CONSENSUS STATEMENT

Consensus Definitions and Interpretation Templates for Dynamic Ultrasound Imaging of Defecatory Pelvic Floor Disorders

Proceedings of the Consensus Meeting of the Pelvic Floor Disorders Consortium of the American Society of Colon and Rectal Surgeons, the Society of Abdominal Radiology, the International Continence Society, the American Urogynecologic Society, the International Urogynecological Association, and the Society of Gynecologic Surgeons

Jonia Alshiek, M.D., M.Sc.[1,2] • Sthela M. Murad-Regadas, Ph.D.[3]
Anders Mellgren, M.D.[4] • Phyllis Glanc, M.D.[5] • Gaurav Khatri, M.D.[6]
Lieschen H. Quiroz, M.D.[7] • Milena M. Weinstein, M.D.[8]
Ghazaleh Rostaminia, M.D., M.Sc.[9] • Lucia Oliveira, M.D.[10]
Hina Arif-Tiwari, M.D.[11] • Linda Ferrari, M.D.[12]
Liliana G. Bordeianou, M.D., M.P.H.[13] • S. Abbas Shobeiri, M.D., M.B.A.[1]

On Behalf of the Members of the Expert Panel on Dynamic Ultrasound Imaging of Defecatory Disorders of the Pelvic Floor
1 Department of Obstetrics and Gynecology, Inova Health System, Fairfax, Virginia
2 Urogynecology Unit, Hillel Yaffe Medical Center, Technion Medical School, Hadera, Israel
3 Department of Surgery, School of Medicine of the Federal University of Ceará, Fortaleza, Brazil
4 Department of Surgery, University of Illinois, Chicago, Illinois
5 Department of Medical Imaging, Sunnybrook Health Sciences Center, University of Toronto, Toronto, Ontario, Canada
6 Department of Radiology, University of Texas Southwestern Medical Center, Dallas, Texas
7 Department of Obstetrics and Gynecology, The University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma
8 Department of Obstetrics and Gynecology, Massachusetts General Hospital, Pelvic Floor Disorders Center, Harvard Medical School, Boston, Massachusetts
9 Department of Obstetrics and Gynecology, Northshore Hospital, Chicago, Illinois
10 Department of Colorectal Surgery, Hospital Casa de Saúde São José, Rio de Janeiro, Brazil
11 Department of Medical Imaging, College of Medicine, University of Arizona, Tucson, Arizona
12 Pelvic Floor Unit, St. Thomas' Hospital, London, United Kingdom
13 Department of Surgery, Massachusetts General Hospital, Pelvic Floor Disorders Center, Harvard Medical School, Boston, Massachusetts

Funding/Support: None reported.

Financial Disclosure: None reported.

This article is being published concurrently in *Diseases of the Colon & Rectum*, *International Urogynecology Journal*, and *Urogynecology*. The articles are identical except for minor stylistic and spelling differences in keeping with each journal's style. Citation from any of the 3 journals can be used when citing this article. This consensus has been reviewed by the supporting societies.

Jonia Alshiek, Sthela M. Murad-Regadas, and Anders Mellgren contributed equally as first coauthors. Liliana G. Bordeianou and S. Abbas Shobeiri contributed equally as senior coauthors.

Dis Colon Rectum 2023; 66: 200–216
DOI: 10.1097/DCR.0000000000002651

Correspondence: Liliana Bordeianou, M.D., M.P.H., Massachusetts General Hospital Surgery, 55 Fruit St, GRB 425, Boston, MA 02114. E-mail: lbordeianous@mgh.harvard.edu

See "editorial" on page 169.

The Pelvic Floor Disorders Consortium (PFDC) is a multidisciplinary organization of colorectal surgeons, urogynecologists, urologists, gynecologists, gastroenterologists, radiologists, physiotherapists, and other advanced care practitioners. Specialists from these fields are all dedicated to diagnosing and managing patients with pelvic floor conditions but approach evaluation and treatment of such patients with their unique perspectives given differences in their training. The PFDC was formed to enable collaboration between these specialties in developing and evaluating educational programs, creating clinical guidelines and algorithms, and promoting high-quality care for this unique patient population. The recommendations included in this document represent the work of the PFDC Working Group on Ultrasound in Imaging of Defecatory Disorders of the Pelvic Floor (members listed alphabetically in Table 1). The objective was to generate inclusive, rather than prescriptive, guidance for all practitioners interested in considering pelvic floor ultrasound imaging in their assessment of defecatory pelvic floor disorders.

STATEMENT OF THE PROBLEM

Dynamic pelvic floor ultrasound (PFUS) has been shown to be an effective and relatively inexpensive method for evaluating pelvic organs, including the urethra, bladder, vagina, cervix and uterus, anal canal, rectum, and other pelvic floor structures, such as the levator ani muscles. PFUS can be performed using transperineal/introital, endovaginal, or endoanal/endorectal approaches. There is considerable evidence for the use of PFUS imaging to quantify pelvic floor disorders. Still, there is significant variation across disciplines regarding the degree of utilization of PFUS for such indications and the preferred choice of specific PFUS technique.[1–4] Also, there is variability in the definitions of pathology described on PFUS between specialists, which results in more significant variability in how different physicians and specialties interpret and use findings seen on PFUS. These factors create challenges for health care providers in their efforts to counsel patients and effectively communicate and cooperate between specialities. Patients with pelvic floor disorders often have recurrent or multifactorial symptomatology, which may require care from multiple disciplines. Furthermore, many health care providers may be concurrently managing different aspects of pelvic floor dysfunction in the same patient in parallel. Lack of coordination and communication in imaging terminology can create misunderstandings and confusion for health care providers and patients.

The American Institute of Ultrasound in Medicine and the International Urogynecologic Association generated a practice parameter guideline that made one of the first attempts at standardization of the language in the field of pelvic floor ultrasonography.[5] However, the document had limited reference to defecatory pelvic floor disorders. Thus, this effort was undertaken with the explicit goal of inviting and including representatives from all relevant clinical specialties for whom PFUS holds clinical significance. This document aims to create a universal set of recommendations for a minimum common language for PFUS interpretation and reporting of defecatory pelvic floor disorders, with relevance across disciplines and all PFUS modalities.

METHODOLOGY

This document was developed by the Pelvic Floor Disorders Consortium (PFDC) Working Group on Ultrasound Imaging of Defecatory Disorders and created under the guidance of the American Society of Colon and Rectal Surgeons (ASCRS). The PFDC comprises clinicians with demonstrated expertise in the care and treatment of patients with pelvic floor conditions. The Working Group was created by enlisting PFDC volunteers. Invitation criteria included leadership in pelvic floor disorders with academic scholarship and a history of crossdisciplinary collaboration. Members of the working group participated in at least 2 group preliminary phone calls and researched an assigned topic. Each topic had at least 2 members assigned, always from different specialties. Each pair identified the literature on a relevant topic and performed a systematic review of the literature using a specified format.

These systematic reviews involved an organized search of MEDLINE, PubMed, Embase, and the Cochrane Database of Collected Reviews performed up to April 1, 2019. Retrieved publications were limited to the English language, but no limits on the year of publication were applied. The search terms included "fecal incontinence," "urinary incontinence," "constipation," "lower urinary tract symptoms in men and women," and "pelvic floor disorders in men and women." The search strategies used "dynamic ultrasound," "pelvic organ prolapse," "obstructed defecation," "anal incontinence," "pelvic pain," "dyspareunia," "obstetric injury," "OASIS" (obstetric anal sphincter injuries), "anal sphincter injury," "pelvic floor ultrasound," "translabial ultrasound," "transperineal ultrasound," "endoanal ultrasound," "endorectal ultrasound," "transvaginal ultrasound," "echodefecography," "enterocele," "internal intussusception," "rectocele," "sigmoidocele," "perineal descent," "levator ani tears," "levator ani avulsion," "levator injury," "pelvic floor dysfunction," and "rectal prolapse" as primary search terms. Directed searches of the embedded references from the primary articles were also sometimes performed. Criteria for inclusion of references included articles that described original descriptions of relevant ultrasound measurements or clinically relevant literature describing the use of ultrasound imaging in

TABLE 1. Members of the workgroup on the use of dynamic ultrasound in the evaluation of defecatory pelvic floor disorders

Name and degree	*Affiliation*	*City, state, country*
Amy Halverson, M.D.	Department of Surgery, Northwestern Memorial Hospital and Feinberg School of Medicine	Chicago, IL, USA
Jonia Alshiek, M.D.[1]	Urogynecology Unit, Hillel Yaffe Medical Center, Technion Medical School	Technion Medical School, Hadera, Israel
Hina Arif-Tiwari, M.D.	Department of Medical Imaging, College of Medicine, University of Arizona.	Phoenix, AZ, USA
Liliana Bordeianou, M.D.	Section of Colorectal Surgery, Massachusetts General Hospital Pelvic Floor Disorders Center, Harvard Medical School	Boston, MA, USA
Shuqing Ding, Ph.D.	Department of Surgery, Northwestern Health Sciences University	Bloomington, MN, USA
Andrea Ferrara, M.D.	Department Colorectal Surgery, Colon & Rectal Surgery Clinic of Orlando	Orlando, FL, USA
Linda Ferrari, M.D.	Pelvic floor unit. St. Thomas' Hospital	London, UK
Giuseppe Gagliardi, M.D.	Department of Colorectal Surgery, University of Illinois	Chicago, IL, USA
Phyllis Glanc, M.D.	Department of Medical Imaging, Sunnybrook Health Sciences Center	Toronto, ON, Canada
Gaurav Khatri, M.D.	Department of Radiology, University of Texas Southwestern Medical Center	Dallas, TX, USA
S. Abbas Shobeiri, M.D.	Department of Obstetrics and Gynecology, Inova Health System	Fairfax, VA, USA
Lieschen H. Quiroz	Department of Obstetrics and Gynecology, The University of Oklahoma Health Sciences Center	Oklahoma City, OK, USA
Ari Steiner, M.D.	Department of Radiology, South Nassau Community Hospital	Oceanside, NY, USA
David Sheyn, M.D.	Department of OBGYN, University Hospitals	Cleveland, OH, USA
Joanne Favuzza, M.D.	Department of Surgery, Boston Medical Center	Boston, MA, USA
Sergio Larach, M.D.	Department of Surgery, Digestive and Liver Center of Florida	Orlando, FL, USA
Anders Mellgren, M.D.	Department of Surgery, University of Illinois	Chicago, IL, USA
Yara Lima de Mendonca, M.D.	Colorectal Surgery, Hospital Municipal Ronaldo Gazolla and University of Exeter	Rio de Janeiro, Brazil, and Exeter, UK
Miles Murphy, M.D.	Division of Urogynecology, Department of OB–GYN, Abington—Jefferson Health	Abington, PA, USA
Sthela Murad-Regadas, M.D.	Department of Surgery, School of Medicine of the Federal University of Ceará	Fortaleza, Brazil
Lucia Oliveira, M.D.	Department of Anorectal Physiology, Policinica General do Rio de Janeiro	Rio de Janeiro, Brazil
Ghazaleh Rostaminia, M.D.	Department of Obstetrics and Gynecology, Northshore Hospital	Chicago, IL, USA
Milena Weinstein, M.D.	Department of Obstetrics and Gynecology, Massachusetts General Hospital	Boston, MA, USA
Steven Wexner, M.D.	Department of Surgery, Cleveland Clinic Florida	Weston, FL, USA

clinical practice. The workgroup presented its preliminary research to the consortium at large for further discussion.

