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FULL PAPER

The value of pre-operative multicompartiment pelvic floor ultrasonography: a 1-year prospective study

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Objective: Comprehensive assessment of the pelvic floor (PF) provides information and diagnoses of coexisting abnormalities that may affect operative decisions. Our aim was to establish if pre-operative PF ultrasonography (PFUS) in patients complaining of PF dysfunction can complement clinical findings and contribute to additional management strategies.

Methods: Females were recruited from the urogynaecology/gynaecology clinics between July and October 2009 and underwent pelvic organ prolapse quantification (POPQ) by an independent examiner. PFUS was performed using two-dimensional (2D) transperineal ultrasound (TPUS), high-frequency 2D/three-dimensional (3D) endovaginal ultrasound (EVUS) using a biplane probe with linear and transverse arrays and a 360° rotational 3D-EVUS. The clinician performing PFUS was blinded to POPQ results. POPQ and PFUS were repeated at 1 year. Two clinicians analysed the scans independently.

Results: 158 of 160 females had a POPQ and PFUS. 105 females had pelvic organ prolapse and/or incontinence and 53 asymptomatic females were controls. 26 additional ultrasound diagnoses were noted at baseline and 46 at 1 year using 2D-TPUS and EVUS. Only one female with additional diagnoses on PFUS needed surgical intervention for this condition.

Conclusion: Multicompartiment PFUS identifies additional conditions to that diagnosed on clinical assessment. However, it neither changes the initial surgical management nor the management at 1-year follow-up and therefore clinical assessment should not be substituted by PFUS.

Advances in knowledge: PFUS can be helpful in providing additional information; however, it does not change the initial management of the patient and therefore should not replace clinical assessment.

Adequate pelvic floor (PF) assessment is of paramount importance in clinical practice and research relating to PF disorders.¹ The most common type of PF dysfunction (PFD) is pelvic organ prolapse (POP), which affects approximately 50% of parous females over 50 years of age, with a lifetime prevalence risk of 30–50%.² The International Continence Society (ICS) recommends a POP quantification (POPQ) system for the clinical assessment of POP.³ However, concerns have been raised regarding decisions based on clinical assessment alone, as this may have a limited role in evaluating the morphological and structural changes leading to PFD.^{4,5}

A review of the literature shows that the majority of morphologic studies of the female genital tract have been conducted using ultrasound^{6–11} and MRI.^{12,13} Dietz et al⁶ demonstrated the use of translabial ultrasound to quantify POP for the first time and established a good correlation between imaging, clinical staging and POPQ. Santoro et al⁹ highlighted the benefits of an integrated approach to PF

ultrasonography (PFUS). In addition, PFUS can provide information that may affect operative decisions.^{5,6} Although the diagnosis of coexisting abnormalities on ultrasound may be applied in planning reconstructive procedures,² there are no prospective studies evaluating the outcome of these additional conditions diagnosed on PFUS.

We hypothesized that the PFUS can substitute clinical assessment by diagnosing additional conditions. The aims of this study were firstly, to establish if pre-operative PFUS in patients complaining of PFD can diagnose additional conditions to that of clinical assessment. Secondly, we wished to determine whether any additional diagnoses identified on pre-operative PFUS would have changed the outcome.

METHODS AND MATERIALS

Between July and October 2009, females were recruited from the urogynaecology and gynaecology clinics. All females were referred following a standard referral pathway by general practitioners. Females who had symptoms of

POP and/or urinary incontinence (UI) were eligible to participate as study patients, and females with other gynaecological symptoms were included as controls. We excluded females who presented with pelvic masses such as ovarian cysts or fibroids, which may have an impact on PF assessment. A detailed history was obtained and demographic data were collected, including age, parity, body mass index (BMI) and previous surgery for prolapse and UI.

Prior to the examination, patients were asked to empty their bladders if they felt it was full or uncomfortable. POPQ assessment was conducted by an independent examiner (RT or AHS) in the left lateral and standing position as per unit protocol, and the examination was completed using bimanual pelvic palpation. The measurements of POPQ points Ba, Bp and C in centimetres were used as they describe the maximum descent of the anterior, posterior and middle compartments, respectively.³

Comprehensive PFUS was performed with the use of ProFocus Ultraview™ (BK Medical, Herlev, Denmark) ultrasound scanner on the same day as the POPQ assessment in an outpatient setting, by two research fellows (FL and AS) who were not aware of the POPQ findings. The patients were scanned in the supine position and without using any rectal or vaginal contrast.^{9,14}

