subdivided into parts according to their attachments, namely the iliococcygeus, pubococcygeus, and ischiococcygeus. The pubococcygeus is further subdivided into separate parts according to the viscera they are related to e.g pubourethralis, pubovaginalis and puborectalis[1-6].

The components of the LAM differ from most other skeletal muscles in their function; as they maintain constant tone; allow voiding and defaecation; contract quickly at the time of acute stress such as cough and sneeze; have ability to distend considerably during labour and then resume normal functioning. The degree of required distension of the puborectalis muscle varies greatly between individuals.

Trauma of the LAM can occur by overdistention of the muscle and by disconnection of the muscle from its insertion to the pubic bone (avulsion).

Levator ani muscle avulsion is known to be associated with pelvic floor dysfunction (PFD) such as pelvic organ prolapse.

Magnetic resonance imaging (MRI) was the first imaging technique to demonstrate LAM avulsion and is considered the reference standard. Currently, three-dimensional (3D) ultrasound (US), a technique which is less expensive and more easily accessible, is being used extensively for the diagnosis of LAM avulsion. However, before US can be implemented in clinical practice its diagnostic accuracy needs to be assessed. For detection of LAM avulsion 3D transperineal ultrasound (TPUS) has shown reasonable agreement with MRI in women with a stage #2 cystocele[7] and 3D endovaginal ultrasound (EVUS) has been shown to be comparable to MRI in a small sample (n=21)[8].

Our aim was to assess the accuracy of all three imaging techniques (TPUS, EVUS and MRI) in the diagnosis of LAM avulsion and to correlate them with signs and symptoms of PFD, with a view to establish if US can substitute MRI for the diagnosis of LAM avulsion.

Methods and materials

We performed a cross-sectional study on 135 women four years after their first delivery, who were previously recruited as part of a prospective longitudinal study. Symptoms were assessed with the validated International Consultation on Incontinence Questionnaires. Pelvic floor muscle strength (PFMS) was assessed with the Modified Oxford Score (MOS) and pelvic organ prolapse with the validated ICS-POP-Q.

All patients underwent 3D/4D Transperineal US (with the use of convex probe 4-8.5 MHz, Voluson, GE), (Fig.) high frequency 3D Endovaginal US (with the use of rotational 360° automatic acquisition transducer. 6-12MHz, type 8838, BK Medical) (Fig.) and MRI (1.5 Tesla , Siemens). Images were acquired at rest and analysed blinded to clinical and other imaging findings. The LAM was assessed in the plane of minimal hiatal dimensions using the validated DeLancey score[9] (Fig) and confirmed in the sagittal plane on MRI and EVUS.

Diagnostic test characteristics were calculated using MRI as the reference standard. Correlation of LAM avulsion with signs and symptoms were assessed with the Chi^2, Fisher's exact and Mann-Whitney U test.

Images for this section:

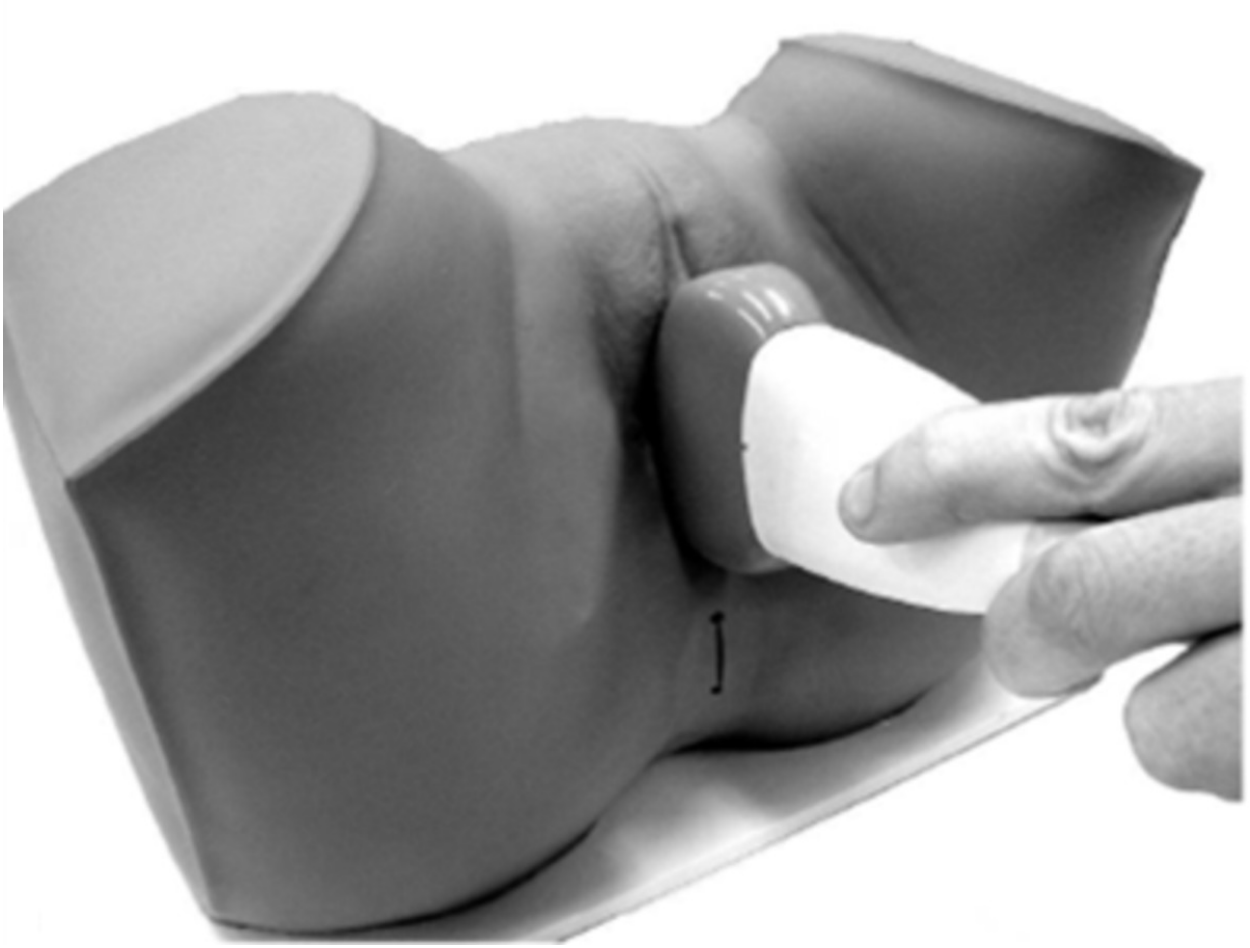

Fig. 1: Transperineal ultrasound- technique. The probe is placed gently on the perineum and automatic 3D acquisition of the pelvic floor organs is taken.