Pelvic Floor Consortium Expert Meeting

The Pelvic Floor Consortium Expert Meeting convened on June 2, 2019, in Cleveland, Ohio. It included 126 in-person (or online) participants from the United States, Europe, Asia, England, and Canada. These experts belonged to several subspecialties (colorectal surgery, gastroenterology, urogynecology, urology, physiotherapy, and radiology). They included members of numerous professional societies involved in the diagnosis and treatment of pelvic floor disorders. The event was also audited by formal representatives from the ASCRS, the Society of Abdominal Radiology (SAR), the American Urogynecologic Society, the International Urogynecological Association (IUGA), and the Society of Gynecologic Surgeons. The meeting was funded by the ASCRS.

The participants at the expert consortium meeting analyzed the proposed sonographic techniques and definitions for each of the conditions reviewed in this statement, ultimately offering consensus recommendations for the technique and interpretation of PFUS as well as a standardized and clinically relevant synoptic reporting template. The group labeled this final template as the "Ultrasound Interpretation Template for the Initial Measurement of Patient-Reported Defecatory Pelvic Floor Complaints," or "Ultrasound-IMPACT" (see Supplement 1 at http://links.lww.com/DCR/C46).

For a recommendation to make it into the Ultrasound-IMPACT template, expert consensus was required. Expert consensus was defined as >70% agreement among the voting participants. A subsequent committee meeting was then held to summarize these statements while keeping the expert consensus panel discussion directives in mind.

In summary, this work is not meant to be an exhaustive description or pictorial essay of all disease processes found on PFUS imaging. Rather, this article sought to identify areas of consensus across disciplines so that a common language can be used to achieve the shared goal of caring for patients with defecatory pelvic floor disorders. Areas where consensus was not achieved remain potential topics for research to help further standardize best practices in the future and across all relevant disciplines.

Final Review

Once the document was finalized, the proposed recommendations were presented for review by the ASCRS Pelvic Floor Disorders Steering Committee. This Steering Committee is directed to develop clinical practice recommendations on colorectal pelvic floor disorders based on the best available evidence. The ASCRS Steering Committee edited the document and sent it to the ASCRS Executive Committee for final approval for publication. Similar reviews and endorsements were also given by the American Urogynecologic Society Publications Committee and Board of Directors, the SAR Board of Directors and SAR Disease Focused Panel on Pelvic Floor Dysfunction, the ICS Board of Directors, and the Executive Board of the Society of Gynecologic Surgeons. In addition, the document was reviewed by the IUGA Board of Directors. In accordance with the IUGA policy, the IUGA Board of Directors distributed the document for review by its entire membership and subsequently endorsed the document. Before submission of the document for publication, a rereview of the relevant literature was performed to include articles published between April 1, 2019, and March 1, 2021, and to assure that key new works pertaining to topics of defecatory pelvic floor disorders were also considered.

RECOMMENDATIONS

Overview of Techniques

1. Many forms of dynamic ultrasound imaging exist, each with its advantages. Choice of the technique used may depend on the specific indication and the available expertise of the sonographer and interpreting physician (degree of consensus: 100%).

Dynamic PFUS has 3 commonly used modalities: endoanal/endorectal (aPFUS), transperineal/introital (pPFUS), and endovaginal (vPFUS). Regardless of modality, these studies can be performed in a radiology department or an office setting, depending on the available level of sonographic expertise and appropriate equipment. Advantages of ultrasound evaluation include good patient tolerance, lack of radiation exposure, and the ability to decide on a case-by-case basis to perform ultrasound imaging as appropriate. It is essential to ensure that the imaging clinician, whether in-office or in the radiology department, has undergone specific training to provide quality imaging and interpretation of the examination.[6]

An appropriate transducer can be placed gently on the perineum or between the labia and the anus during ultrasound imaging. For the average patient, the examination is not painful. Following the acquisition of static images, a dynamic ultrasound video (cine loop) can be performed by instructing the patient to perform a strain/Valsalva maneuver and, in some cases, to attempt to empty ultrasound gel from the rectum to simulate defecation. Recommended ultrasound imaging protocols typically involve both dynamic 2-dimensional (2D) and 3-dimensional (3D) volume acquisitions using aPFUS (Fig. 1A), pPFUS (Figs. 1B and C), or vPFUS (Fig. 1D) techniques. Each modality conveys complementary information and may be used on the basis of the specific clinical indication. Physicians using ultrasound imaging may have various transducers and varying degrees of skill sets for different ultrasound assessment portions.

For further discussion, the terminology we use when referencing these techniques is described in the following paragraphs.

Dynamic aPFUS

Traditionally, aPFUS is performed using an ultrasound scanner with a 7- to 10-MHz rotating transducer (focal range, 3–45 mm), providing a 360° axial view of the anal canal (Fig. 1A). The patient is usually scanned in either the left lateral or the dorsal lithotomy position depending on local preferences. Images are acquired at rest, during

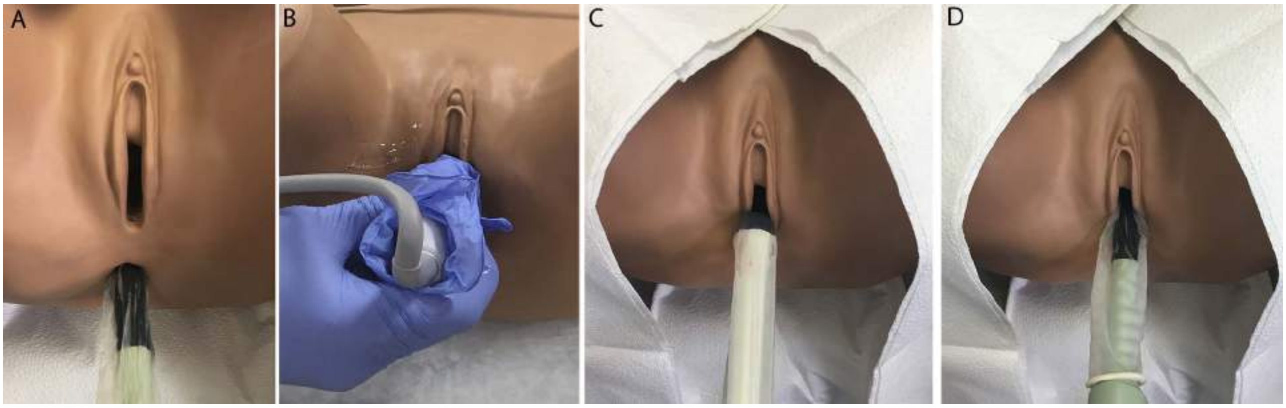

FIGURE 1. Examples of PFUS modalities. A, Endoanal/endorectal PFUS. The transducer is inserted in the anal canal to a depth of 5–6 cm. B, pPFUS using a 2D/3D curvilinear transducer. The probe tip is gently placed between the labia. C, pPFUS using an end-fire endocavitary probe. The transducer tip is gently placed between the labia and perineum. pPFUS also is commonly performed using a curved 3D probe placed along the labia. D, Endovaginal PFUS using a 2D/3D automatic transducer inserted 5–6 cm in the vagina to the level of the bladder-urethra junction. 2D = 2-dimensional; 3D = 3-dimensional; PFUS = pelvic floor ultrasound; pPFUS = transperineal/introital PFUS.

contraction of the pelvic floor muscles, and during a strain/Valsalva maneuver. For 2D imaging, the transducer is placed into the anal canal, and circumferential images of the top, middle, and distal anal canal are acquired. Characterization of the perineal body and the distance from the anal canal to the vagina is measured. For 3D volumetric imaging, the tip of the transducer is placed in the cephalad part of the anal canal. The transducer automatically acquires 3D volumetric data through the full length of the anal canal, which can be rendered into axial, sagittal, coronal, or additional oblique planes if needed for image analysis.

After the transducer is inserted up to 6 cm above the anal verge, various additional maneuvers may be performed to evaluate the levator plate, the anal sphincter complex, and the surrounding structures. This dynamic variant of aPFUS (also sometimes called "echodefecography") involves insertion of ultrasound gel into the rectum after rectal cleansing with an enema. This is then followed by an evacuation maneuver, which further enhances the dynamic evaluation of the pelvic floor in defecatory dysfunction conditions.[7]

Dynamic pPFUS

Traditionally, operators have performed transperineal ultrasound with a 2- to 6-MHz curved array transducer (Fig. 1B) or 6- to 9-MHz end-fire transducer (Fig. 1C) with 3D/4-dimensional capabilities to image the pelvic floor. Images are acquired at rest and during contraction and strain/Valsalva maneuvers. Sometimes a patient is asked to defecate ultrasound gel during the examination. Images are obtained by placing a covered transducer between the labia minora and the perineum, typically beginning in a midsagittal position.[8] The imaging starts with assessing the pelvic floor hiatus in a 2D midsagittal plane of the pelvic floor structures, including, from anterior to posterior, the following structures: pubic symphysis, urethra, bladder, vagina, anorectum, and levator plate. The levator plate is defined as the echogenic tissue in the midline posterior to the anorectal junction. Visualization is easier if the bladder contains a small volume of urine, and the rectum may remain empty or can be gently filled with a small amount of gel.[9,10] Synthetic graft components are visualized with various ultrasound techniques, and ultrasound imaging is considered one of the primary modalities for this purpose, in particular for those with a suburethral component such as midurethral slings.

Following static images, cineloops are acquired at rest in the sagittal plane from right to left to include the obturator muscles. The key dynamic maneuver is acquired in the sagittal midline plane while the patient performs a sustained maximum pelvic floor strain/Valsalva maneuver. Many practitioners will add a pelvic floor contraction dynamic sequence to aid in determining which patients may benefit from pelvic floor physiotherapy. The dynamic strain/Valsalva technique is useful to visualize rectouterine pouch hernias, internal rectal intussusception, or

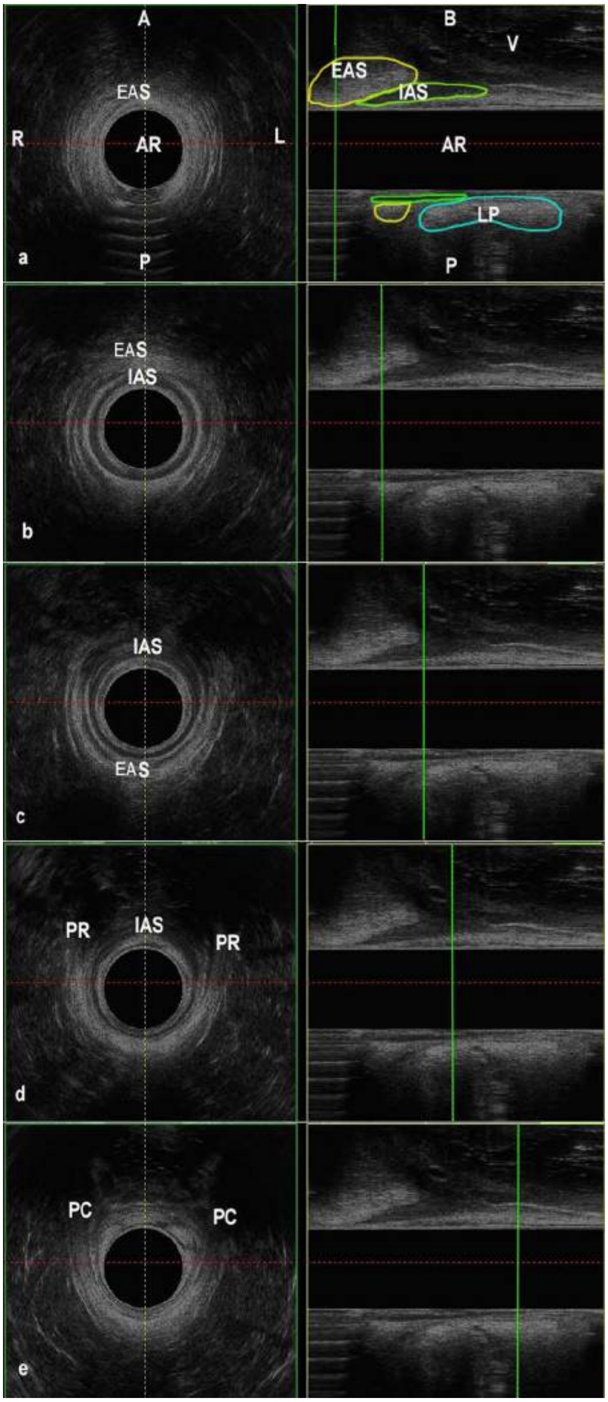

FIGURE 2. Examples of anal sphincter anatomy in side-by-side images of the anal canal as obtained during aPFUS. The "A" column shows the axial view obtained with the aPFUS transducer. The "B" column shows the patient's right midsagittal view at the same level. The level of images in column A is denoted by the green line in column B. The midsagittal structures are outlined in panel B. A, Inferior or low anal canal with superficial EAS. B, Midanal canal with the main part of EAS and IAS. C, Upper midanal canal with the U-shaped configuration of EAS where the EAS is incomplete anteriorly. D, Upper anal canal with PR and IAS. E, Upper anal canal with PC fibers. aPFUS = endoanal/endorectal pelvic floor ultrasound; AR = anorectum; EAS = external anal sphincter; IAS = internal anal sphincter; L = left; LP = levator plate; P = posterior; PC = pubococcygeus; PR = puborectalis; R = right; V = vagina.

