Radial-scanning flexible EUS of the anorectum and pelvis

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ABSTRACT

Standard upper gastrointestinal flexible radial EUS probes are well suited for imaging of anorectum and pelvic pathologies. They offer multiple advantages over conventional rigid rectal probes. The current transducers allow imaging at variable frequencies and are Doppler capable. The flexible shaft of the endoscope and optics allow easy probe insertion to upper sigmoid. Flexible radial EUS probes allow evaluation of anal sphincter complex, rectosigmoid mural pathologies, and paraluminal pelvic disorders. A thorough understanding of pelvic anatomy and image orientation is the key to appropriate image interpretation. In this review, we describe the principles and methodology for anorectal EUS imaging using a flexible radial EUS probe.

Key words: Anal canal, anal sphincters, aorta, EUS, iliac vessels, inferior vena cava, pelvis, prostate, rectum

INTRODUCTION

Anorectal ultrasound using rigid mechanical or electronic, radial or sector scan probes, has traditionally been the domain of radiologists and urologists. However, with the wide-spread availability of flexible EUS probes, anorectal ultrasound is being gradually adopted by endoscopists. There are many potential gastroenterological applications of anorectal ultrasound using a flexible radial scanning EUS probe. These include evaluation of anal sphincter defects and obstructed defecation, anorectal abscesses and fistulas, lower colonic submucosal lesions, and staging of anorectal cancers. Tissue sampling of pararectal nodes and tumors and therapeutic work like transrectal drainage of pelvic collections using a linear probe is usually preceded by a radial ultrasound scan to define the anatomy. In this review, we will describe the normal anorectal and pelvic anatomy using a flexible upper gastrointestinal radial EUS probe.

PATIENT PREPARATION

We prefer to prepare the patient for a rectal EUS examination with polyethylene glycol solution, like standard colonoscopy. An excellent bowel preparation is crucial, as stool in the rectosigmoid introduces artifacts, obscures

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lesions, and can clog the suction channel and optics of the EUS instrument. Stool in the lumen can make evaluation of polyps and masses very difficult and obscure extraluminal structures. The suction channel diameters of the latest flexible radial EUS probes offered by different manufacturers are 2.2 mm (GF-UE160, Olympus), 2.4 mm (EG-3670URK, Pentax), and 2.8 mm (EG-580UR, Fujinon). These small suction channels of the EUS probes make it difficult to suction residue in the colon.

Enema-alone preparation may be acceptable in certain settings. If enemas are used, they should be given within 1–2 h of the procedure. For evaluation of anal canal alone, even an unprepared study may be acceptable.

PATIENT POSITION

The patient should lie down across the table so that he/ she does not roll off the couch if turning is needed. The buttocks may protrude a little off the table, to allow opening of the anal orifice during examination. This position also allows any expelled luminal contents to drop down the table, rather than pool on the table itself. Lateral positioning may lead to asymmetry of the pelvic anatomy, especially in females, but this is of little practical significance. In this article, we will describe the anatomy with the patient in the left lateral position.

EUS INSTRUMENTS FOR ANORECTAL STUDY

Rigid nonoptical probes can be introduced to a limited depth only, and lack the maneuverability of the flexible endoscopes. Currently, flexible radial EUS probes may be considered as the instruments of choice for anorectal examination. These flexible EUS probes can usually be visually advanced to the upper sigmoid in the absence of luminal obstruction. Imaging is usually done at 6 MHz or 7.5 MHz frequency.

If required, a linear EUS probe may be introduced after an adequate radial EUS study for the purpose of tissue sampling or drainage of pelvic fluid collections. It is very difficult to define the pelvic anatomy and the anal sphincter complex with a linear EUS probe alone.

IMAGE ORIENTATION IN THE LOWER GASTROINTESTINAL TRACT

Familiarity with image orientation is important to define the location of any pathology detected in the rectum

or anal canal on cross-sectional imaging or endoscopic examination.

There are two modes of display in radial scanning – "NORMAL" and "INVERSE" (reverse) orientation. These can be selected on the ultrasound processor settings in each case. "NORMAL" orientation corresponds to imaging from the distal (aboral) end of the ultrasound endoscope or miniprobe. In upper gastrointestinal and pancreatobiliary imaging, the "NORMAL" mode is commonly used and corresponds to the computed tomographic (CT) image orientation [Figures 1a-d].

However, in the lower gastrointestinal tract (GIT), if we display the radial EUS images in the "NORMAL" mode, the EUS image orientation is the reverse of CT imaging of the pelvis.

The "INVERSE" orientation is display of EUS images from the insertion direction. This "INVERSE" orientation if used in the lower GIT would correspond to the CT image orientation of the pelvis. This is the orientation used by urologists and radiologists for most transrectal ultrasound studies by rigid radial probes [Figures 1e and f].

We should also note that the endoscopic image is always displayed from the insertion direction. Therefore, if a lesion is seen in the upper left quadrant of the endoscopic image, it will be displayed in the lower left quadrant of the radial EUS image in the "NORMAL" mode. Hence, the endoscopic and radial EUS images have an upside-down relationship, but the left and right orientation on the endoscopic and EUS images correspond.

In this review, all images were obtained using a flexible radial scanning EUS probe ((GF-UE160), Olympus Medical Systems, Tokyo, Japan), connected to a high-quality compact US processor (EU-ME2 Premier Plus, Olympus Medical Systems, Tokyo, Japan). The anatomy and the images in this review are described in the "NORMAL" mode.