PFUS consisted of two-dimensional (2D) transperineal ultrasound (TPUS) and high-frequency 2D/three-dimensional (3D) endovaginal ultrasound (EVUS). TPUS was performed with the patient placed in the dorsal lithotomy, with the hips flexed and abducted. All examinations were performed using 6-MHz convex transducer (Type 8802, ProFocus Ultraview) positioned in the midsagittal line on the perineum between the mons pubis and the anal canal (transperineal approach) to visualize the pubic symphysis, urethra, vagina, anal canal and rectum. Imaging was performed at rest and on three maximal Valsalva manoeuvres. For the Valsalva manoeuvre, patients were asked to

perform a forcible exhalation effort against the closed mouth and to bear down as if they were having a bowel evacuation. At analysis, the image with maximum PF descent was selected for measuring organ descent. In order to avoid false-negative results and to allow full development of pelvic organ descent, the transducer was gently positioned on the perineum.^{9,14} The measurements of prolapse on the image were taken offline demonstrating maximum descent. A reference line was drawn parallel to the inferoposterior margin of the symphysis pubis,¹⁴ perpendicular to which the leading edge of descent was measured in millimetres (Figure 1). The sonographical definition of a clinically significant cystocele and rectocele (15 and 10 mm below the reference line, respectively)¹⁵ and 10 mm below the reference line for middle compartment prolapse were used.

High-frequency 2D-/3D-EVUS was performed using a 13-MHz 360° rotational probe (Type 2050) and a 12-MHz biplane transducer with linear and transverse arrays (Type 8848) in order to assess anterior (urethra) and posterior (anorectum) PF compartments according to the pre-determined protocol in axial and sagittal sections.⁹ Posterior compartment assessment on maximal Valsalva enabled differentiation between rectocele and enterocele and allowed for assessment of intussusception.

Two experienced clinicians analysed the scans independently. We used a software called Virtual Dub v. 1.9.4 (Free Software Foundation Inc., Cambridge, MA) that slices the image into multiple frames. Each image was sliced into approximately 140–160 frames, and each frame was individually analysed by the two research fellows to identify the frame with maximum PF descent that was used to measure the prolapse.

Ethics approval: the study was approved by the National Research Ethics Service, Bromley Local Research Ethics Committee, South London REC office (ethics study number: 08/H0806/115). All females who participated gave written informed consent.

Statistical analysis

For statistical analysis, the POPQ point measurement was converted to millimetres. Measurements on TPUS were in millimetres and were rounded to the nearest zero. SPSS® v. 15 (SPSS Inc., Chicago, IL) was the statistical package used.

RESULTS

Of the 160 females recruited, 158 had a POPQ and PFUS assessment (105 females with POP and/or UI and 53 controls). 18 scans (11.4%) were not analysable (17 of poor quality in the POP group and 1 missing in the control group). The mean age was 49.5 years [standard deviation (SD), 14.1 years], BMI, 29.3 kg m⁻² (SD, 6.5 kg m⁻²) and the median parity of 2 (range, 0–6). 22 (13.7%) females had previously undergone a hysterectomy, 13 (8.1%) had previous POP surgery and 16 (10.0%) had previous surgery for UI. Of the 160 females, 125 (78%) came for 1-year follow up, 81 (76.4%) from prolapse group and 44 (83.0%) from control group. There was a good–excellent agreement between the two clinicians {anterior compartment: $R^2 = 0.77$ [95% confidence interval (CI), 0.71–0.83], middle compartment: $R^2 = 0.87$ [95% CI, 0.82–0.90], posterior compartment: $R^2 = 0.93$ [95% CI, 0.91–0.95]}.

Figure 1. Enterocoele on two-dimensional transperineal ultrasound measuring 12 mm below reference line (solid horizontal line refers to the reference line parallel to postero-inferior margin of symphysis pubis and arrow marked E measures the enterocoele perpendicular to the reference line). AC, anal canal; B, bladder; E, enterocoele; P, probe; R, rectum; SP, symphysis pubis; U, urethra.

Additional prolapse diagnosis

Table 1 demonstrates anterior, posterior and middle compartment prolapse diagnosed on POPQ and TPUS. There were diagnoses of anterior (25), middle (40) and posterior (13) compartment prolapse on POPQ that were not seen on 2D-TPUS. None of the cystoceles was missed on POPQ. Three females had rectoceles and five had middle compartment prolapse additionally picked up on 2D-TPUS that were not diagnosed on POPQ. However, none of these females with additional diagnoses of POP on 2D-TPUS needed surgical intervention for POP at baseline or at 1 year. 1 of 78 females (1.3%) with POP on clinical examination opted for pessary treatment, and the rest opted for PF muscle exercises only.