rectoceles. 3D volume acquisitions enable multiplanar reformats in the coronal, axial, and sagittal planes, plus the rendered 3D view. The rendered 3D view and the axial multiplanar reformats are beneficial in determining the integrity of the levator ani muscles at their insertions and identifying levator ani avulsion. As the imaging quality of 3D systems improves, studies are progressively demonstrating a good correlation between aPFUS and pPFUS of the anal sphincter complex, particularly for OASIS, with sensitivity improving with expertise.[11,12] The technique has become one of the more common pelvic floor imaging modalities because of its availability.[13]

Dynamic vPFUS

A vPFUS is performed using a side-fire transducer that obtains either axial or radial images of the pelvic floor. If performed with the same transducer used for aPFUS (Fig. 1D), vPFUS should be performed before aPFUS to avoid the introduction of rectal contents into the vagina after aPFUS. In addition to static images, dynamic evaluation of the pelvic floor can be achieved by instructing the patient to contract the pelvic floor muscles and then perform strain/Valsalva maneuvers while capturing cineloops of the bladder, rectum, anorectal angle flattening, and levator plate movement. Although the vPFUS transducer supports the vaginal apex and may reduce posterior vaginal prolapse (rectocele), rectal movement and persistent rectal intussusception may still be visualized. Rectouterine pouch hernias are visualized infrequently with vPFUS; these may be best pictured with pPFUS because of the nonobstructive nature of that approach. Once the dynamic images are obtained, the 3D volume may also be obtained to assess the integrity of levator ani musculature (LAM). vPFUS modality may also be used for discrimination between subdivisions of the LAM that may be injured (puborectalis, puboanalis, pubococcygeus/iliococcygeus), particularly in women after delivery.[14]

IMAGING OF SPHINCTER ANATOMY

1. Although all forms of ultrasound imaging mentioned in this document may visualize anal sphincter anatomy, the criterion standard in ultrasound imaging of anal sphincter integrity is the aPFUS technique (degree of consensus: 94%).

Fecal incontinence is a common condition with a profound and disabling impact on the quality of life. Understanding the anal sphincter anatomy may be helpful when choosing treatment for this condition. Ultrasound imaging is a relatively inexpensive examination that offers additional information regarding sphincter integrity and augments regular physical examination.[15–18]

All forms of ultrasound imaging described above can visualize a typical anal sphincter complex, but aPFUS is considered the validated reference standard in evaluating anal sphincter anatomy (Fig. 2) and identifying defects. Performing pPFUS and vPFUS with conventional ultrasound transducers can also be useful in identifying sphincter normality for clinical purposes, but they are less detailed and have lower sensitivity.[19] During the past decade, there has been a flurry of publications demonstrating the utility of pPFUS for the assessment of the anal complex.[11] If there is any doubt about the integrity of the anal sphincter or pathology by pPFUS or vPFUS, the findings need to be further investigated with aPFUS. Using aPFUS, a clinician can identify the anal canal's distinct

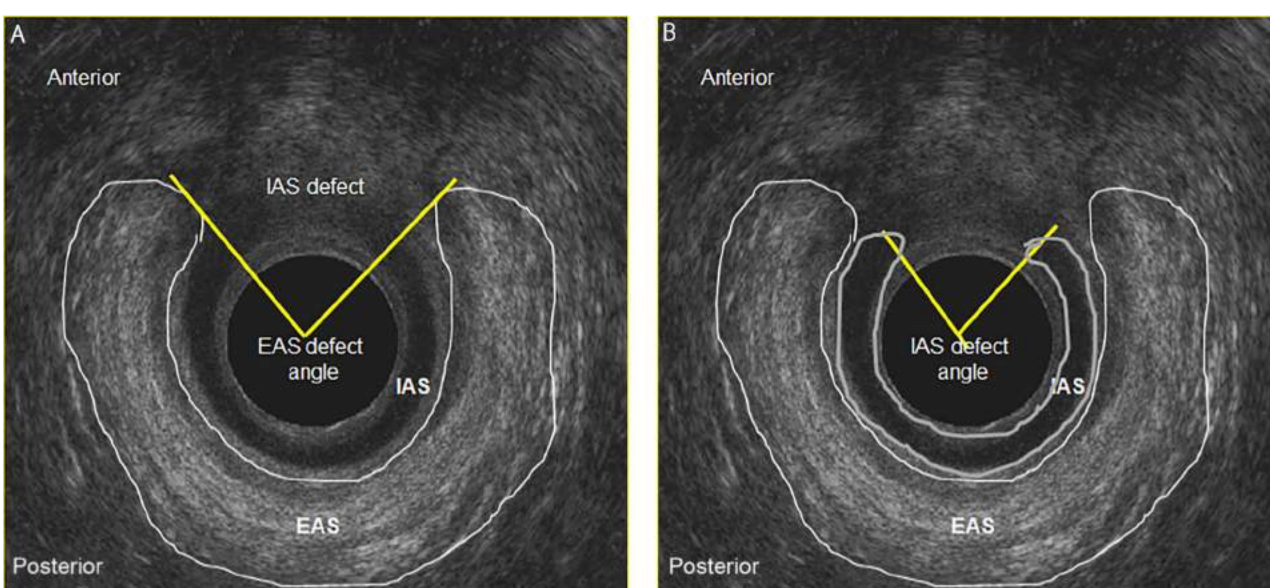

FIGURE 3. Demonstration of midanal canal anal sphincter defects as visualized on aPFUS, axial view. A, Angle of the EAS defect. B, Angle of the IAS defect. aPFUS = endoanal/endorectal pelvic floor ultrasound; EAS = external anal sphincter; IAS = internal anal sphincter.

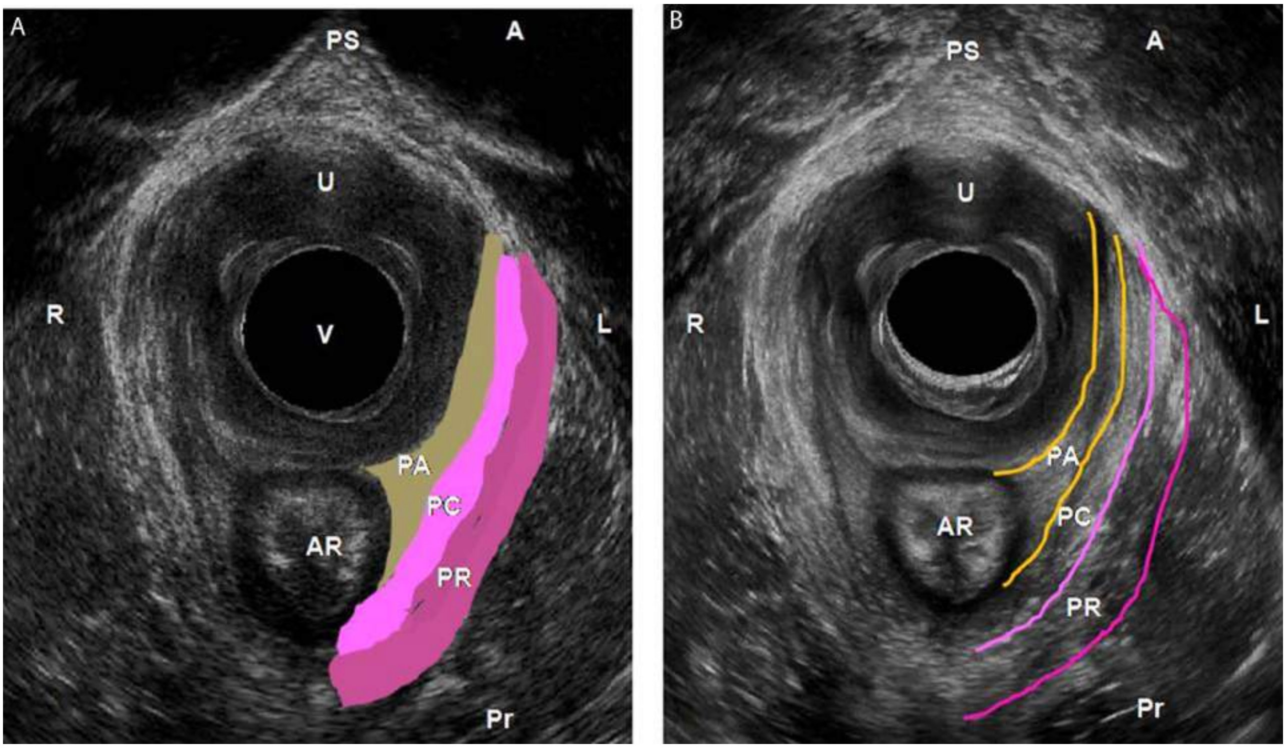

FIGURE 4. Levator ani anatomy demonstrated via vPFUS, axial view. A, The levator hiatus in the plane of minimal hiatal dimension. The levator ani muscle subdivisions are colored on the patient's left for easy recognition. B, Same image in render mode may help appreciate scarring, although none is present in this image. A = anterior; AR = anorectum; L = left; PA = puboanalis; PC = pubococcygeus; PR = puborectalis; Pr = posterior; PS = pubic symphysis; R = right; U = urethra; V = vagina; vPFUS = endovaginal pelvic floor ultrasound.

muscular layers: the innermost anal mucosa, the internal sphincter (upper and middle anal canal), the longitudinal muscles, the intersphincteric space (upper and middle anal canal), and the outer striated sling-like levator plate muscles (puborectalis and pubococcygeus in the upper anal canal) or the striated external sphincter (middle and lower anal canal).[20–23] Its findings have been correlated with symptoms of both fecal incontinence and anorectal physiology findings.[18,24] As with all PFUS techniques, aPFUS is associated with a learning curve, and specialized instruction/teaching are recommended for optimal technique and interpretation of the examination.[6,25] In the absence of aPFUS capability, both pPFUS and vPFUS have good test accuracy and can be used as a screening tool to identify sphincter complex abnormalities with subsequent referral to specialists as necessary.[26–28] With rising expertise and technological improvements in pPFUS and vPFUS, some literature suggests possible equivalency of these modalities to aPFUS.[29] An MRI for detailed anatomic evaluation may be of value in the absence of access to aPFUS.

2. When an anal sphincter injury is suspected, complete characterization of the injury requires both a description of the degree of injury to the internal and external anal sphincter (EAS) and information about the size of the perineal body and the length of the mentioned injury in relationship to the length of the entire anal sphincter (degree of consensus: 90%).