EXAMINATION METHOD WITH THE FLEXIBLE RADIAL EUS PROBE

Often, no sedation is needed for anorectal EUS examination. Analgesia and/or sedation may be needed in the presence of any painful anal pathology.
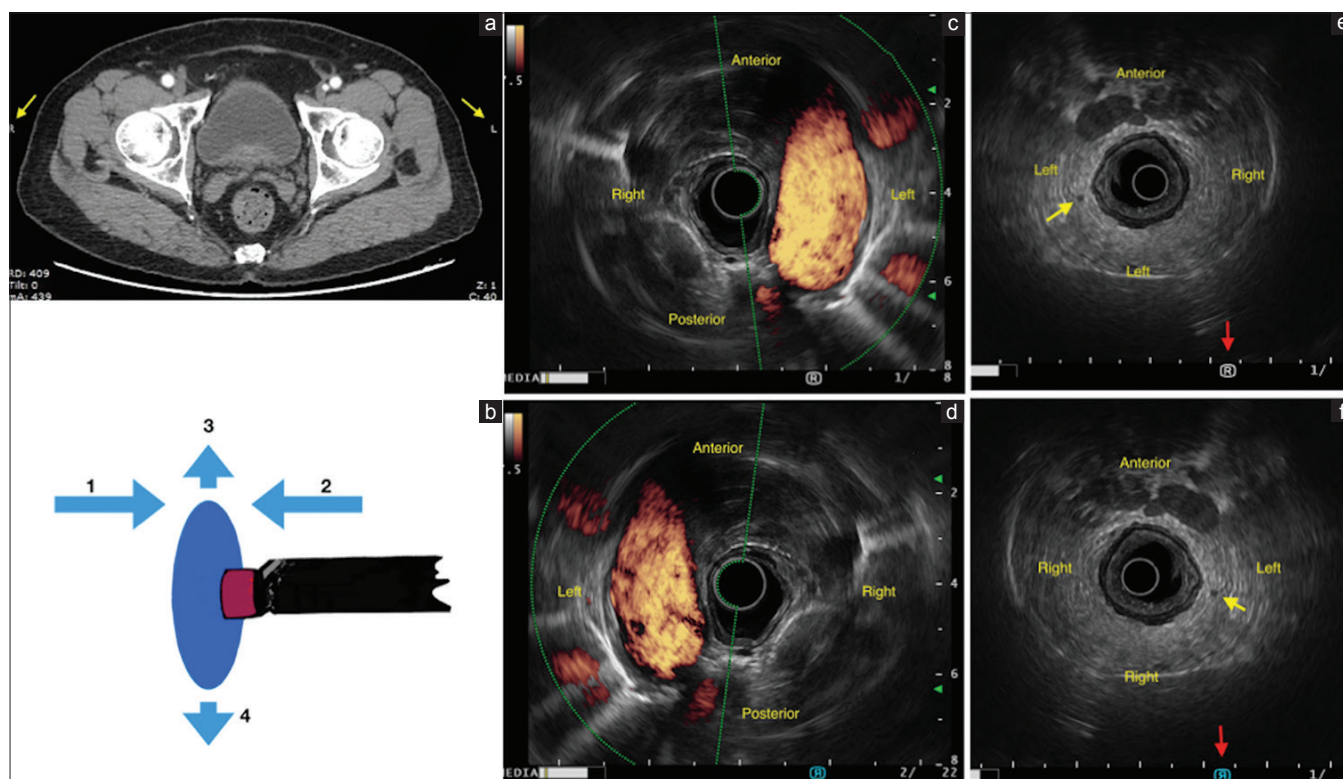
Figure 1. (a) Cross-sectional images of computed tomographic and magnetic resonance imaging scans are oriented as if the patient is being imaged from below, with the right side of the patient toward the left of the image. Note the direction marks on the computed tomographic image in this patient (arrows). (b) Display direction of EUS images. Note that the endoscopic images and EUS images have an upside-down relation, but right and left directions correspond. These relationships are important to localize and describe lesions. (1) Display direction of EUS image in "NORMAL" mode; (2) Display direction of EUS image in "INVERSE" or reverse mode; (3) Endoscope image "up" direction; 4: EUS image "up" direction. (c) Radial EUS imaging in the upper GIT is traditionally done in the "NORMAL" orientation and corresponds to the computed tomographic images. Note that the aortic arch in this transesophageal study is depicted on the left side, similar to the computed tomographic orientation. (d) "INVERSE" or reverse orientation would flip the images, with the aortic arch now seen on the right side. The reverse orientation is seldom used in the upper gastrointestinal tract. (e) When imaging the anorectum in the "NORMAL" mode, radial EUS images are the reverse depiction of computed tomographic orientation. This is because the direction of the probe is from below upward. In the NORMAL mode, the patient's right side is depicted on the right side of the image. The pelvic organs are placed superiorly in the image, which now corresponds to the patient's anterior side. (f) To display images similar in orientation to the cross-sectional radiological images, use the "INVERSE" mode for anorectal imaging. In Figures 1e and f, note the yellow arrow on a small pararectal lymph node; the red arrow points out the image orientation indicator. For ease of understanding, the images in this review are created in the "NORMAL" mode

A digital examination is done first. The peri-anal area and anal canal should be visually evaluated for external fistula openings, external skin tags, fissures, prolapsed hemorrhoids, and any growth. On per-rectal examination with the finger, the resting and squeeze anal sphincter tone should be evaluated, any bogginess or focal tenderness should be looked for, and any growth within the reach of the finger should be palpated. Anal pathologies are very difficult to detect with EUS alone, and the operator should have a fair idea of what he/she is required to evaluate with preceding history and physical examination.

We prefer that a standard sigmoidoscopy should precede the EUS examination. This allows evaluation of bowel preparation, clear out any luminal residue for subsequent EUS examination, detect and define small lesions and mucosal changes, and judge any luminal stenosis. We often add a small amount of simethicone to the instilled water at this stage to "de-foam" the lumen.

After introducing the EUS probe, all the air is suctioned out, and the lumen is distended gradually with water instillation. Water instillation and balloon inflation help to flatten folds and aid the proximal advancement of the EUS probe. Foot-paddle-actuated water pump to flood the rectosigmoid lumen with water is a useful adjunct. Usually, 200–250 mL water instillation along with balloon insufflation is enough. Too much water instillation may mobilize stool in proximal colon or lead to patient evacuating during the procedure.

The direction of optical viewing field of the current flexible radial EUS probes is 55°

forward oblique (GF-UE160, Olympus) or end viewing (EG-3670URK, Pentax; EG-580UR, Fujinon). However, the optical direction of view and scope diameter does not make a difference in insertion depth of the probe. The flexible radial EUS probe can usually be introduced to the upper sigmoid or sigmoid-descending colon junction. Further negotiation is not necessary, and only small bowel loops will be visualized as the probe is advanced more proximally.