Additional diagnoses at baseline 2D-TPUS vs PFUS (TPUS + high-frequency EVUS)

At baseline assessment, 2D-TPUS detected 11 enteroceles (Figure 1), 6 vaginal cysts (Figure 2), 4 urethral calcifications (Figure 3) and 2 intussusceptions (Figure 4). 2D-TPUS when used in combination with EVUS detected 11 enteroceles, 1 intussusception (1 female had enterocoele + intussusception), 4 urethral calcifications and 6 vaginal cysts. Two females had urethral diverticula (Figure 5) diagnosed both on clinical examination and PFUS. Therefore, when 2D-TPUS was used in isolation, none of these additional diagnoses was picked up. However, when used in combination with high-frequency EVUS, we could additionally diagnose two intussusceptions and a combined enterocoele and intussusception in one female (Figure 6).

Additional diagnoses at 1-year 2D-TPUS vs PFUS (TPUS + high-frequency EVUS)

On assessment at 1 year, using only 2D-TPUS, 26 females had enteroceles, 7 had intussusceptions, 1 had both enterocoele and intussusception. However, when 2D-TPUS and EVUS were used in combination, we diagnosed 28 enteroceles, 9 intussusceptions, 2 females had both enterocoele and intussusception and 4 had vaginal cysts (Figure 2). Details of these diagnoses and the interventions required are shown in Table 2.

Outcome of additional diagnoses

At baseline, 10 (11.3%) enteroceles and 3 (3.4%) intussusceptions were visualized in females with symptomatic prolapse and in the control group 2 enteroceles (3.8%) and 1 intussusception (1.9%). Of the 89 females with symptomatic prolapse, 43 (48.3%) underwent surgery for POP (12 vaginal hysterectomy + anterior repair, 18 anterior repair, 5 posterior repair, 2 vaginal hysterectomy, 2 posterior repair + vaginal hysterectomy, 2 sacrocolpopexy and 2 posterior repair + sacrospinous fixation), 10 females (11.2%) opted for pessaries and 34 (40.4%) for no treatment.

We found that 12 out of 18 enteroceles and 5 out of 9 intussusceptions at 1 year were seen in females who had undergone surgery for symptomatic prolapse within the 12-month study period. Although there was an increase in the number of enteroceles identified on PFUS at 1 year in both the POP (18 vs 10) and control groups (12 vs 2), the size of the enterocoele was small (negative measurements, *i.e.* above the reference line). We also noted that despite the increased number of enteroceles being diagnosed at 1 year, the size of these were not different at 1 year compared with baseline (9 mm compared with 10 mm). Three of nine females with enteroceles on PFUS at baseline [median, 11 mm (range, 7–15 mm)] also had rectoceles (both on clinical examination and PFUS) and underwent a rectocele repair, but none of these females underwent enterocoele repair, as this was not evident on clinical examination.

Compared with baseline, at 1 year, the number of intussusceptions also increased in the POP group (four vs nine) and in the controls (one vs two). One female out of three with intussusception on PFUS had symptoms of obstructed defaecation and underwent defaecating proctography, which confirmed intussusception. She underwent a stapled transanal rectal resection procedure.

Using PFUS, we could visualize six vaginal cysts at baseline. At 1 year, two vaginal cysts had disappeared, while the remaining

Table 1. Anterior, posterior and middle compartment prolapse diagnosed on pelvic organ prolapse quantification (POPQ) and analysable two-dimensional transperineal ultrasound (2D-TPUS) at baseline

Prolapse on POPQ	Prolapse on 2D-TPUS			
	Negative	Positive	Sensitivity (%)	Specificity (%)
Cystocele				
Negative	92	0	59.0	100.0
Positive	25	36		
Rectocele				
Negative	76	3	39.3	96.2
Positive	40	26		
Cervix/vault				
Negative	93	5	69.0	94.9
Positive	13	29		

Figure 2. Vaginal cyst on two-dimensional transperineal ultrasound. B, bladder; P, probe; SP, symphysis pubis; U, urethra; VC, vaginal cyst.

four vaginal cysts remained asymptomatic. The two females diagnosed with urethral diverticula had urodynamically proven stress UI and underwent diverticulectomy resulting in symptom improvement.