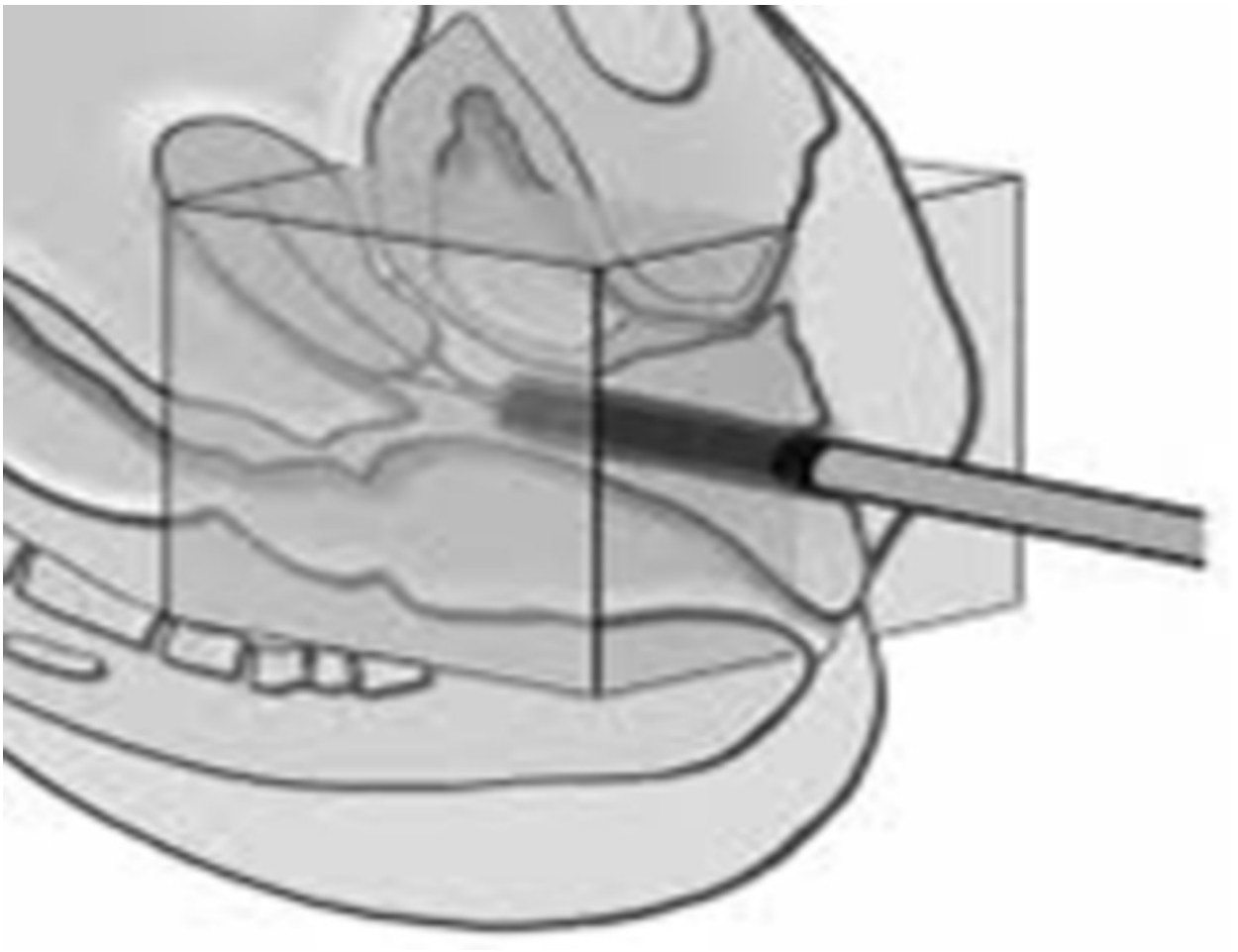

Fig. 2: Endovaginal Ultrasound (EVUS)- automatic 3D data is acquired by the use of 360 degrees rotational probe.

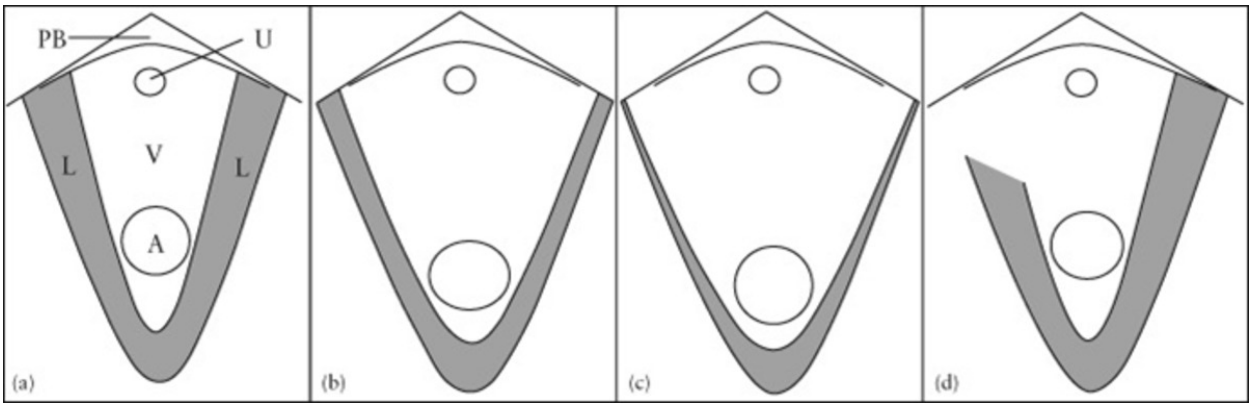

Fig. 3: Validated Delancey's score for LAM avulsion. Unilateral score: 0 = Normal 1 = < 50% muscle missing 2 = > 50% muscle missing 3 = Complete avulsion Sum Score

(bilateral): 0 = No damage 1-3 = Minor avulsion 4-6 = Major avulsion or Unilateral score 3: Major avulsion