Imaging starts with slow deliberate withdrawal of the probe, without torque on the shaft. The big and small wheels are used as needed to keep the probe in the center of the lumen and at an adequate distance from the gastrointestinal wall for mural imaging. If the transducer is at an angle to the rectal wall, the rectal wall would be imaged tangentially. In the anal canal, contraction of the anal sphincters often induce asymmetry in the scan angle because of the flexible bending section of the instrument [Supplementary Figure 1]. This tangential imaging angle can lead to erroneous interpretation of anal sphincter dimensions and defects. Rigid rectal EUS probe does not suffer from this disadvantage.

For keeping the rectal wall at optimal focal distance from the probe, the lumen is slightly distended with water. The lumen may be collapsed if perirectal areas are to be imaged. Electronic image rotation is used to place the pelvic organs like bladder anteriorly. Now, the right side of the patient is to the right of the screen, and anterior is toward the top if imaging is done in the "NORMAL" mode [Figure 1e].

MURAL IMAGING

The rectum extends for around 15 cm above the anal verge. Typically, five layers of the rectal wall can be demarcated on EUS [Supplementary Figure 2]. There is no sonographic demarcation between the sigmoid colon and the rectum. However, in the sigmoid colon, the outer longitudinal layer is condensed into the *taenia coli*, and we cannot resolve the muscularis propria into two concentric layers. Careful EUS evaluation allows the *taenia coli* to be seen as focal thickening of the hypoechoic muscularis propria layer in the sigmoid [Supplementary Figure 3]. These areas of focal thickenings are best seen with the lumen collapsed. On distention, the wall of the sigmoid flattens out and the *taenia* are not distinguished. The *taenia* merge a few centimeters above the rectosigmoid junction to form a continuous outer layer of longitudinal muscle investing the entire length of the rectum, although no exact transition point can be made out.

The rectum contains the transverse folds of Houston. Although the number of these folds can vary, the middle fold is most constant, projecting from the right and anterior wall above the rectal ampulla. This fold lies below the level of the anterior peritoneal
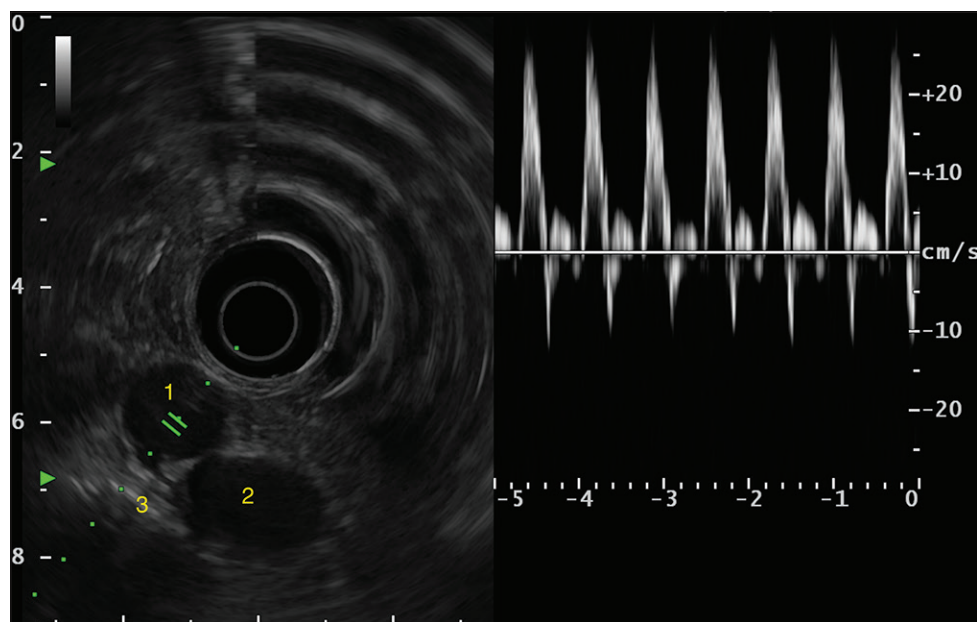