DISCUSSION

In this observational study, we have found that 2D dynamic TPUS when used in combination with high-frequency dynamic EVUS enhanced the visualization of additional PF abnormalities that were not identified on clinical examination.

Using 2D-TPUS alone, at baseline, we found 11 females had enteroceles and 2 had intussusceptions. However, when 2D-TPUS was used along with EVUS, we identified 11 enteroceles and 4 intussusceptions, and 2 females had both enterocele and intussusception. These additional diagnoses using PFUS were also noted at 1 year, that is using 2D-TPUS alone, we identified 26 enteroceles and 7 intussusceptions, and 1 female had both diagnoses. However, when 2D-TPUS was used in combination

Figure 3. Urethral calcification on two-dimensional transperineal ultrasound. B, bladder; C, calcification; P, probe; U, urethra.

Figure 4. Intussusception at maximum Valsalva on two-dimensional endovaginal ultrasound. The large arrow points to the rectum. The small arrow indicates the rectum within which is the intussusception (I) times two. AC, anal canal.

with EVUS, we identified 28 enteroceles, 9 intussusceptions and 2 females had both enterocele and intussusception. Therefore, when TPUS was used in combination with EVUS, more additional diagnoses was found.

We used POPQ for the assessment of female POP, as this standard system has been recommended by the ICS³ and has been shown to have good reproducibility independent of the examiner's experience.¹⁶ In contrast to the older system of POP assessment where four or five stages were used,¹⁷ the POPQ staging³ improves validity as the measurement of descent is measured in centimetres relative to the hymen. PFUS is increasingly used by clinicians and researchers as part of the work-up of PFD.^{1,5-7,15,18} Our previous study has demonstrated a moderate-to-good correlation between 2D-TPUS and POPQ assessment for all three PF compartments.¹⁹ Other studies have also shown good correlation between one or more PF

Figure 5. Urethral diverticulum on three-dimensional endovaginal ultrasound. B, bladder; BN, bladder neck; U, urethra; UD, urethral diverticulum.

Figure 6. Additional diagnoses at baseline and 1 year using two-dimensional transperineal ultrasound (TPUS) and three-dimensional endovaginal ultrasound (EVUS). Number of additional diagnoses along the y-axis.

compartments and clinical examination.^{6,14,15} Dietz et al⁶ have previously demonstrated good correlation for middle compartment prolapse ($r = 0.77$). In a study of 61 females, Broekhuis et al¹⁴ demonstrated moderate-to-good correlation between POP on clinical examination, MRI and translabial ultrasound in the anterior compartment ($r = 0.49$ – 0.70). In another study, Eisenberg et al²⁰ showed that 2D, 3D and four-dimensional TPUS correlated with clinical examination, but they used the Baden–Walker classification instead of the validated POPQ ($r = 0.68$ for anterior compartment, 0.46 for enterocoele and 0.40 for rectocoele).

We found that compared with PFUS, POPQ is better at diagnosing cystourethrocele, rectocoele and uterocervical prolapse. An explanation for this is that while early prolapse can be identified clinically using POPQ, the ultrasound cut-off for the diagnosis of prolapse is a limitation. Kluivers et al¹ also reported in a study of 265 females that ultrasound prolapse quantification is not superior to POPQ/Baden–Walker assessment when considered as a test for symptomatic prolapse. We did not compare the stages of prolapse using different assessment techniques as we have previously published on the accuracy of assessing POPQ points using dynamic 2D-TPUS in females with POP.¹⁹

In our study, we have shown that in keeping with other studies,^{21–25} morphological abnormalities that may not be apparent on vaginal

examination, can be detected using ultrasound. However, the clinical relevance of these additional diagnoses using PFUS in females without related symptoms has not been previously established. Enterocoele is described as a herniation of fluid containing peritoneum, small bowel, sigmoid or omentum into the *cul-de-sac* separating the vagina from the rectal ampulla. On clinical examination, an enterocoele is diagnosed if it can be visualized or if there is palpable descent of bowel anterior to the anorectum at maximum Valsalva. In our study, on clinical examination and POPQ, an enterocoele was not identified in any of the females. This is probably owing to the fact that the enterocoeloses were small and therefore not clinically apparent. On dynamic 2D-TPUS, an enterocoele can be visualized in the sagittal plane as a downward movement of iso- or hyperechoic abdominal contents as a herniation anterior to the anorectal junction. Small bowel peristalsis may help with the identification of structures filling the hernia, and occasionally, intraperitoneal fluid will outline the *cul-de-sac*.²¹ The sonographical definition of a clinically significant cystocoele and rectocoele has been described;^{6,15} however, there is no comparable cut-off value for a clinically significant enterocoele on ultrasound. In our study, none of the females had an isolated enterocoele. In order to define ultrasound cut-off for diagnosing enterocoele, we need a larger group of symptomatic females with isolated enterocoeloses.