Results

Mean age was 34.8 (SD 5.5) years, BMI 26.5 (SD 6.0) and parity 1.5 (SD 0.6). Time after first delivery was 3.8 (0.4 SD) years. Time between US and MRI was 21 (SD 49) days. On MRI 23 (17%) had a minor and 3 (2%) a major LAM avulsion. Both TPUS and EVUS showed a poor sensitivity (26-39%) for minor LAM avulsion and an excellent sensitivity (100%) for major LAM avulsion (Table 1). Specificity was excellent (93-97%) for both US techniques for minor and major LAM avulsion. Both US techniques identified all major LAM avulsions seen on MRI and identified an additional 13 (EVUS 6, TPUS 4, both 3). In contrast, all three imaging techniques agreed in only 4 of the 23 minor LAM avulsions found on MRI. TPUS agreed in 6, missed 12, classified 5 as major and found 3 additional minor LAM avulsions. EVUS agreed in 9, missed 10, classified 4 as major and found 7 additional minor LAM avulsions.

LAM avulsion on MRI did not correlate with any symptoms, but minor avulsion was associated with a reduction in PFMS (p=0.004). Women with minor LAM avulsion on EVUS had more symptoms of stress urinary incontinence (p=0.007) and POP (p=0.039). Women with minor and major LAM avulsion on EVUS had reduced PFMS (p= 0.037, p=0.021). Major LAM avulsion on EVUS correlated with cystocele grade # 2 (p=0.013) on clinical examination. Minor or major LAM avulsion on TPUS did not correlate with any symptoms of PFD, but did correlate with reduced PFMS (p=0.000, p=0.025).

Images for this section:

Type of LAM avulsion	Technique	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Minor (17%)	TPUS	0.26	0.97	0.67	0.87	9.94	0.76
	EVUS	0.39	0.94	0.56	0.88	6.26	0.65
Major (42%)	TPUS	1.00	0.95	0.90	1.00	18.86	0.00
	EVUS	1.00	0.93	0.85	1.00	14.67	0.00

Table 1: Table 1. Diagnostic test characteristics of EVUS and TPUS for minor and major LAM avulsion using MRI as the reference standard. LAM = Levator ani muscle EVUS= Endovaginal ultrasound TPUS= Transperineal ultrasound PPV=Positive predictive value NPV=Negative predictive value LR+=Likelihood ratio positive LR-=Likelihood ratio negative

	MRI		EVUS		TPUS	
	Major	Minor	Major	Minor	Major	Minor
	N: 3	N: 28	N: 12	N: 16	N: 10	N: 9
Symptoms of PFD						
Urinary incontinence (range 0-21) - *mean (SD)*	3.0 (3)	5.0 (6.0)	5.3 (6.5)	4.4 (6.9)	6.3 (5.2)	2.1 (3.2)
Stress Urinary incontinence - *n (%)*	2 (67)	15 (65)	7 (58)	13 (81)*	7 (70)	3 (33)
Urge Urinary incontinence - *n (%)*	1 (33)	7 (30)	3 (25)	2 (13)	2 (20)	1 (11)
POP symptoms - *n (%)*	0 (0)	11 (48)	3 (25)	6 (38)*	3 (30)	3 (33)
Signs of PFD						
Modified Oxford score (range 0-5) - *mean (SD)*	2.0 (1.0)	2.4 (1.6)*	2.3 (1.8)*	2.6 (1.6)*	1.7 (1.2)*	2.1 (1.9)*
AC prolapse > stage 1 - *n (%)*	2 (67)	11 (48)	9 (75)*	9 (56)	6 (60)	4 (44)
AC prolapse > stage 2 - *n (%)*	1 (33)	1 (4)	3 (25)*	1 (6)	1 (10)	1 (11)

Table 2: Table 2. LAM avulsion on MRI, EVUS and TPUS correlated to signs and symptoms of PFD. * = p < 0.05 MRI = magnetic resonance imaging EVUS= endovaginal ultrasound TPUS= transperineal ultrasound PFD= pelvic floor dysfunction AC= anterior compartment a= fisher exact test b= Chi2 test c= MWU test