Figure 2. The flexible EUS probe can usually be advanced to above the pelvic brim. Cross-sections of the aorta and inferior vena cava are seen. The abdominal aorta ends at the left side of the body of 4th lumbar (L4) vertebra. The inferior vena cava is formed by the union of the common iliac veins on the right side of 5th lumbar (L5) vertebra. (1) Aorta; (2) Inferior vena cava; (3) Vertebra
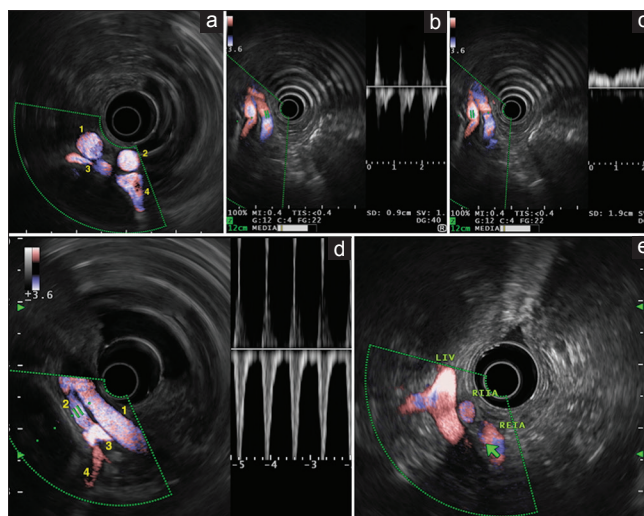
Figure 3. (a) The aorta is seen to divide into the left and right iliac arteries, seen in cross-section here. The two common iliac veins terminate into the inferior vena cava behind the right common iliac artery. The left common iliac vein lies medially and behind the corresponding artery. The right common iliac vein is behind and to the right of the corresponding artery. (1) Left common iliac artery; (2) Right common iliac artery; (3) Left common iliac vein; (4) Right common iliac vein. (b) As the probe is withdrawn, the right-sided iliac vessels can be traced; the left iliac vessels move away from the field of view. The right common iliac artery and vein are seen in long axis along the left and bottom of the screen, as the probe is slowly withdrawn. The artery is closer to the probe. (c) The right iliac vein is behind and lateral to the corresponding artery. The ala of the sacrum lies behind the common iliac vessels. (d) The right common iliac artery divides between the 5th lumbar (L5) vertebra and the sacrum, into the right external iliac and internal iliac (hypogastric) arteries. Here, we see the "fork-like" division of the right common iliac artery into its internal and external divisions. The external iliac artery is larger, anterior, and lateral, and is positioned closer of the two branches to the EUS probe. The internal iliac artery is smaller, medial, and posterior. Note that the internal iliac artery further divides into anterior and posterior divisions. The posterior branch leads to uterine, vesical, and rectal arteries. However, these individual branches cannot be defined and traced further. The body of ilium bone and the iliac muscle lies deep to these branches of the common iliac vessels. The ureter is related to the common iliac artery at its point of division, although it usually cannot be seen here. (1) Right external iliac artery; (2) Right internal iliac artery; (3) Anterior branch of right internal iliac artery; (4) Posterior branch of right internal iliac artery. (e) A different perspective of the right common iliac artery and vein divisions. LIV: Left internal iliac vein; RIIA: Right internal iliac artery; REIA: Right external iliac artery
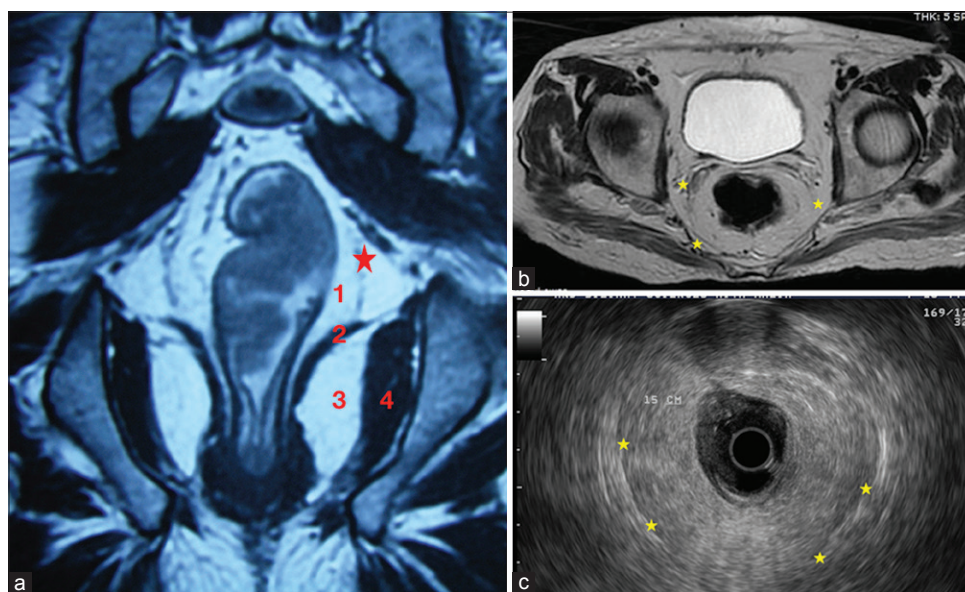

Figure 4. (a) Coronal T1-weighted magnetic resonance image of the pelvis showing the pelvic fascial compartments. Mesorectal fascia is marked by (★). The levator ani muscle separates the extraperitoneal pelvis into a supralevator or pelvirectal space above, and an ischiorectal space below. The obturator internus muscle corresponds to the lateral pelvic wall. (1) Mesorectum; (2) Levator ani; (3) Ischioanal/ischiorectal space; (4) Obturator internus. (b) The lower-third "extra-peritoneal rectum" is encircled by a variably thick fibro-fatty sheath of mesorectum containing perirectal lymph nodes, superior hemorrhoidal vessels, and fibrous tissue. The mesorectum and its external margin (fascia recti/propria) is clearly visible in patients when it is sufficiently fatty. In this axial T2-weighted magnetic resonance image of the pelvis, the rectum, perirectal fat, and mesorectal fascia are clearly seen. T2-weighted magnetic resonance image shows the mesorectal fascia as a low signal intensity layer (★) enveloping the high signal intensity mesorectal fat. (c) On EUS, a faint demarcation of the mesorectal fascia can be made out (★)

reflection. The rectal valves are obliterated by an inflated ultrasound balloon on the EUS probe and cannot be used as sonographic landmarks.

As we further withdraw slowly from the rectum to the anal canal, the inner circular layer of the rectal muscularis propria abruptly expands into the thick hypoechoic band of the internal anal sphincter (IAS). The outer hypoechoic longitudinal muscle layer continues down as the conjoint longitudinal muscle between the IAS and the external anal sphincter (EAS). This transition point of expansion of the inner circular muscle layer of the rectum into the IAS is well seen by real-time imaging and also marks the anorectal junction, besides the puborectalis sling. The anal wall structure is described below.

LOWER ABDOMINAL AND PELVIC VASCULATURE

The radial EUS probe is advanced to the sigmoid colon carefully under vision, as described previously.

If the probe has been advanced above the pelvic brim, small bowel loops with fluid and air artifacts are seen. The first identifiable structures to appear are usually seen in the left lower quadrant – these are the aorta and the inferior vena cava (IVC) or the iliac vessels [Figure 2]. Ileal loops and air artifacts are seen in the other quadrants at this level.