Table 2. Additional diagnoses on PFUS (two-dimensional transperineal ultrasound + three-dimensional endovaginal ultrasound) at baseline and at 1-year follow-up with interventions during study period

Additional diagnoses	At baseline, ^a <i>n</i> = 54	At baseline, ^b <i>n</i> = 89	Intervention, <i>n</i> = 1	At 1 year, ^a <i>n</i> = 44	At 1 year, ^b <i>n</i> = 81
Enterocoele					
<i>n</i>	2	9	–	12	16
Median (range) (mm)	10 (7 to 13)	10 (–9 to 16)		–10 (–20 to 6)	9 (–16 to 16)
Intussusception					
<i>n</i>	1	3	1 stapled transanal rectal resection	2	7
Bladder calcification					
<i>n</i>	1	3	–	1	2
Vaginal cyst					
<i>n</i>	4	2	–	2	2
Enterocoele + intussusception					
<i>n</i>	0	1	–	0	2

^aControls.

^bProlapse group.

We found more enterocoels and intussusceptions at 1 year compared with baseline and were seen more in females who underwent surgical correction of POP. It is possible that these additional diagnoses became more prominent on PFUS following surgical correction of the prominent POP. However, none of these females developed symptoms of prolapse. As these diagnoses were also identified in asymptomatic controls, it would suggest that these findings are not always pathological.

We observed that enterocoels and intussusceptions were better visualized on high-frequency dynamic EVUS during Valsalva because difficulty may be encountered in delineation of an enterocoele in the presence of a concomitant prolapse. Using linear array of the biplane transducer for EVUS, the 180° rotation of the probe enhances imaging of the posterior compartment, thereby outlining enterocoels and intussusceptions with clarity. Moreover, we found that this technique enabled clear visualization of the relationship between enterocoele and intussusception to the anorectum.

Similar to our study, others have identified cysts and masses incidentally during vaginal ultrasound in asymptomatic females.^{22,23} Although this finding may not be clinically relevant, the detection of these cysts has not been previously described using PFUS. Therefore, researchers using PFUS need to be aware of this and have an agreed strategy for management.

Urethral diverticula diagnosed in our study on PFUS were also clinically detectable. Although most of them are clinically suspected, the common imaging techniques used to confirm the urethral diverticulum are voiding cystourethrography,²⁴ positive pressure urethrography²⁴ and MRI.^{25,26} The gold standard in diagnosis of urethral diverticula has been MRI,^{24–26} despite the cost, limited availability and being a time-consuming investigation. PFUS has advantages of avoiding radiation and has

no special requirements or contraindications when compared with other imaging modalities. PFUS, especially high-frequency 3D-EVUS, can complement the clinical diagnosis of a urethral diverticulum, delineate its circumferential extent and establish its proximity to the bladder neck (Figure 5), which can be useful in planning surgery. We feel that PFUS has the potential to replace MRI in the diagnosis and surgical management of urethral diverticula.

Strengths

We are not aware of another prospective study comparing clinical examination to PFUS to identify additional diagnoses. In our study, in order to minimize bias, the clinician performing TPUS was blinded to the POPQ findings. In addition, POPQ points Ba, Bp and C, as well as TPUS measurements, were measured at maximum Valsalva to demonstrate maximum prolapse descent.

Limitations

Our numbers were relatively small and most of our study population had prolapse of more than one compartment, which may influence the assessment. A focused analysis of isolated single compartment prolapse will require much larger numbers but is likely to improve our understanding further and allow for assessment of levator ani morphology.^{27–29} The reference line we used to measure enterocoele may not be representative. MRI studies have used the pubococcygeal line³⁰ as a reference line. This, however, cannot be used with TPUS to measure enterocoele as the sacrum cannot be visualized using this technique.

CONCLUSIONS

Multicompartment PFUS identifies additional conditions to that diagnosed on clinical assessment. However, at 1-year follow-up, it does not appear that additional pre-operative information obtained by PF ultrasound would have been clinically useful in the management. Longer term follow-up is now underway.

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