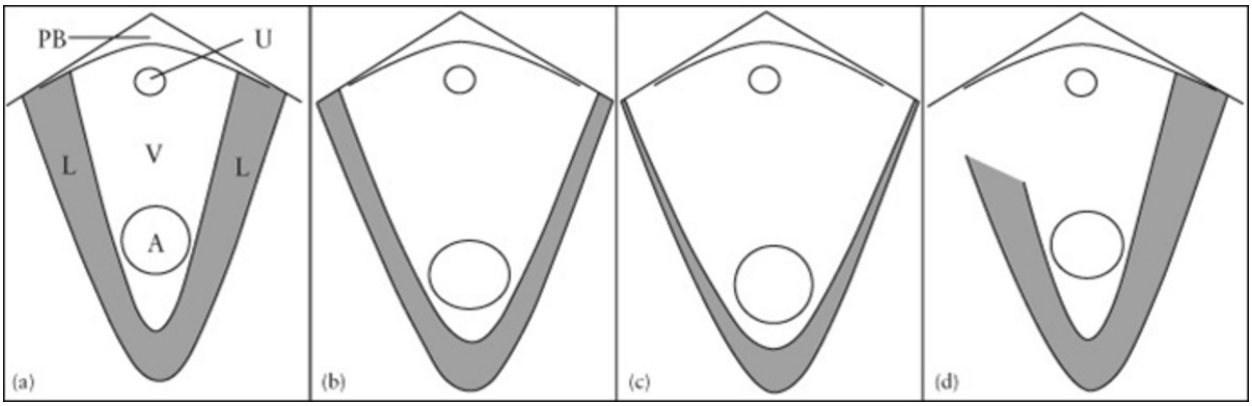

Fig. 3: Validated Delancey's score for LAM avulsion. Unilateral score: 0 = Normal 1 = < 50% muscle missing 2 = > 50% muscle missing 3 = Complete avulsion Sum Score (bilateral): 0 = No damage 1-3 = Minor avulsion 4-6 = Major avulsion or Unilateral score 3: Major avulsion

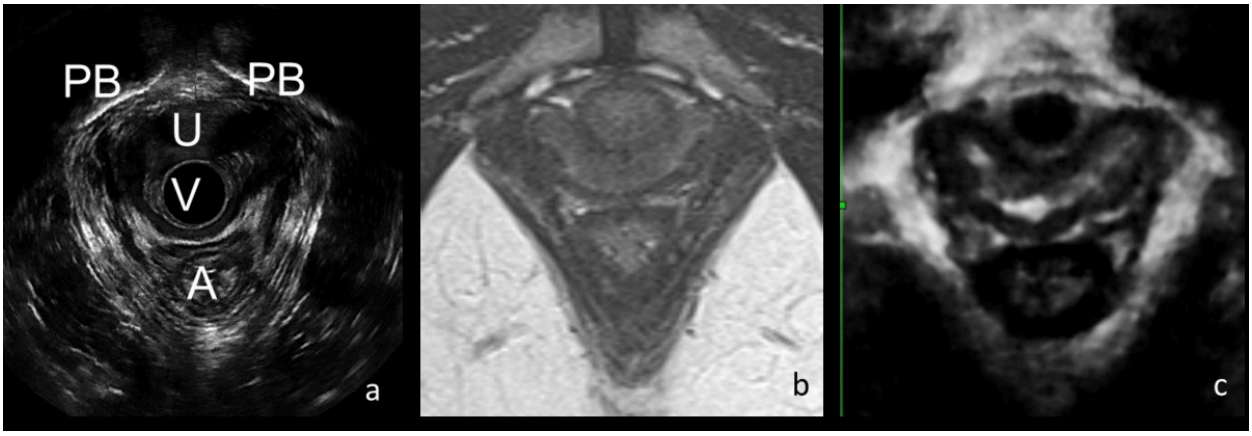

Fig. 4: Example of intact LAM on EVUS (a), MRI (b) and TPUS (c). PB- pubic bone U- urethra V- vagina A- anal canal

