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Applications of Anorectal Ultrasound in Anorectal Disorders

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Abstract

Endoanal ultrasound (EAUS) and endorectal ultrasound (ERUS) have been introduced to clinical use since the 1980s. The techniques have been used to assess various anorectal disorders and conditions, including anorectal abscess and fistula, fecal incontinence, anorectal tumor, anorectal pain and occasionally evaluation of adjacent pelvic pathology. Information acquired includes anatomical location of disease, extent of disease, involvement of anal sphincter by disease and the status of anal sphincter. This information is valuable for treatment planning, prevention of disease recurrence, prevention and/or correction of sphincter defect and follow-up evaluation. The technique is cheap, simple, well tolerated, and repeatable with acceptable accuracy. Although the interpretation is operator-dependent, technology has developed to improved image quality such as 3D-reconstruction, peroxide-enhanced technique and volume render mode. This chapter reviews the current application of anorectal ultrasound in the common anorectal disorders.

Keywords: endoanal ultrasound, endorectal ultrasound, transanal ultrasound, transrectal ultrasound, anorectal disorder

1. Introduction

Endoanorectal ultrasound (EARUS) was first described in 1956 by Wild and Reid but was not popularized due to technological limitations [1]. Law and Bartram, in 1989, had described the technique of endoanal ultrasound (EAUS) using 2D-plastic-coned probe [1, 2] and correlated the image with histological findings of the anal canal [1]. Early use of endoectal ultrasound (ERUS) is mostly by urologist to demonstrate bladder, prostate and seminal vesicle. Pahlman et al. [3] had used rectal ultrasound for preoperative staging of rectal tumor. Konishi et al. [4],

Anorectal disorders	EAUS*	ERUS**
Anorectal sepsis: abscess/fistula	✓	=
Fecal incontinence	✓	-
Anal sphincter injury	✓	-
Anorectal pain/pelvic pain	✓	✓
Anal cancer	✓	✓
Rectal cancer	-	✓
Pelvic pathology: retrorectal/gynecological/prostate	-	✓

*EAUS: endoanal ultrasound.
**ERUS: endorectal ultrasound.

Table 1. Anorectal disorder which endoanal and endorectal ultrasound can be used.

had used ERUS to assess the depth of rectal tumor invasion in order to select the patient for local excision. However, the resolution was limited by the machine frequency [4]. After sequential developments, EARUS has become an important part of the assessment for various anorectal conditions, both benign and malignant. The operator may be a radiologist, gastroenterologist or surgeon [5].

Currently, sonography for viewing anorectal region can be performed transanally, transvaginally or transperineally [6]. Here, the focus is on the transanal technique. It is well tolerated by most patients, needs minimal preparation, no radiation exposure and can be performed in the office setting [5] and in both genders. **Table 1** categorizes anorectal disorders that could be assessed by EARUS.

2. Equipment, technique and normal anatomy

Anal canal is defined functionally from the proximal aspect of the internal anal sphincter (IAS)/levator ani muscle above down to the anal verge below [7]. This area is surrounded by IAS and external anal sphincter (EAS) [7] which persistently contract. Thus, the probe is usually in close contact with the wall of the anal canal. However, in the rectum above, the water-filled balloon is used as a conduction media from the transducer to the rectal wall.

The examining position can be left lateral decubitus, lithotomy or prone jackknife position [8]. Bowel preparation or sedation is not required except in the presence of fecal impaction or severe anorectal pain, respectively. After careful digital rectal examination, the probe is lubricated and gently inserted into the anal canal. Standard orientation is that the anterior part of the patient is at 12 o'clock, posterior part at 6 o'clock, right side at 9 o'clock, and left side at 3 o'clock [8]. If it is a two-dimensional probe, the examiner should manually advance and withdraw the probe to demonstrate each anatomical level. If it is a three-dimensional probe, the examiner should hold the probe steadily in the middle of the anal canal while the image is acquired. The three planes of analysis are (1) the deeper plane: at the upper level of anal canal where the typical hyperechoic U-shaped sling of the puborectalis muscle is seen

(2) the intermediate plane: at the middle level of anal canal where the hypoechoic IAS, the perineal body and the transverse perineal muscle are seen and EAS forms a complete ring
(3) the superficial plane: at the lower level of the anal canal where IAS has terminated and only hyperechoic subcutaneous part of the EAS is seen [2, 9]. **Figure 1** demonstrates normal endoanal ultrasonographic views of the anal canal at each level.