Obstetric anal sphincter injury is a common cause of fecal incontinence.[30,31] Severe obstetric lesions occur after 1% to 5% of natural births, and endoanal ultrasonography can show hidden defects in at least a third of women after their first birth.[32–34] However, some of these findings may not have clinical significance: in a study of 908 patients, a false positive OASIS rate of 7% was demonstrated.[31] Other mechanisms of anal sphincter injury, such as anorectal procedures and anorectal pathology, can also result in anal incontinence. In a study of 123 anorectal surgery patients, subsequent lesions of the EAS and internal anal sphincter (IAS) were identified in 21% of cases.[34]

PFUS is helpful for the identification and quantification of OASIS injuries and for recognition of IAS defects.[35] These injuries have a pathognomonic appearance on aPFUS (Fig. 3). IAS tears usually appear as relatively hyperechoic defects in the hypoechoic muscle, and EAS tears appear as relatively hypoechoic defects in the hyperechoic circular wall of the anal musculature. In general, EAS defects are found more frequently in the midanal canal in the anterior quadrant in females.[36] For the visualization of sphincter injuries, 3D aPFUS has higher intraobserver reliability than 2D aPFUS (98% for 3D versus 88% for 2D).[37]

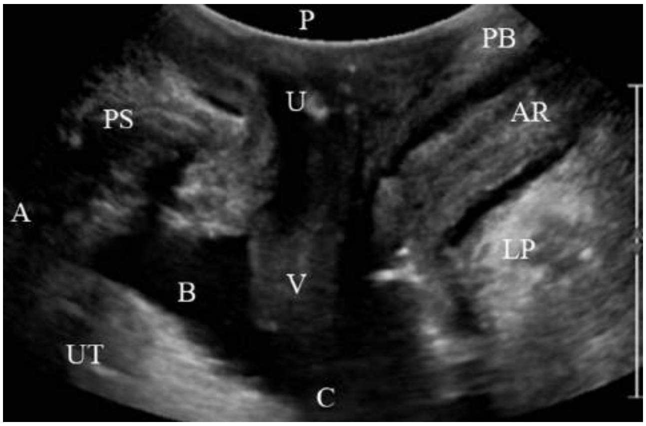

FIGURE 5. A 2D midsagittal view of the plane of minimum dimension on pPFUS with the transducer probe aimed cephalad: 2D midsagittal image at rest to demonstrate the plane of minimum dimension, which extends from the inferior aspect of PS to the LP posterior to the AR junction. This line corresponds to the pubococcygeal line used in MRI. During dynamic maneuvers such as a sustained strain/Valsalva maneuver, evaluation of presence, type, and degree of descent of pelvic organs below this line is recorded to evaluate pelvic organ prolapse. 2D = 2-dimensional; A = Anterior; AR = anorectum; B = bladder; C = cephalad; LP = levator plate; P = probe; PB = perineal body; pPFUS = perineal/introital pelvic floor ultrasound; PS = pubic symphysis; U = urethra; UT = uterus; V = vagina.

Important caveats in imaging include the following: 1) identification of the puborectalis muscles immediately cephalad to the anal sphincter; 2) differentiation of an anterior external sphincter injury versus a short anal sphincter in a female in the middle anal canal; 3) recognition that the distal anal canal only contains external sphincter; and 4) and a thinned out perineal body may be a sign of middle anal sphincter injury. The operator should carefully measure the degree of separation between the IAS and EAS and the specific level at which this separation is present. Further comments should be made as to whether this is a combined lesion of the IAS and EAS (see Video 1 at http://links.lww.com/DCR/C117). The number of defects and the extent of the defect circumferentially (radial angle in degrees or hours of the clock) and longitudinally (proximal, distal, or full length) should also be reported. In addition, 3D PFUS allows measurement of length, thickness, and angle of sphincter defect in multiple imaging planes. Other forms of PFUS can also provide this information when performed by appropriately trained sonographers and interpreting physicians.

3. Complete imaging of sphincter anatomy should also include a description of the levator ani muscle anatomy with a detailed measurement of the size of the levator hiatus (degree of consensus: 83%) and a description of the presence/absence of concomitant levator ani muscle injury (degree of consensus: 94%).

Various types of injury to the LAM are common after vaginal birth and may be associated with pelvic organ prolapse.[38,39] The LAM includes the puborectalis, pubococcygeus, iliococcygeus, puboperinealis, and puboanalis muscles[40] (Fig. 4). The pubococcygeus/iliococcygeus, puboperinealis, and puboanalis muscles are clearly seen by vPFUS.[1] Data from women who have fecal incontinence of unknown cause suggest that women with obstructive defecatory symptoms have a wider rectum and more descent of the levator plate, regardless of the stage of prolapse or the severity of rectocele.[41,42] Many women with visible anal sphincter tears may have coexisting LAM disruption or

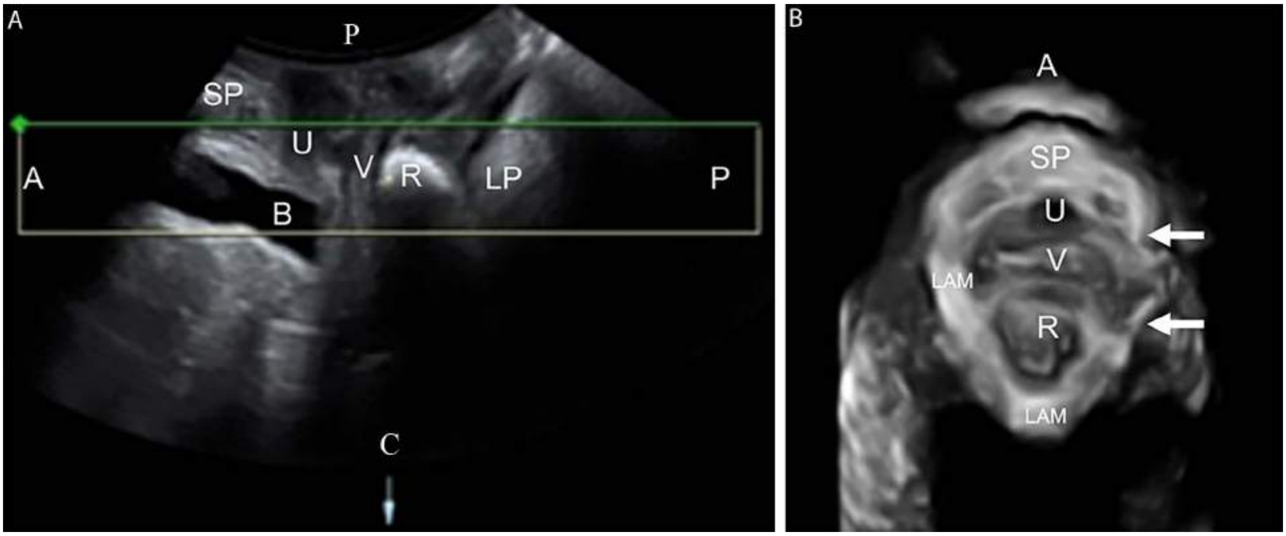

FIGURE 6. Levator ani avulsion demonstrated via pPFUS using a 3D perineal probe placed on the perineum between the labia. pPFUS images with the transducer aimed posteriorly and on the top of the image. A, Midline sagittal plane with the render box oriented in the caudal-cranial direction (green line) to include the plane of minimum dimension. B, 3D-rendered view; arrows point to a left-sided defect in the LAM complex represented as a break in the echogenic muscular sling surrounding the urogenital hiatus. 3D = 3-dimensional; A = anterior; B = bladder; LAM = levator ani muscle; LP = levator plate; P = posterior; pPFUS = perineal/introital pelvic floor ultrasound; R = rectum; SP = symphysis pubis; U = urethra; V = vagina.

dysfunction, and these women may have worsened outcomes following traditional surgical procedures such as overlapping sphincteroplasty repairs, presumably because levator dysfunction can be associated with pudendal nerve injury during LAM overdistention[43,44] or avulsion.[26,45] Thus, a careful concurrent characterization of LAM to further stratify OASIS patients may be clinically helpful.[31,46]

The LAM complex compresses and closes the pelvic outlet and provides support for the pelvic organs.[42] A laxity or defect in the LAM is associated with the widening of the plane of minimum dimension or enlargement of the circumference of the urogenital hiatus.[43,47] The minimum distance between the pubic symphysis and the posterior aspect of the anorectal junction at the level of the levator plate is termed the *plane of minimum dimension*, sometimes also referred to as *minimal anatomic levator hiatus* (Fig. 5). The plane of minimum dimension is located at the most caudal level of the LAM, at which the puborectalis muscle overlaps with pubococcygeus/iliococcygeal fibers posterior to the anorectum and creates the levator plate.[48,49] The levator plate represents the junction of the LAM complex in the posterior midline at the level of the anorectal junction. LAM deficiency represents atrophy and global loss of the muscles. It is different from detachment or avulsion of the muscle from its origin at the pubic bone (Fig. 6), which can lead to distortion and/or downward displacement affecting the muscle and the functions of the pelvic organs.[43,50] To evaluate the pelvic floor with vPFUS, as with other PFUS techniques, ultrasound imaging always starts with 2D dynamic pPFUS to assess for pelvic organ prolapse, followed by 3D vPFUS to assess LAM integrity (see Video 2 at http://links.lww.com/DCR/C47). If an anal sphincter injury or anorectal pathology is suspected, an aPFUS can be performed as well, although the expertise in all forms of PFUS is rapidly evolving. Some advocates argue that an ultrasound assessment of the pelvic floor should be used in routine clinical practice and that an assessment of avulsion and sphincter trauma should be a key quality indicator of maternity services; however, this idea is still widely debated.[39,51]

Dynamic Imaging of Pelvic Floor Movement

1. Ultrasound evaluation of the degree of relaxation of the puborectalis muscle can be obtained via several equally effective techniques and could offer an alternative imaging option to patients undergoing evaluation for pelvic floor dyssynergia (degree of consensus: 95%).

Abnormalities in pelvic floor movement and relaxation (such as pelvic floor dyssynergia) are associated with obstructed defecation and incomplete emptying.[52] Understanding the movement of the puborectalis during the defecatory effort is essential when diagnosing pelvic floor dyssynergia, anismus, or the syndrome of paradoxical contraction of the puborectalis.[9] In the past, this diagnosis was made by either EMG testing or by fluoroscopic or MRI defecography. EMG testing has been used to identify the lack of relaxation (or even a paradoxical contraction) of the puborectalis with strain/Valsalva.[53] In fluoroscopic and MRI defecography, this pathology can be visualized by measuring the anorectal angle and visualizing the upward movement of the levator plate and anorectal junction.[54] In many circumstances, more than 1 imaging modality may be used to confirm the diagnosis of dyssynergia.[55]

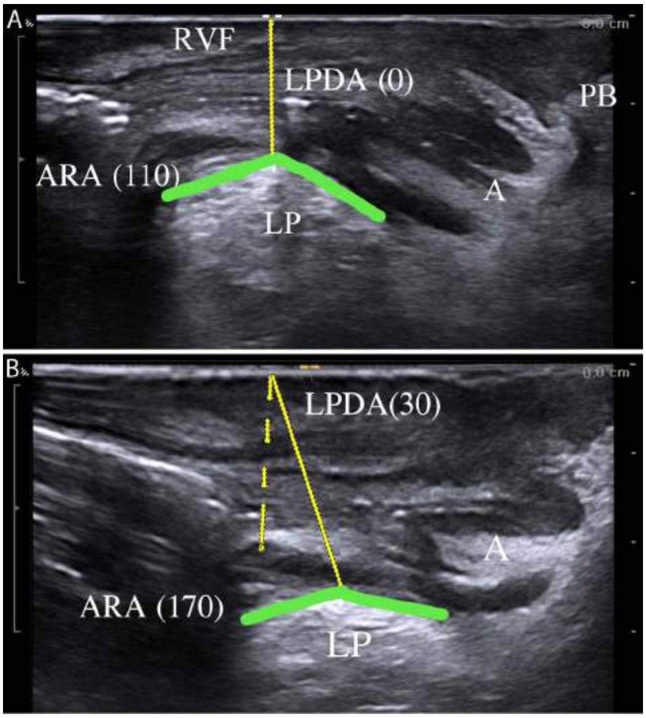

FIGURE 7. The movement of the levator plate as visualized on a 2-dimensional endovaginal pelvic floor ultrasound, midsagittal view. A, The anal canal at rest; the distance from the vagina in the anterior portion of the image to LP is measured (yellow line). The anorectal angle is marked along the posterior border of the anus and rectum and measures 110° at rest, as outlined in green. B, Anal canal during a strain/Valsalva maneuver; the flattening of the anorectal angle and movement of the levator plate caudad may be noted. The dashed yellow line demarcates the distance from the vagina to the LP during a strain/Valsalva maneuver, whereas the solid line denotes the location of the same measurement at rest in this patient. Please note that with this movement, the anorectal angle increased to 170°. A = anus; ARA = anorectal angle; LP = levator plate; LPDA = levator plate descent angle; PB = perineal body; RVF = rectovaginal fascia.