The aorta is to the left of the IVC on the screen, with the vertebral column or sacral brim seen as an echogenic curved structure behind these vessels [Figure 2]. Slight torque and withdrawal display the aortic bifurcation into the left and right common iliac arteries [Figure 3a]. As the scope is withdrawn, the right iliac vessels are displayed on the left half of the screen [Figures 3b and c]. The left iliac vessels move away from the transducer and cannot be traced further. The further divisions of the right iliac vessels into their internal and external divisions can usually be demonstrated [Figures 3d and e].
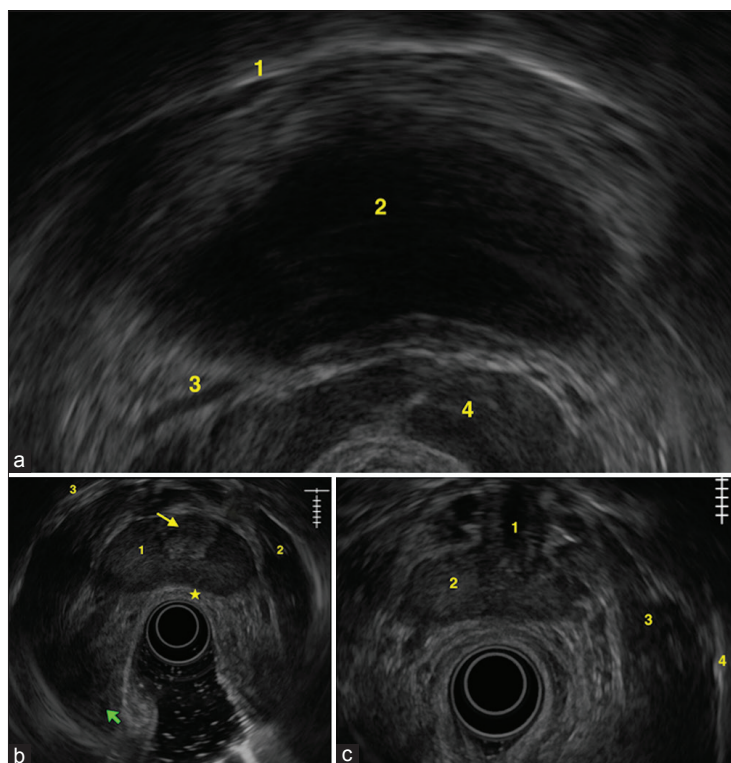

Figure 5. (a) The pelvic organs are placed superiorly in the image by electronic image rotation. Here, we see the bladder as a large anechoic structure, with the hyperechoic reflection of the pubic bones deep to it. The ureters may be seen entering the lateral aspect of the bladder. The seminal vesicles are seen behind and slightly below the bladder. (1) Pubis symphysis; (2) Bladder; (3) Left ureter; (4) Seminal vesicles. (b) Hyperechoic reflection of the symphysis pubis is seen anteriorly. The hyperechoic Denonvilliers fascia can be seen between the anterior rectal wall and the prostate and seminal vesicles (★). The obturator internus muscle which contributes to the lateral wall of the pelvic cavity is seen on both sides. The prostate is a walnut-shaped anterior organ below the bladder, with central and peripheral zones. The prostatic urethra can be made out in the center (arrow). (1) Prostate (peripheral zone); (2) Obturator internus muscle; (3) Symphysis pubis. (c): The penile or bulbar urethra turns anteriorly as an anechoic structure, with the corpus cavernosa on either side. (1) Penile urethra; (2) Prostate; (3) Obturator internus muscle; (4) Hyperechoic reflection of ischium
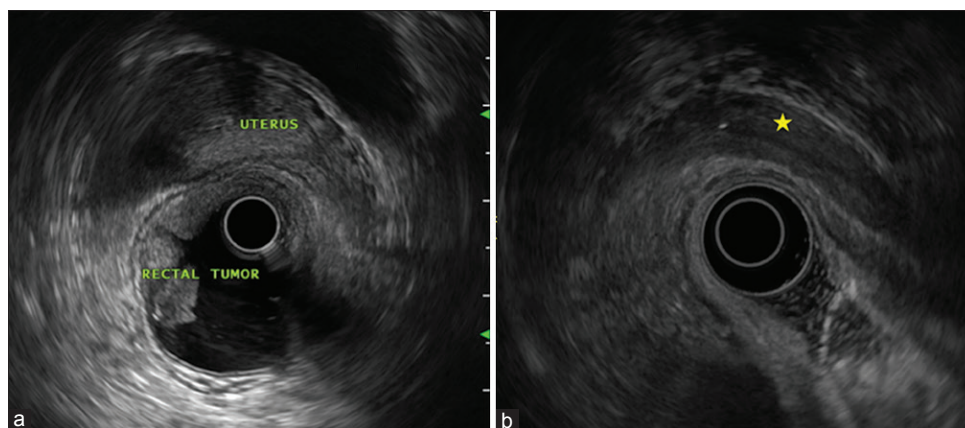
Figure 6. (a) The uterus is depicted across the rectum because of its asymmetric lie, and the lateral position of the patient. The uterine fundus is toward the left of the screen in this patient. The bladder is seen further away on the top. The peritoneum is reflected anteriorly from the rectum onto the posterior fornix of the vagina and the uterus, and then forward on to the posterosuperior surface of the bladder. (b) The upper vagina (★) is seen as a dark horizontal ellipse, with central air stripe. It is separated from the rectum by the rectovaginal septum
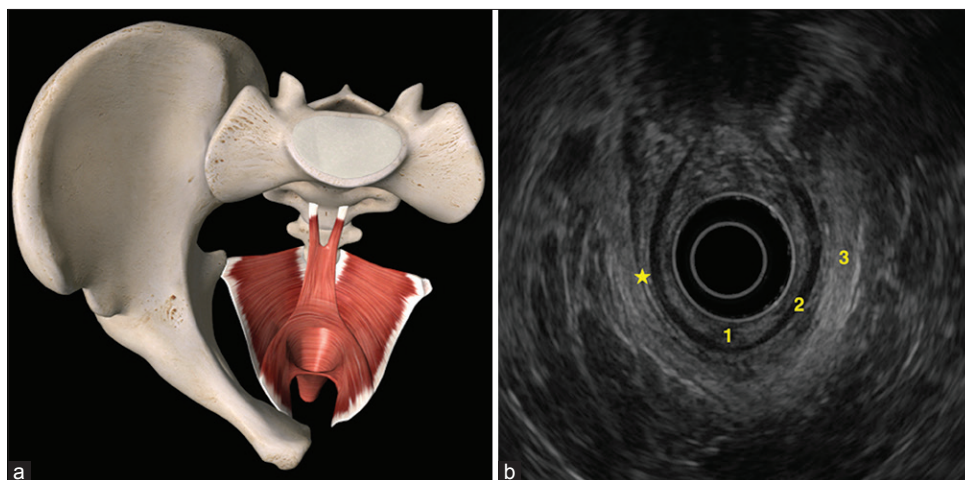