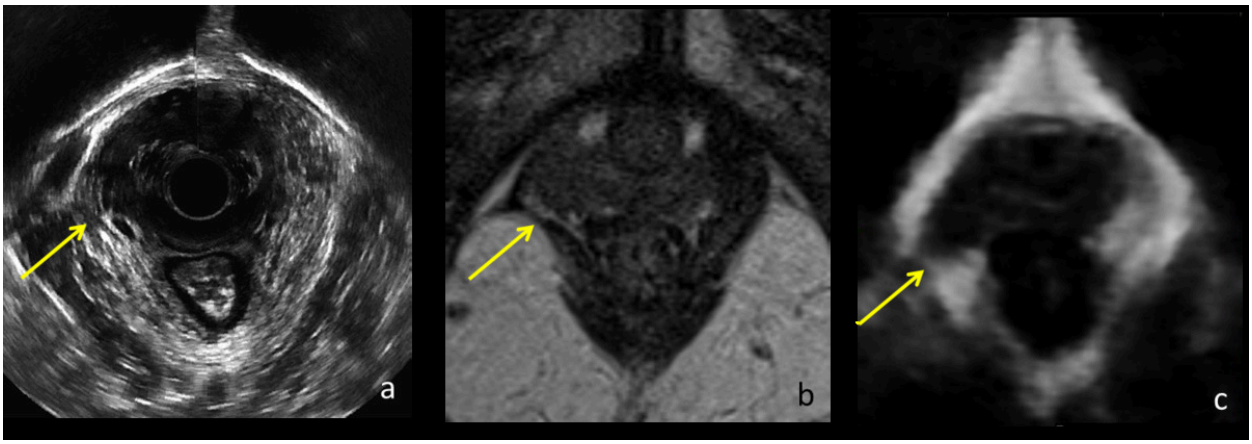

Fig. 5: Example of minor avulsion of the right LAM (arrow) on EVUS (a), MRI (b) and TPUS (c). Normal thickness muscle is seen on the left.

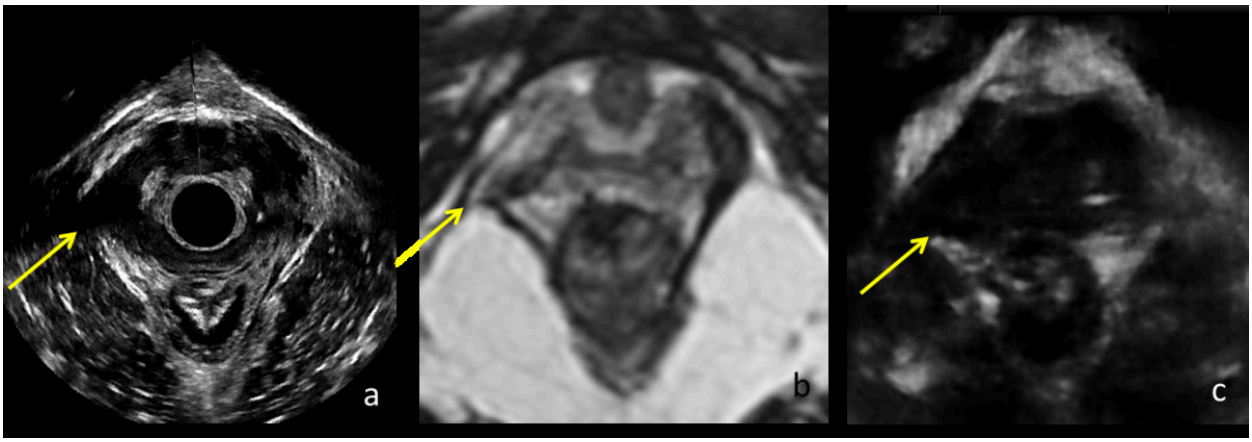

Fig. 6: Example of majoravulsion of the right LAM (arrow) on EVUS (a), MRI (b) and TPUS (c). Normal thickness muscle is seen on the left.

Conclusion

This is the first prospective study to investigate the accuracy of three imaging techniques for LAM avulsion in the same patient. Ultrasound is a good diagnostic tool for the assessment of major LAM avulsion (high sensitivity), but poor for detecting minor avulsions (low sensitivity). LAM avulsion seen on EVUS correlates better with expected symptoms than MRI and TPUS. It therefore appears that EVUS is better in diagnosing symptomatic LAM avulsion and could substitute MRI as a reference standard. Using EVUS instead of MRI enables widespread postnatal screening and early identification of women at higher risk of developing PFD. Timely motivation and early implementation of physical therapy and lifestyle changes might reduce future PFD.

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