Studies have demonstrated that the movement of the levator plate (Fig. 7) can be easily seen on pPFUS, vPFUS, and aPFUS and that the presence or absence of dyssynergia should be part of a routine ultrasound interpretation synoptic report. Each approach has been validated in subjects with pelvic floor dyssynergia versus controls[7,56–59] with a reasonable index of agreement between various scanning modes.[60] Although the 3D vPFUS evaluates the integrity of LAM, the 2D dynamic pPFUS and vPFUS evaluate the movement of the levator plate structures in the midsagittal

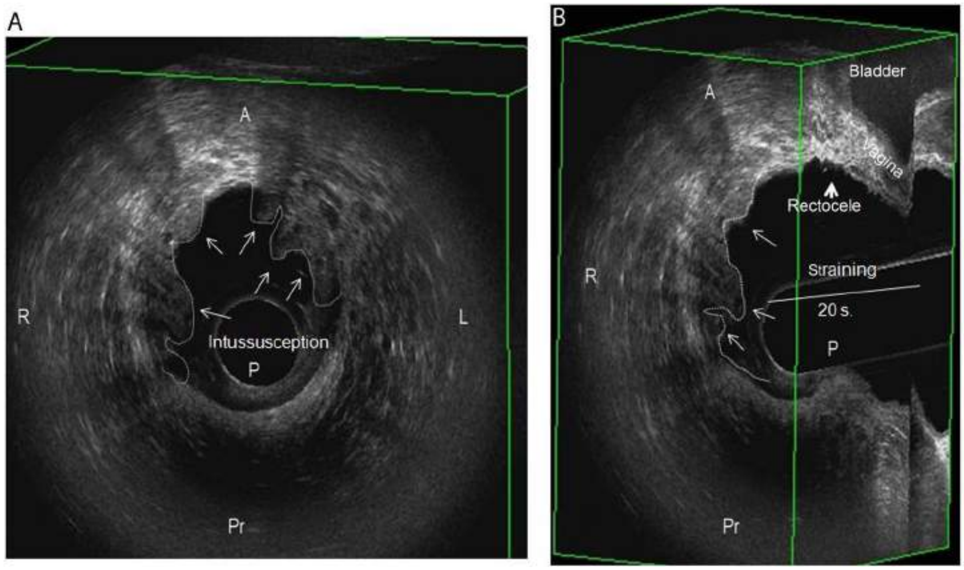

FIGURE 8. Internal intussusception as visualized on endoanal/endorectal pelvic floor ultrasound. A, Axial oblique plane showing full thickness anterior intussusception (arrows). B, Sagittal oblique plane showing rectocele (arrowhead) with associated anterior intussusception (arrows). A = anterior, Pr = posterior; R = right; L = left; P = probe.

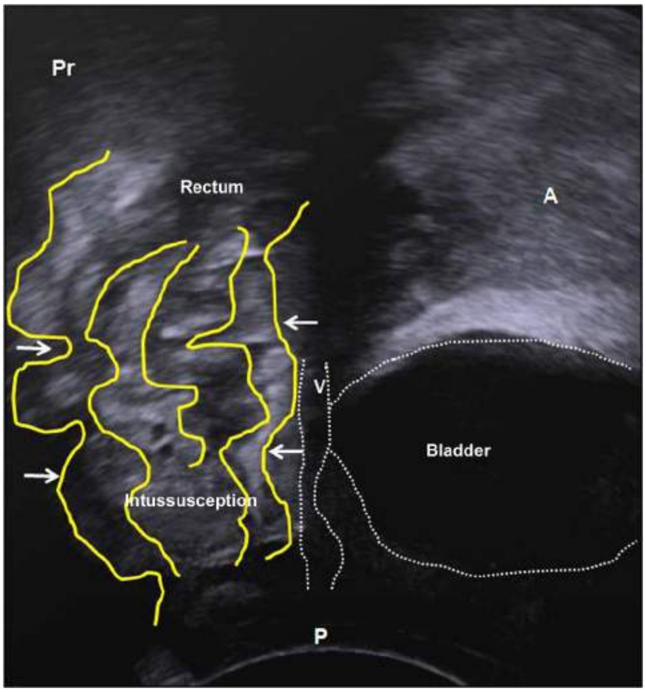

FIGURE 9. Internal intussusception as visualized on perineal/introital pelvic floor ultrasound, 2-dimensional midsagittal view. The transducer (bottom of the image) is aimed posteriorly. Note the infolding or telescoping of the rectum as it abnormally descends through the proximal and midrectum and distal anal canal (arrows). The intussusception is outlined in yellow. A = anterior; P = probe; Pr = posterior; V = vagina.

plane. aPFUS, pPFUS, and vPFUS have been correlated with standard defecography,[9,10,61] although some debate regarding the agreement for anorectal angle measurements continues.[4,62] The inconsistency in agreement for anorectal angle measurement between the ultrasound and fluoroscopic defecography may be because fluoroscopic defecography infers a change in anorectal angle based on visualization of radiopaque contrast within the rectum rather than the levator plate itself. During vPFUS, dyssynergia is recognized when ultrasound imaging demonstrates an upward lift or a lack of downward movement of the elevated levator plate with a strain/Valsalva maneuver.[63]

2. Ultrasound evaluation of prolapse of the rectum can be obtained via several equally effective techniques and could offer an alternative imaging option to patients undergoing evaluation for symptoms of obstructed defecation syndrome (degree of consensus: 75%).

Internal prolapse or rectal intussusception is a circular or semilunar infolding of the rectal wall during Valsalva. Various classifications of rectal intussusception exist, but we believe that the most clinical interpretation of rectal intussusception involves the differentiation between whether the rectal infolding is intrarectal, intra-anal, or external (also called extra-anal or complete rectal prolapse). Diagnosis is often performed by proctologic examination with a proctoscope, but it can also be demonstrated by dynamic imaging methods such as dynamic PFUS (Figs. 8 and 9), fluoroscopic defecography, and MRI defecography.[7,59,64] For each technique, interobserver agreement and agreement with fluoroscopic or MRI defecography have been demonstrated.[58,65–68]

The consortium experts agreed that it might be reasonable to encourage routine evaluation and reporting of rectal wall mobility using ultrasound imaging. Although there is an initial learning curve,[6] aPFUS, pPFUS, and

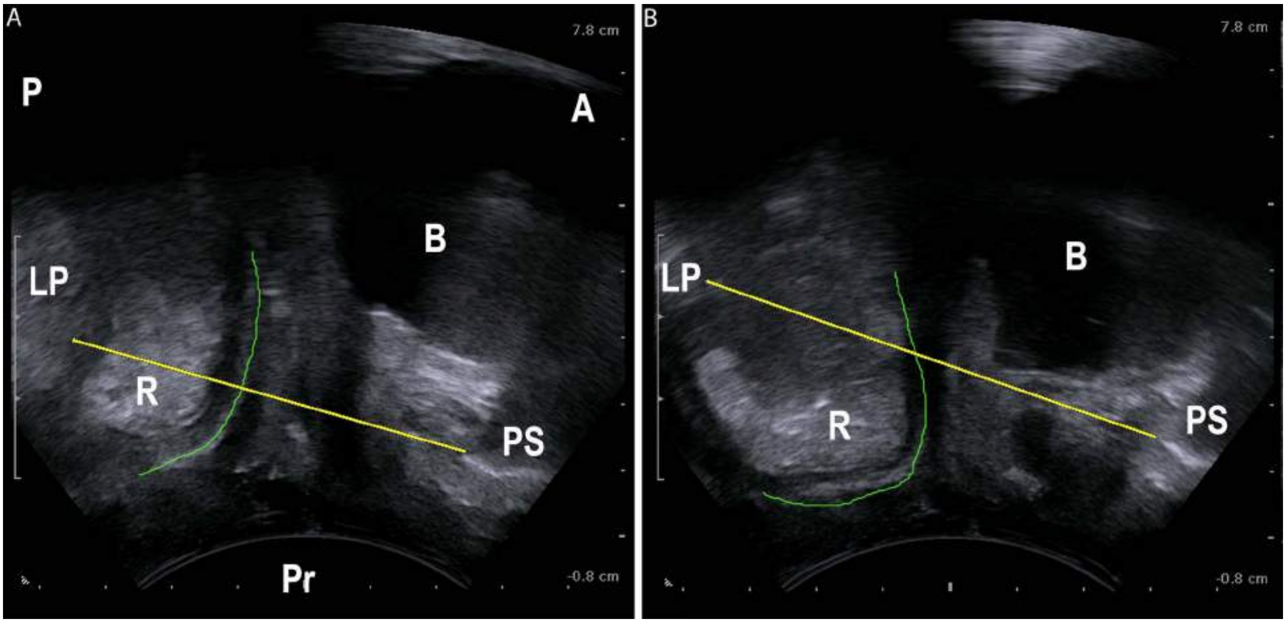

FIGURE 10. Patient with rectocele as visualized on transperineal/introital pelvic floor ultrasound, 2-dimensional midsagittal view using a 2- to 6-MHz probe with 3-dimensional capability, during rest and then during maximum strain/Valsalva maneuver. The transducer (bottom of images) is aimed posteriorly. A, Image of the rectum without Valsalva shows a minimum rectocele, outlined in green. The yellow line outlines the plane of minimal dimension. B, Image of the rectum with Valsalva, demonstrating an increase in the rectocele size as it drops below the plane of minimal dimension. A = anterior; B = bladder; LP = levator plate; P = posterior; Pr = probe; PS = pubis symphysis; R = rectocele.

vPFUS have good test accuracy[69] and patient acceptability for the evaluation of rectal prolapse. Additional imaging modalities could be considered when treatment escalation is considered, especially during the early learning curve.

3. A) Ultrasound evaluation of rectoceles and their emptying can be obtained via several equally effective techniques and could offer an alternative imaging option to patients undergoing evaluation for symptoms of obstructed defecation syndrome (degree of consensus: 97%).
   B) For all ultrasound modes of imaging, measurements of the longest distance describing the rectocele outpouching from the anterior wall of the rectum are clinically the most helpful (degree of consensus: 96%).
   C) If possible, commenting on gel or stool retention within a rectocele is encouraged (degree of consensus: 97%).