Figures 7. (a) The puborectalis portion of the levator ani muscles originates from the pubis and slings around the rectum. It is one of the three muscles which make up the levator-ani complex. (b) On EUS, the puborectalis muscle is seen as a U-shaped mixed echogenic band that slings around the rectoanal junction. This muscular sling maintains the anorectal angle. (1) Mucosa-submucosa complex of upper anal canal; (2) Internal anal sphincter; (3) Puborectalis sling. The conjoined longitudinal ligament is marked by (★)

PERITONEAL REFLECTION

It is not possible to definitely distinguish between the intraperitoneal and extraperitoneal rectum, unless small bowel loops are seen alongside the rectal image. In females, the anterior peritoneal reflection forms the rectouterine pouch of Douglas, 5–6 cm above the anorectal junction. In males, the level of peritoneal reflection (rectovesical pouch) is higher – 7–8 cm above the anorectal junction. On EUS, this corresponds to the level of seminal vesicles anteriorly. The rectovesical or rectouterine pouch can be visualized when they contain fluid. The obturator internus muscle and the internal iliac vessels, and the prostate in males, and uterus and vagina in females lie below the peritoneal reflection.

MESORECTUM

Surrounding the extraperitoneal rectum is the mesorectum containing fat, blood vessels, and nodes. The mesorectum tapers distally and extends inferiorly to the level of the levator ani. The rectum and the surrounding mesorectum are enclosed in a circumferential fascial layer known as the mesorectal fascia or fascia propria. The mesorectal fascia can be well defined on T2-weighted magnetic resonance imaging (MRI) [Figure 4a and b]. The mesorectal fascia can be sometimes distinguished as a circular thin fascia in the middle and lower rectum on EUS [Figure 4c]. Normal mesorectal lymph nodes are rarely larger than 3 mm. Since they have an echo pattern similar to the surrounding fat, they are normally not imaged.
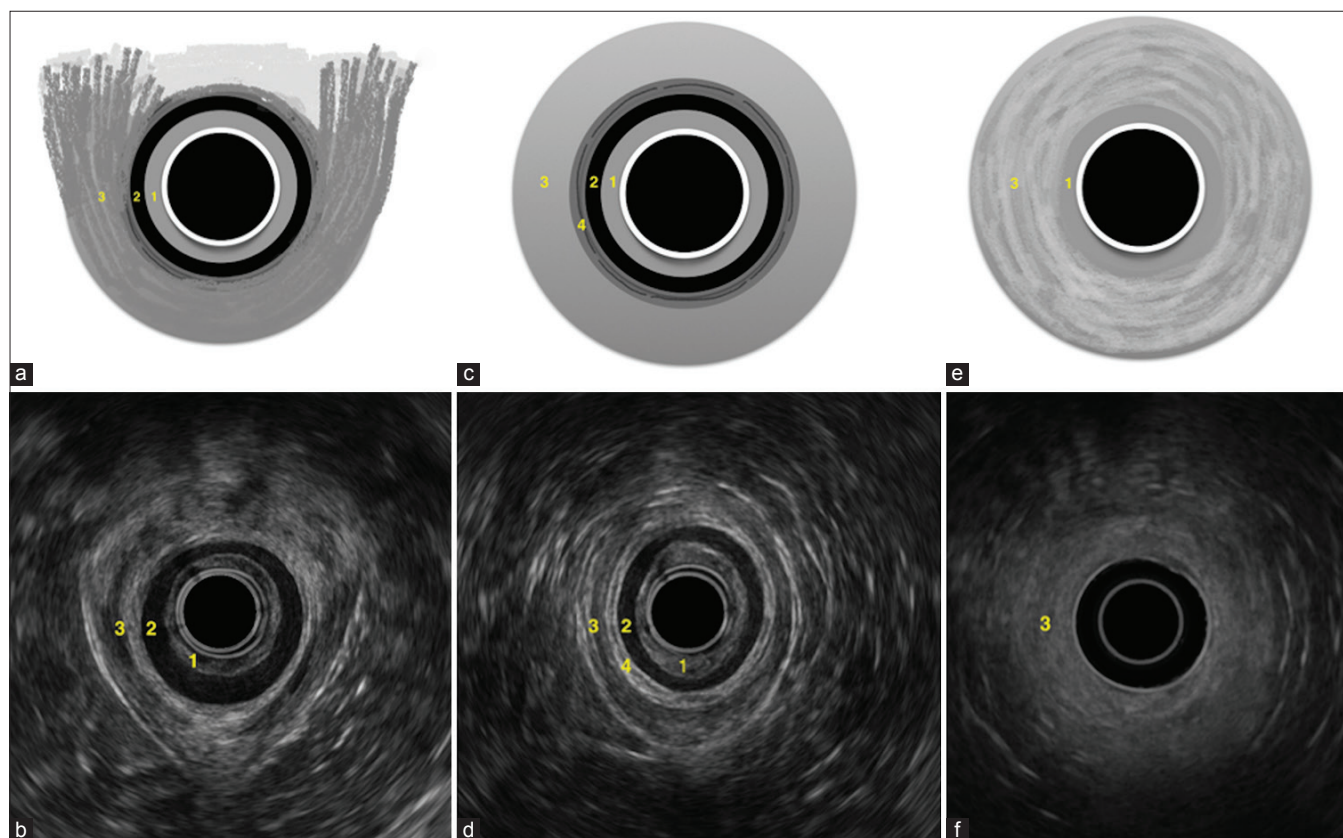
Figures 8. Schematic representation and EUS images of the anal canal. The anal canal can be divided into upper, middle, and lower-thirds. (a and b) The upper third of the anal canal is identified by a complete ring of hypoechoic internal anal sphincter, a hyperechoic sling of puborectalis posteriorly and laterally, and absence of the external anal sphincter in the midline anteriorly. (c and d) The puborectalis is continuous with the striated external anal sphincter , and this ring of external anal sphincter closes anteriorly in the middle third of the anal canal. In addition, the internal anal sphincter is thickest in this part. (e and f) In the lower third of the anal canal, the internal anal sphincter is not seen, and the hyperechoic external anal sphincter is the only circular muscle around the anal canal. The mixed echogenicity fibers of the median conjoint ligament are difficult to demarcate clearly from the hyperechoic external anal sphincter. They thin out distally in the lower third of the anal canal. The space around the anal canal is the ischioanal space. (1) Mucosa-submucosa complex; (2) Internal anal sphincter; (3) Striated muscle of puborectalis and external anal sphincter; (4) Median conjoint ligament