A rectocele may be secondary to the herniation of the rectal muscularis, mucosa, and its contents along the posterior vaginal wall through a defect of the rectovaginal fibromuscularis. It can be present in asymptomatic women[70] or may cause obstructive defecation symptoms, such as incomplete bowel emptying, need for strain/Valsalva during defecation, or feeling of a vaginal bulge.[71] Dynamic observation of rectoceles involves a detailed description of the size of the rectocele outpouching in the longest AP diameter to intersect with a line drawn orthogonal to the anterior aspect of the anal sphincter and extending to the expected site of the anterior wall of the rectum. In addition, a description of the rectocele's ability to hinder rectal emptying may further assist in surgical decision-making.

Rectoceles have been measured using aPFUS, vPFUS, and pPFUS (Fig. 10). These techniques have been compared and validated against MRI and fluoroscopic defecography.[58] Evacuation proctography, MRI, pPFUS, and vPFUS have been shown to have similar diagnostic test accuracy, and pPFUS and vPFUS have good test accuracy and patient acceptability.[26] There is no evidence that 4-dimensional pPFUS is superior to dynamic 2D acquisition in this regard.[10] Some subtle variations exist between the various methods. For example, compared to pPFUS, during aPFUS, the transducer is placed inside the rectum. This may limit or block the full descent of the rectal wall during a strain/Valsalva maneuver, and this is a source of a possible false negative in patients with associated rectoceles. However, when aPFUS was compared with dynamic pPFUS using 60 mL of acoustic gel in the rectum, perfect concordance was noted between techniques ($k = 0.98$; 95% CI, 0.69–1.0).[3] Ultrasound imaging has very good agreement with physical examination[71] and reliably demonstrates rectocele emptying, both with and without rectal gel.[9,71]

Of note, vPFUS may be less effective in identifying rectoceles, as the transducer in the vagina can prohibit protrusion of the rectocele and/or the vaginal apex.[26] Comparisons between vPFUS and pPFUS found that rectoceles are less common on transvaginal imaging but may be predictive for surgical interventions.[72]

4. Ultrasound evaluation of rectouterine pouch structures and hernias (sigmoidocele, enterocele, peritoneocele) can be obtained via several equally effective techniques and could offer an alternative imaging option to patients

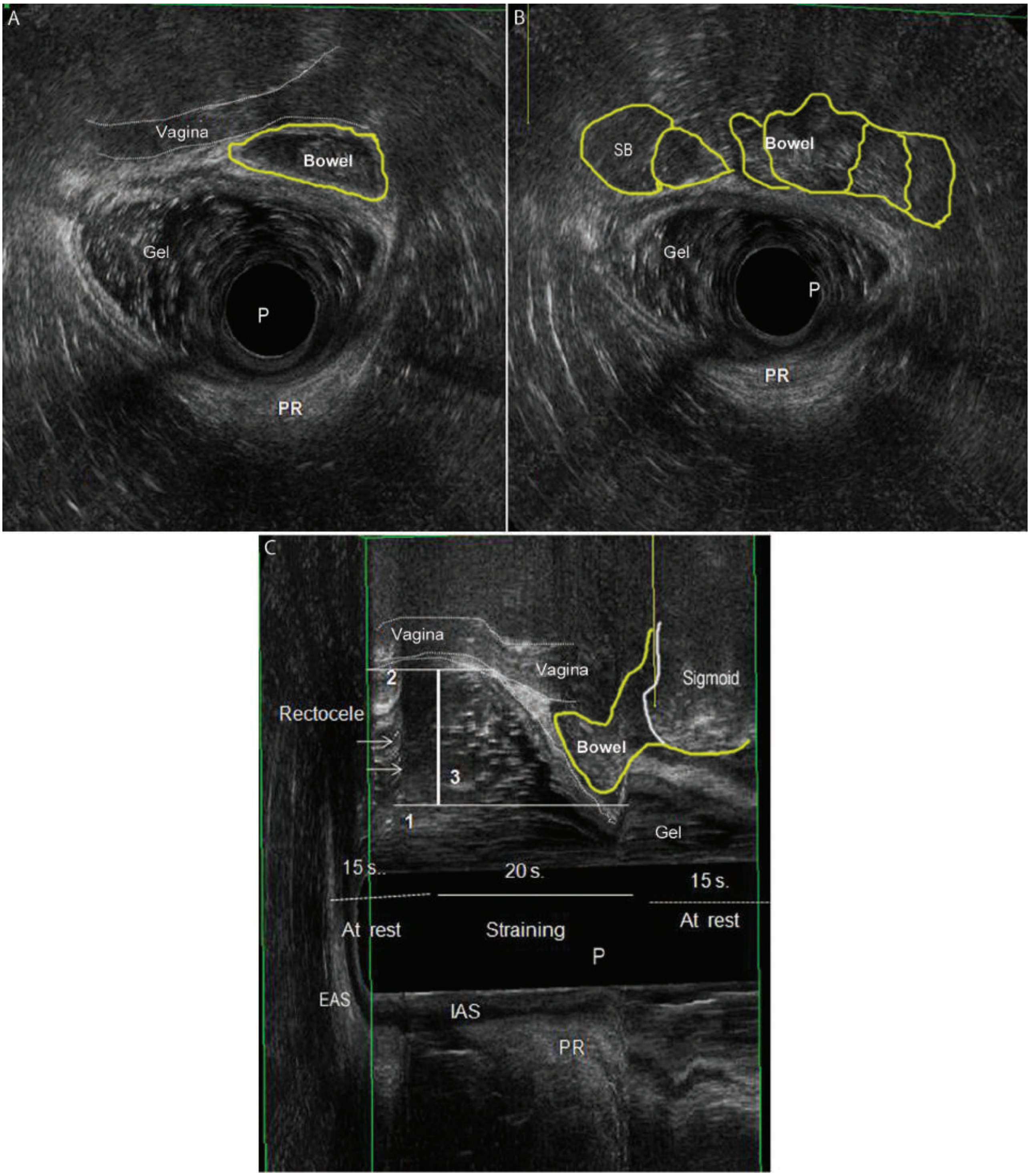

FIGURE 11. Patient with enterocele/sigmoidocele and rectocele as seen on endoanal/endorectal pelvic floor ultrasound with ultrasound gel. Note the bowel (yellow circle) in the rectovaginal space between the rectum and the vagina (axial plane). A, Axial plane view shows the bowel in the rectovaginal space between the rectum and the mid-vagina. B, Axial plane view shows the bowel in the rectovaginal space between the rectum and the upper vagina. C, Sagittal plane view shows the bowel between the rectum and the vagina consistent with enterocele (yellow outline) and rectocele (arrows). Line 1 = initial rest position of the anterior rectal wall; line 2 = displaced position of the anterior rectal wall at point of maximal straining; and line 3 = the distance between both lines, which determines the rectocele size. EAS = external anal sphincter; IAS = internal anal sphincter; P = probe; PR = puborectalis; SB = small bowel.

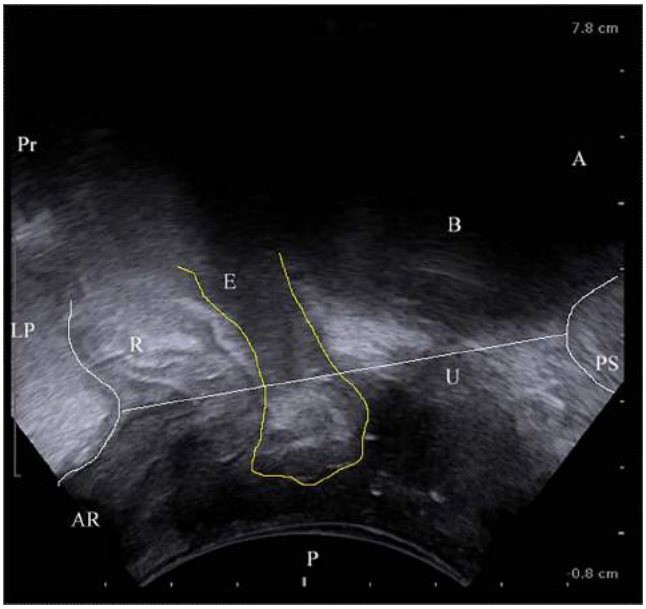

FIGURE 12. Patient with enterocele/sigmoidocele (small or large bowel) and rectocele as visualized on transperineal/introital pelvic floor ultrasound, 2D midsagittal view. The transducer (bottom of the image) is aimed posteriorly. Note the enterocele (E) protruding past the minimal levator hiatus reference line. The patient also has a minor rectocele (R). 2D = 2-dimensional; A = anterior; AR=anorectum; B = bladder; E = enterocele; LP = levator plate; P = probe; Pr = posterior; PS = pubic symphysis; R = rectocele; U = urethra.

undergoing evaluation for symptoms of obstructed defecation syndrome or pelvic organ prolapse (degree of consensus: 97%).

Diagnosing pelvic organ prolapse by physical examination alone has limitations, including the tendency to evaluate surface anatomy and to not assess the surrounding pelvic viscera. Therefore, we recommended integrating imaging evaluation as part of the diagnosis, measurement, and treatment of complex pelvic floor defects. Some varieties of pelvic organ prolapse of the posterior and apical compartment (sigmoidocele, enterocele, and peritoneocele) can be difficult, if not impossible, to diagnose by physical examination alone. Currently, there are no standardized definitions based on exact measurements of pelvic organ prolapse involving rectouterine pouch hernias.[62] These herniations are usually associated with concomitant pelvic floor disorders and are rarely present as a single herniation.[62] A pelvic peritoneal sac that herniates into the rectovaginal space may be referred to as an enterocele[13] if it contains a portion of the small bowel.[73] It is called a peritoneocele if it contains only peritoneal fat or a sigmoidocele if it includes a portion of the sigmoid colon. Because the rectovaginal space may be occupied by the distended rectum during defecation, the hernia may become evident only at the end of evacuation.[74]

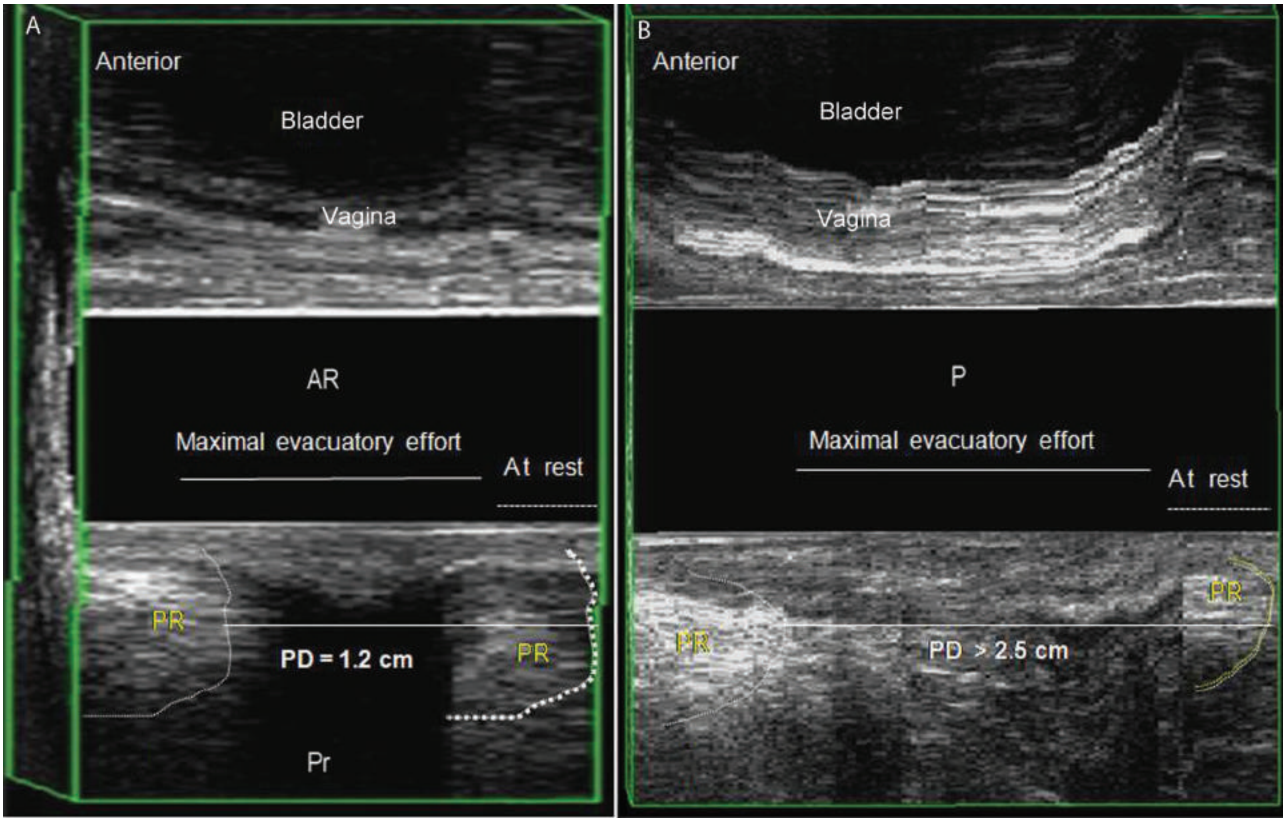

FIGURE 13. Example of a patient with perineal descent as visualized on dynamic endoanal pelvic floor ultrasound, in the sagittal plane. A, Normal perineal descent: PD from rest to maximal evacuatory effort. B, Pathologic perineal descent in a different patient with PD >2.5 cm. AR = anus and rectum; P = probe; PD = puborectalis descent; Pr = posterior; PR = puborectalis.

All of the 3 approaches—aPFUS, pPFUS, and vPFUS—have described steps that allow dynamic image captures (Figs. 11 and 12) to visualize the herniation of the peritoneal sac with or without the small bowel in the rectovaginal space, with a strong correlation of these observations to MRI findings.[54,58,65,68,75] In the discussion of ultrasound imaging for the diagnosis of rectouterine pouch hernias, the consortium experts acknowledged that a well-conducted dynamic US is dependent on the operator's skill as well as the degree of patient cooperation with the test. Rectouterine pouch hernias can be best seen during straining or rectal gel emptying maneuvers. This assessment should be performed after rectal gel (or rectum content) is fully evacuated to optimize conditions to diagnose pathology. Ultrasound imaging gives relevant information about the immediate local anatomy, such as layers of the bowel wall or sphincter complex, because of the high-resolution transducer's proximity to these structures. The experts agreed that additional education efforts would be needed to increase expertise with these techniques among practitioners.

5. A) Ultrasound description of perineal descent can be obtained via several equally effective techniques (degree of consensus: 81%).
   B) Perineal descent is defined as a drop of the anorectal junction of >2 cm from its position at rest with Valsalva (degree of consensus: 71%).

Perineal descent has been frequently observed to coexist with pelvic organ prolapse and defecatory pelvic floor disorders. The clinical significance of its presence or absence is much debated. The consortium experts discussed the relevance of including quantification of this perineal descent into the recommended synoptic report for PFUS. It was agreed that the addition of this measurement is not particularly time consuming and that it could potentially aid future research on its significance in this patient population.

All PFUS modalities can be used to measure perineal descent (Fig. 13).[7,65,76] Most of these approaches have good agreement between themselves and with MRI defecography,[7,42,54,77] and their measurements are highly reproducible.[58] Some disagreement seems to exist between experts on whether the measurement should be obtained during a strain/Valsalva maneuver or at rest.[3] The consortium experts agreed that the images should be obtained when the perineum is lowest (with evacuation or with maximum strain/Valsalva). Perineal descent should be reported as the distance of the anorectal junction below the plane of minimum dimension or the location of the anorectal junction at rest, and it may be clinically significant when the drop is >2 cm from its position at rest and should be noted in the synoptic report.[42]

CONCLUSIONS

Consensus was reached by the PFDC on the many clinically relevant definitions and considerations for performing, interpreting, and reporting ultrasound imaging of the pelvic floor, regardless of the preferred imaging modality. A corresponding minimum synoptic interpretation template was suggested on the basis of these consensus guidelines (see Supplement 1 at http://links.lww.com/DCR/C46). The described technical steps and template can be augmented with additional sonographic maneuvers and report elements based on local practice patterns and additional expertise in a particular modality. The suggested minimum interpretation language suggested in this guidance should be considered when performing and interpreting PFUS in patients with pelvic floor–related evacuation disorders.

KEY WORDS: Anal incontinence; Anal sphincter; Anorectal tumors; Dyspareunia; Fecal incontinence; Levator ani muscle; Obstetric perineal injury; Obstructed defecation; Pelvic floor; Pelvic organ prolapse; Perianal abscess and fistula; Synthetic implants; Ultrasound; Urinary incontinence.

SUPPLEMENTAL DIGITAL CONTENT

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML and PDF versions of this article on the journal's website (www.dcrjournal.com).

ACKNOWLEDGMENTS

This work is in the memory of our contributor Dr. Giuseppe Gagliardi, who died during the drafting of the article. The authors thank Brook Gurland, MD, for providing the videos. The author also thank the additional members of the Expert Panel on Dynamic Ultrasound Imaging of Defecatory Disorders of the Pelvic Floor: Amy Halverson, M.D.; Shuqing Ding, Ph.D.; Andrea Ferrara, M.D.; Ari Steiner, M.D.; David Sheyn, M.D.; Joanne Favuzza, M.D.; Sergio Larach, M.D.; Yara Lima de Mendonca, M.D.; Miles Murphy, M.D.; and Steven Wexner, M.D.

REFERENCES

1. Shobeiri SA, LeClaire E, Nihira MA, Quiroz LH, O'Donoghue D. Appearance of the levator ani muscle subdivisions in endovaginal three-dimensional ultrasonography. *Obstet Gynecol.* 2009;114:66–72.
2. van Gruting IM, Stankiewicz A, Thakar R, IntHout J, Santoro GA, Sultan AH. Imaging modalities for the detection of posterior compartment disorders in women with obstructed defaecation syndrome. *Cochrane Database Syst Rev.* 2015:CD011482.
3. Murad-Regadas SM, Karbage SA, Bezerra LS, et al. Dynamic translabial ultrasound versus echodefecography combined with the endovaginal approach to assess pelvic floor dysfunctions: how effective are these techniques? *Tech Coloproctol.* 2017;21:555–565.

4. Perniola G, Shek C, Chong CCW, Chew S, Cartmill J, Dietz HP. Defecation proctography and translabial ultrasound in the investigation of defecatory disorders. *Ultrasound Obstet Gynecol.* 2008;31:567–571.
5. AIUM/IUGA practice parameter for the performance of urogynecological ultrasound examinations. Developed in collaboration with the ACR, the AUGS, the AUA, and the SRU. *J Ultrasound Med.* 2019;38:851–864. PMID: 30895666.
6. Jalalizadeh M, Alshiek J, Santoro GA, Wieczorek AP, Shobeiri SA. Six-year experience in teaching pelvic floor ultrasonography using pelvic floor phantoms. *Obstet Gynecol.* 2018;132:337–344.
7. Murad-Regadas SM, Regadas FSP, Rodrigues LV, Silva FR, Soares FA, Escalante RD. A novel three-dimensional dynamic anorectal ultrasonography technique (echodefecography) to assess obstructed defecation, a comparison with defecography. *Surg Endosc.* 2008;22:974–979.
8. Flusberg M, Kobi M, Bahrami S, et al. Multimodality imaging of pelvic floor anatomy. *Abdom Radiol (NY).* 2021;46:1302–1311.
9. Beer-Gabel M, Teshler M, Barzilai N, et al. Dynamic transperineal ultrasound in the diagnosis of pelvic floor disorders: pilot study. *Dis Colon Rectum.* 2002;45:239–245.
10. van Gruting IMA, Kluivers K, Sultan AH, et al. Does 4D transperineal ultrasound have additional value over 2D transperineal ultrasound for diagnosing posterior pelvic floor disorders in women with obstructed defecation syndrome? *Ultrasound Obstet Gynecol.* 2018;52:784–791.
11. Stuart A, Ignell C, Örnö AK. Comparison of transperineal and endoanal ultrasound in detecting residual obstetric anal sphincter injury. *Acta Obstet Gynecol Scand.* 2019;98:1624–1631.
12. Ignell C, Örnö AK, Stuart A. Correlations of obstetric anal sphincter injury (OASIS) grade, specific symptoms of anal incontinence, and measurements by endoanal and transperineal ultrasound. *J Ultrasound.* 2021;24:261–267.
13. Dietz HP. Ultrasound in the investigation of pelvic floor disorders. *Curr Opin Obstet Gynecol.* 2020;32:431–440.
14. Van Delft K, Shobeiri SA, Sultan AH, Thakar R. Haematomas may masquerade as levator ani muscle defects. *Int Urogynecol J Pelvic Floor Dysfunct.* 2012;23:S43–S244.
15. Sultan AH, Nicholls RJ, Kamm MA, Hudson CN, Beynon J, Bartram CI. Anal endosonography and correlation with in vitro and in vivo anatomy. *Br J Surg.* 1993;80:508–511.
16. Sultan AH, Kamm MA, Hudson CN, Nicholls JR, Bartram CI. Endosonography of the anal sphincters: normal anatomy and comparison with manometry. *Clin Radiol.* 1994;49:368–374.
17. Sultan AH, Kamm MA, Talbot IC, Nicholls RJ, Bartram CI. Anal endosonography for identifying external sphincter defects confirmed histologically. *Br J Surg.* 1994;81:463–465.
18. Sultan AH. The role of anal endosonography in obstetrics. *Ultrasound Obstet Gynecol.* 2003;22:559–560.
19. Roos AM, Abdool Z, Sultan AH, Thakar R. The diagnostic accuracy of endovaginal and transperineal ultrasound for detecting anal sphincter defects: the PREDICT study. *Clin Radiol.* 2011;66:597–604.
20. Bollard RC, Gardiner A, Lindow S, Phillips K, Duthie GS. Normal female anal sphincter: difficulties in interpretation explained. *Dis Colon Rectum.* 2002;45:171–175.
21. Fritsch H, Brenner E, Lienemann A, Ludwikowski B. Anal sphincter complex: reinterpreted morphology and its clinical relevance. *Dis Colon Rectum.* 2002;45:188–194.
22. Morren GL, Beets-Tan RG, van Engelshoven JM. Anatomy of the anal canal and perianal structures as defined by phased-array magnetic resonance imaging. *Br J Surg.* 2001;88:1506–1512.
23. Williams AB, Bartram CI, Halligan S, Marshall MM, Nicholls RJ, Kmiot WA. Endosonographic anatomy of the normal anal canal compared with endocoil magnetic resonance imaging. *Dis Colon Rectum.* 2002;45:176–183.
24. Sultan AH, Thakar R. Diagnosis of anal sphincter tears to prevent fecal incontinence: a randomized controlled trial. *Obstet Gynecol.* 2005;106:1108–1109.
25. Shobeiri SA, Rostaminia G, Shobeiri H. Development of an in-house endoanal ultrasound teaching phantom. *J Ultrasound Med.* 2013;32:1393–1396.
26. van Gruting IMA, Stankiewicz A, Kluivers K, et al. Accuracy of four imaging techniques for diagnosis of posterior pelvic floor disorders. *Obstet Gynecol.* 2017;130:1017–1024.
27. Volløyhaug I, Taithongchai A, Arendsen L, van Gruting I, Sultan AH, Thakar R. Is endoanal, introital or transperineal ultrasound diagnosis of sphincter defects more strongly associated with anal incontinence? *Int Urogynecol J Pelvic Floor Dysfunct.* 2020;31:1471–1478.
28. Taithongchai A, van Gruting IMA, Volloyhaug I, Arendsen LP, Sultan AH, Thakar R. Comparing the diagnostic accuracy of 3 ultrasound modalities for diagnosing obstetric anal sphincter injuries. *Am J Obstet Gynecol.* 2019;221:134.e1–134.e9.
29. Meriwether KV, Hall RJ, Leeman LM, Migliaccio L, Qualls C, Rogers RG. Anal sphincter complex: 2D and 3D endoanal and translabial ultrasound measurement variation in normal postpartum measurements. *Int Urogynecol J Pelvic Floor Dysfunct.* 2015;26:511–517.
30. Andrews V, Thakar R, Sultan AH. Outcome of obstetric anal sphincter injuries (OASIS)—role of structured management. *Int Urogynecol J Pelvic Floor Dysfunct.* 2009;20:973–978.
31. Sioutis D, Thakar R, Sultan AH. Overdiagnosis and rising rate of obstetric anal sphincter injuries (OASIS): time for reappraisal. *Ultrasound Obstet Gynecol.* 2017;50:642–647.
32. Starck M, Bohe M, Fortling B, Valentin L. Endosonography of the anal sphincter in women of different ages and parity. *Ultrasound Obstet Gynecol.* 2005;25:169–176.
33. Murad-Regadas SM, da S Fernandes GO, Regadas FS, et al. Usefulness of anorectal and endovaginal 3D ultrasound in the evaluation of sphincter and pubovisceral muscle defects using a new scoring system in women with fecal incontinence after vaginal delivery. *Int J Colorectal Dis.* 2017;32:499–507.
34. Karoui S, Savoye-Collet C, Koning E, Leroi AM, Denis P. Prevalence of anal sphincter defects revealed by sonography in 335 incontinent patients and 115 continent patients. *AJR Am J Roentgenol.* 1999;173:389–392.
35. Malouf AJ, Williams AB, Halligan S, Bartram CI, Dhillon S, Kamm MA. Prospective assessment of accuracy of endoanal MR imaging and endosonography in patients with fecal incontinence. *AJR Am J Roentgenol.* 2000;175:741–745.
36. Deen KI, Kumar D, Williams JG, Olliff J, Keighley MR. The prevalence of anal sphincter defects in faecal incontinence: a prospective endosonic study. *Gut.* 1993;34:685–688.
37. Christensen AF, Nyhuus B, Nielsen MB, Christensen H. Three-dimensional anal endosonography may improve diagnostic confidence of detecting damage to the anal sphincter complex. *Br J Radiol.* 2005;78:308–311.