The mesorectal fascia becomes contiguous anteriorly with the Denonvilliers' fascia, which passes between the rectum and the prostate and seminal vesicles in males [Figure 5b] and the vagina in females (when it is also called the rectovaginal septum) [Figure 6b]. Around the mesorectal fascia is a thin and relatively avascular layer of loose areolar tissue, which separates it from the posterior and lateral walls of the true pelvis.

PELVIC SIDE WALLS AND PELVIC FLOOR

The obturator internus muscle is seen along the lateral pelvic wall [Figures 5a and b], with the echogenic ischium bone (part of the bony pelvis) outside of it. The pelvic floor consists of the sheet like levator ani muscle, which is constituted by three muscles: puborectalis, pubococcygeus, and iliococcygeus muscles. The levator ani is attached laterally to the obturator fascia along the side walls of the pelvis. The puborectalis component of the levator ani is the sonographic landmark for the anorectal junction [Figures 7a and b]. The anorectal junction is slightly below the tip of the coccyx and level with the apex of the prostate in males.

PELVIC ORGANS

As the EUS probe is withdrawn, the bladder is visualized first as a large anechoic structure. The EUS image is electronically rotated to display the bladder on the top of the image, which now corresponds to the patient's anterior side. In well-hydrated patients, the ureters can sometimes be seen entering the bladder from the lateral side, with urine seen flowing inside [Figures 5a]. Small ureterovesical junction stones may be seen here. In catheterized patients, the bladder can be recognized by the inflated Foley's balloon.

In male patients, the seminal vesicles can be seen just below and behind the bladder, at 6–7 cm from the anal verge. These moustache-shaped structures can

superficially resemble enlarged lymph nodes [Figure 5a]. They are variable in size and can be large in men who have not ejaculated for some time. The prostate is a walnut-shaped structure with the prostatic urethra inside the median lobe [Figure 5b and c]. The lateral thirds of the prostate comprise the lateral lobes. The inferolateral surface of the prostate is in contact with the levator ani muscles. Calcifications are common in prostates of older men. The prostatic urethra turns anteriorly (to the top of the screen), as an echo-free structure; the bulbous or the penile urethra is shown in Figure 5c [Video 1].

In female patients, the uterus is seen just below the bladder. The lie of uterus is usually asymmetrical, and this organ is seen to extend across the anterior rectum, with the fundus to one side [Figure 6a]. Calcifications may be seen in the uterus, but it is difficult to define myometrial or endometrial pathologies on EUS. The cervix is seen as a localized expansion on one side; Nabothian cysts may be seen here. The vagina is immediately below the uterus and is seen as a dark horizontal ellipse. It is recognized by an air stripe between its walls [Figure 6b and Video 2].

Perineal body separates the anus from the vagina in women. In men, it separates the anal canal from the membranous urethra. The perineal body is an ill-defined connective tissue structure and is not seen on EUS as a distinct structure. It is the central portion of the perineum where the EAS, the bulbospongiosus, and the superficial and deep transverse perineal muscle meet. Thickness of the perineal body can be estimated as the distance between the sonographic reflection of a gloved fingertip in the vagina and the inner border of the IAS at the level of the mid-anal canal. Normal perineal body thickness is >12 mm. Perineal body measurement may improve evaluation of anterior anal sphincter defects in females.

Adnexal pathologies, especially ovarian cysts and tumors can have a very varied and confusing appearance on EUS and are usually difficult to image.

ANAL CANAL

For evaluation of the anal canal, a balloon is not necessary. The anal canal is 2–5 cm long, with the puborectalis muscle marking the demarcation between the rectum and anal canal. The puborectalis muscle is recognized on EUS as an echogenic band with fine longitudinal striations, diverging anteriorly toward the pubis symphysis [Figures 7a and b]. The anal canal can be divided into three continuous segments, based on the anal sphincters [Figures 8a-f]. Inside the muscular rings of the anal canal is the mucosa–submucosa complex of the anal canal, seen as a mixed echogenic layer. This layer includes the anoderm below the dentate line, and the columnar mucosa with the subjacent submucosal layer above the dentate line. The mucosa cannot be identified separately from the submucosa in the anal canal, at the frequencies used. The endoscopically evident landmarks of the anal canal, namely the dentate line, anal papillae, and the hemorrhoidal cushions are not seen on EUS.

As described above, the inner circular muscle of the rectum thickens in the anal canal to continue as the IAS. The IAS is clearly seen as a circular hypoechoic band in the upper two-thirds of the anal canal [Figure 8a-d].

The intersphincteric space is a potential space between the IAS and the EAS and contains the conjoint longitudinal muscle layer along with anal glands. The intersphincteric space is the location for intersphincteric abscesses. The conjoint longitudinal muscle is the downward continuation of the outer longitudinal muscle of the rectum in the anal canal. The intersphincteric space or the longitudinal muscle layer is difficult to demarcate from the EAS and is often measured along with it.

The EAS is a skeletal muscle, and is seen as a hyperechoic layer with fine parallel fibrillar pattern. It has three parts: deep, superficial, and subcutaneous. The deep or the uppermost fibers of EAS blend with the lower medial fibers of puborectalis. The superficial or middle part of the EAS forms a complete ring around the anal canal [Figures 8c-f]. The middle part of the EAS anchors to the perineal body anteriorly and the anococcygeal raphe posteriorly [Supplementary Figure 4], helping to "suspend" the EAS around the smooth muscle layer of the IAS. The lowermost or the subcutaneous part of the EAS extends approximately 1 cm below the termination of the IAS and surrounds the anal aperture [Video 3].

The normal thickness of the EAS and the IAS are 4–10 mm and 2–4 mm, respectively, as measured on EUS. The borders of the EAS are more difficult to define. With age, the IAS gets slightly thicker, and the EAS gets slightly thinner as measured by transrectal EUS and endoanal MRI.

CONCLUSION

Anorectal and pelvic anatomy is simple to define by the flexible radial EUS probe. Flexible EUS probes can be advanced to well above the pelvic brim and allow interrogation of majority of pelvic pathologies, and interface with other specialties such as urology, gynecology, and surgery. It is imperative that this technology is more widely dispersed in gastroenterology practice.
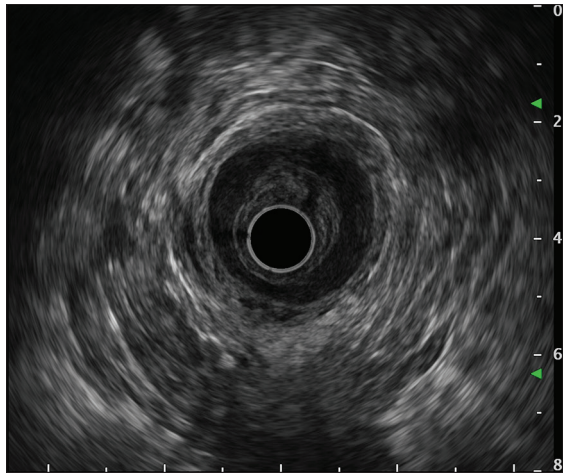
Supplementary materials
Supplementary information is linked to the online version of the paper on the *Endoscopic Ultrasound* website.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

Supplementary Figure 1. If the EUS probe is nonperpendicular to the lumen being imaged, asymmetrical or tangential imaging results. Especially in the anal canal, vigorous sphincter contractions can easily misalign a flexible EUS probe. This can lead to errors in interpretation of sphincter defects and tumor staging
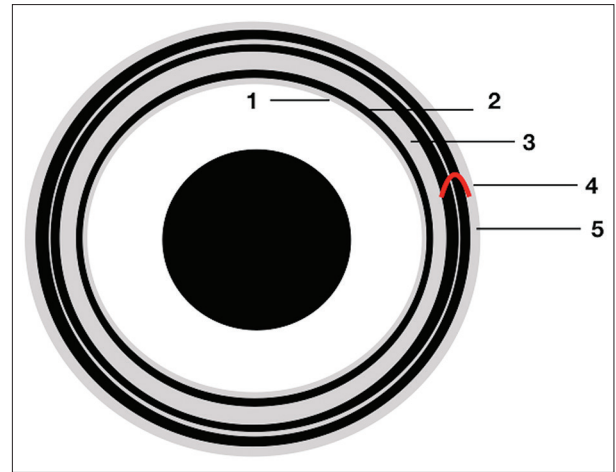
Supplementary Figure 2. The rectal wall can be resolved into five layers at usual imaging frequencies. From inner to outermost layer, they correspond to (1) interface of the balloon/water with the mucosa (hyperechoic), (2) deep mucosa and muscularis mucosa (hypoechoic), (3) submucosa (hyperechoic), (4) muscularis propria (hypoechoic), and (5) serosa and perirectal fat (hyperechoic). With the current transducers, the muscularis propria of the rectum can usually be resolved into two concentric hypoechoic layers denoting the inner circular and outer longitudinal smooth muscle layers
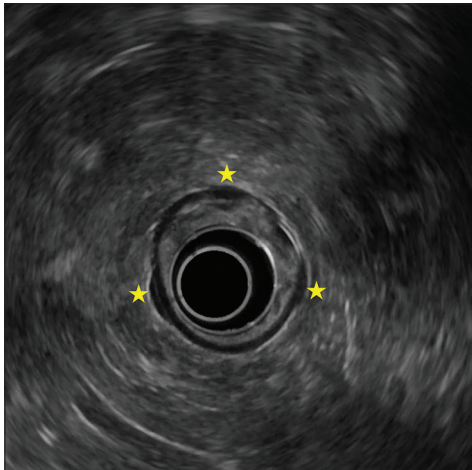
Supplementary Figure 3. The outer longitudinal muscle in the colonic wall, upstream of rectum is pleated into focal longitudinal muscle bands called *taenia coli*. On careful EUS examination of the collapsed sigmoid colon, these are seen as focal thickenings of the muscularis propria layer (★)
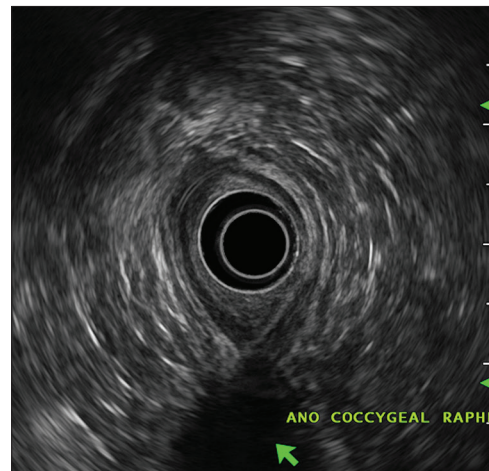
Supplementary Figure 4. The anococcygeal ligament appears as a hypoechoic triangle posteriorly. It attaches the external anal sphincter of the anal canal to the coccyx posteriorly. The anococcygeal ligament is inferior to the levator-ani and should not be mistaken for a midline posterior sphincter defect