38. Dietz HP, Walsh C, Subramaniam N, Friedman T. Levator avulsion and vaginal parity: do subsequent vaginal births matter? *Int Urogynecol J Pelvic Floor Dysfunct.* 2020;31:2311–2315.
39. Denson LE, Terrell DR, Vesely SK, Peck JD, Quiroz LH, Shobeiri SA. The prevalence of pelvic floor hematoma after vaginal delivery. *Female Pelvic Med Reconstr Surg.* 2021;27:393–397.
40. Shobeiri SA, Chesson RR, Gasser RF. The internal innervation and morphology of the human female levator ani muscle. *Am J Obstet Gynecol.* 2008;199:686.e1–686.e6
41. Rostaminia G, Peck JD, Quiroz LH, Shobeiri SA. How well can levator ani muscle morphology on 3D pelvic floor ultrasound predict the levator ani muscle function? *Int Urogynecol J Pelvic Floor Dysfunct.* 2015;26:257–262.
42. Rostaminia G, Javadian P, Awad C, Shobeiri SA. Ultrasound indicators of rectal support defect in women with obstructive defecatory symptoms. *Female Pelvic Med Reconstr Surg.* 2019;25:222–225.
43. Rostaminia G, White D, Hegde A, Quiroz LH, Davila GW, Shobeiri SA. Levator ani deficiency and pelvic organ prolapse severity. *Obstet Gynecol.* 2013;121:1017–1024.
44. Rostaminia G, Manonai J, Leclaire E, et al. Interrater reliability of assessing levator ani deficiency with 360° 3D endovaginal ultrasound. *Int Urogynecol J Pelvic Floor Dysfunct.* 2014;25:761–766.
45. van Delft KW, Thakar R, Sultan AH, IntHout J, Kluivers KB. The natural history of levator avulsion one year following childbirth: a prospective study. *BJOG.* 2015;122:1266–1273.
46. Andrews V, Thakar R, Sultan AH. Structured hands-on training in repair of obstetric anal sphincter injuries (OASIS): an audit of clinical practice. *Int Urogynecol J Pelvic Floor Dysfunct.* 2009;20:193–199.
47. Dietz HP, Shek C, Clarke B. Biometry of the pubovisceral muscle and levator hiatus by three-dimensional pelvic floor ultrasound. *Ultrasound Obstet Gynecol.* 2005;25:580–585.
48. Shobeiri SA, Rostaminia G, White D, Quiroz LH. The determinants of minimal levator hiatus and their relationship to the puborectalis muscle and the levator plate. *BJOG.* 2013;120:205–211.
49. Rostaminia G, White DE, Quiroz LH, Shobeiri SA. Levator plate descent correlates with levator ani muscle deficiency. *Neurourol Urodyn.* 2015;34:55–59.
50. Quiroz LH, Shobeiri SA, White D, Wild RA. Does age affect visualization of the levator ani in nulliparous women? *Int Urogynecol J Pelvic Floor Dysfunct.* 2013;24:1507–1513.
51. Dietz HP. Ultrasound imaging of maternal birth trauma. *Int Urogynecol J Pelvic Floor Dysfunct.* 2021;32:1953–1962.
52. Messelink B, Benson T, Berghmans B, et al. Standardization of terminology of pelvic floor muscle function and dysfunction: report from the pelvic floor clinical assessment group of the International Continence Society. *Neurourol Urodyn.* 2005;24:374–380.
53. Peng Y, He J, Khavari R, Boone TB, Zhang Y. Functional mapping of the pelvic floor and sphincter muscles from high-density surface EMG recordings. *Int Urogynecol J Pelvic Floor Dysfunct.* 2016;27:1689–1696.
54. Vitton V, Vignally P, Barthet M, et al. Dynamic anal endosonography and MRI defecography in diagnosis of pelvic floor disorders: comparison with conventional defecography. *Dis Colon Rectum.* 2011;54:1398–1404.
55. Bordeianou L, Savitt L, Dursun A. Measurements of pelvic floor dyssynergia: which test result matters? *Dis Colon Rectum.* 2011;54:60–65.
56. Van Outryve SM, Van Outryve MJ, De Winter BY, Pelckmans PA. Is anorectal endosonography valuable in dyschesia? *Gut.* 2002;51:695–700.
57. Murad-Regadas SM, Regadas FS, Rodrigues LV, et al. A novel procedure to assess anismus using three-dimensional dynamic anal ultrasonography. *Colorectal Dis.* 2007;9:159–165.
58. Regadas FSP, Haas EM, Abbas MA, et al. Prospective multicenter trial comparing echodefecography with defecography in the assessment of anorectal dysfunction in patients with obstructed defecation. *Dis Colon Rectum.* 2011;54:686–692.
59. Murad-Regadas SM, dos Santos D, Soares G, et al. A novel three-dimensional dynamic anorectal ultrasonography technique for the assessment of perineal descent, compared with defaecography. *Colorectal Dis.* 2012;14:740–747.
60. Murad-Regadas SM, Regadas FS, Barreto RG, Rodrigues LV, de Souza MH. A novel two-dimensional dynamic anal ultrasonography technique to assess anismus comparing with three-dimensional echodefecography. *Colorectal Dis.* 2009;11:872–877.
61. Beer-Gabel M, Teshler M, Schechtman E, Zbar AP. Dynamic transperineal ultrasound vs. defecography in patients with evacuatory difficulty: a pilot study. *Int J Colorectal Dis.* 2004;19:60–67.
62. Albuquerque A, Pereira E. Current applications of transperineal ultrasound in gastroenterology. *World J Radiol.* 2016;8:370–377.
63. Rostaminia G, Peck J, Quiroz L, Shobeiri SA. Levator plate upward lift on dynamic sonography and levator muscle strength. *J Ultrasound Med.* 2015;34:1787–1792.
64. Murad-Regadas SM, Regadas Filho FS, Regadas FS, et al. Use of dynamic 3-dimensional transvaginal and transrectal ultrasonography to assess posterior pelvic floor dysfunction related to obstructed defecation. *Dis Colon Rectum.* 2014;57:228–236.
65. Barthet M, Portier F, Heyries L, et al. Dynamic anal endosonography may challenge defecography for assessing dynamic anorectal disorders: results of a prospective pilot study. *Endoscopy.* 2000;32:300–305.
66. Brusciano L, Limongelli P, Pescatori M, et al. Ultrasonographic patterns in patients with obstructed defaecation. *Int J Colorectal Dis.* 2007;22:969–977.
67. Steensma AB, Oom DM, Burger CW, Schouten WR. Assessment of posterior compartment prolapse: a comparison of evacuation proctography and 3D transperineal ultrasound. *Colorectal Dis.* 2010;12:533–539.
68. Rostaminia G, Abramowitch S, Chang C, Goldberg RP. Descent and hypermobility of the rectum in women with obstructed defecation symptoms. *Int Urogynecol J Pelvic Floor Dysfunct.* 2020;31:337–349.
69. Santoro GA, Wieczorek AP, Shobeiri SA, et al. Interobserver and interdisciplinary reproducibility of 3D endovaginal ultrasound assessment of pelvic floor anatomy. *Int Urogynecol J Pelvic Floor Dysfunct.* 2011;22:53–59.
70. Kenton K, Shott S, Brubaker L. The anatomic and functional variability of rectoceles in women. *Int Urogynecol J Pelvic Floor Dysfunct.* 1999;10:96–99.
71. Dietz HP, Beer-Gabel M. Ultrasound in the investigation of posterior compartment vaginal prolapse and obstructed defecation. *Ultrasound Obstet Gynecol.* 2012;40:14–27.
72. Dietz HP, Zhang X, Shek KL, Guzman RR. How large does a rectocele have to be to cause symptoms? A 3D/4D ultrasound study. *Int Urogynecol J Pelvic Floor Dysfunct.* 2015;26:1355–1359.
73. Pannu HK, Scatarige JC, Eng J. Comparison of supine magnetic resonance imaging with and without rectal contrast to fluoroscopic cystocolpoproctography for the diagnosis of pelvic organ prolapse. *J Comput Assist Tomogr.* 2009;33:125–130.

74. García del Salto L, de Miguel Criado J, Aguilera del Hoyo LF, et al. MR imaging-based assessment of the female pelvic floor. *Radiographics.* 2014;34:1417–1439.
75. Dvorkin LS, Hetzer F, Scott SM, Williams NS, Gedroyc W, Lunniss PJ. Open-magnet MR defaecography compared with evacuation proctography in the diagnosis and management of patients with rectal intussusception. *Colorectal Dis.* 2004;6:45–53.
76. Santoro GA, Shobeiri SA, Petros PP, Zapater P, Wieczorek AP. Perineal body anatomy seen by three-dimensional endovaginal ultrasound of asymptomatic nulliparae. *Colorectal Dis.* 2016;18:400–409.
77. Murad-Regadas SM, Pinheiro Regadas FS, Rodrigues LV, et al. Correlation between echodefecography and 3-dimensional vaginal ultrasonography in the detection of perineal descent in women with constipation symptoms. *Dis Colon Rectum.* 2016;59:1191–1199.