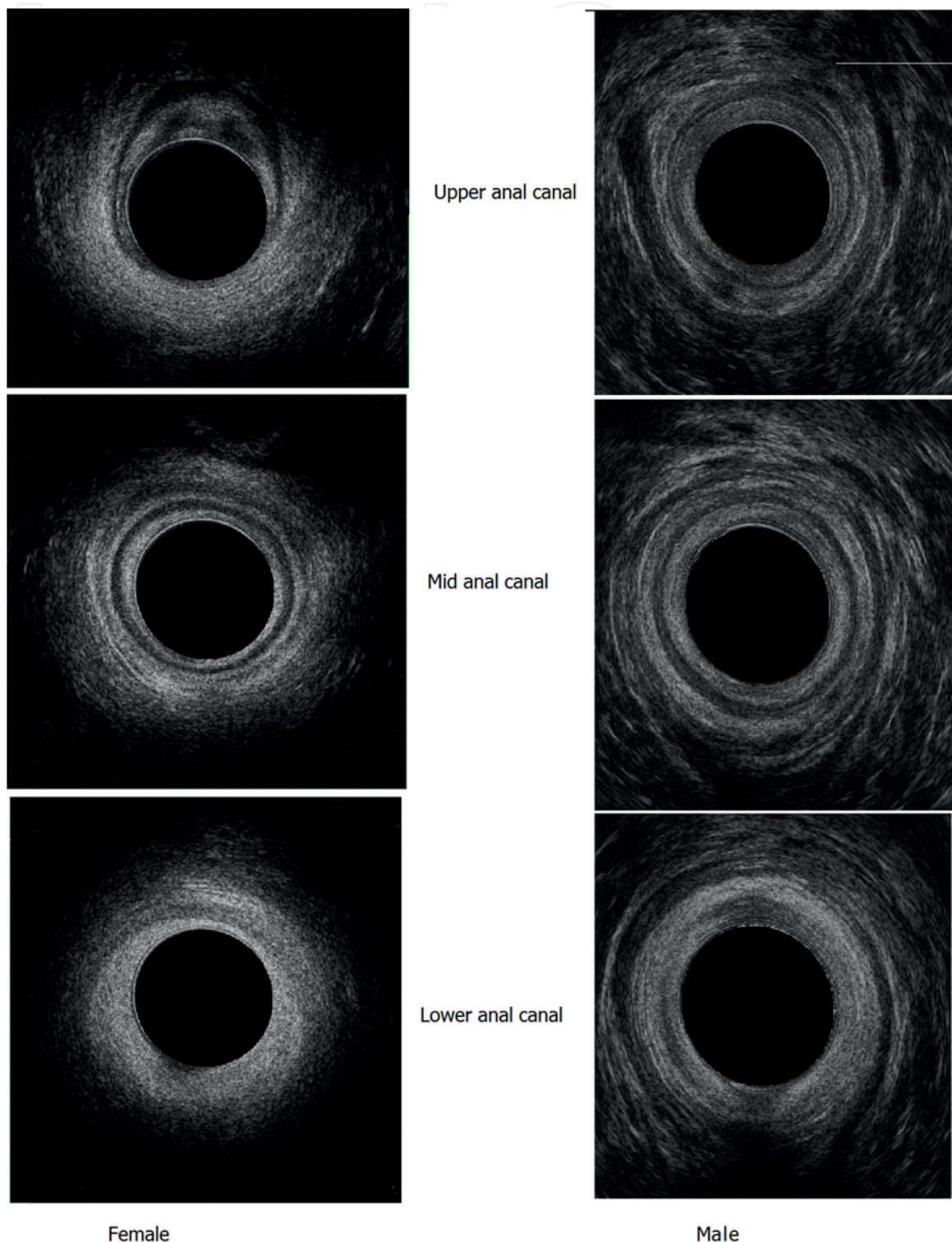


Figure 1. Normal endoanal ultrasonographic views of anal canal at three levels—left: in female and right: in male.



Figure 2. Endorectal ultrasonographic view of rectal wall (five layers).

Endorectal ultrasound (ERUS) views the rectal wall as alternating five hyper- and hypo-echoic layers (**Figure 2**). From the lumen outward, the innermost white (hyperechoic) layer represents the interface between the balloon and rectal mucosa. The inner dark (hypoechoic) layer represents the mucosa and muscularis mucosae. The middle white (hyperechoic) layer represents the submucosa. The outer dark (hypoechoic) layer represents the muscularis propria. The outer white (hyperechoic) layer represents the interface between the muscularis propria and perirectal fat/serosa [10, 11]. These rings should be smooth, homogenous and complete.

3. Application of endoanorectal ultrasound

3.1. Endoanal ultrasound in anorectal abscess and fistula

Most anorectal sepsis are caused by the infection of the anal gland which normally drains into anal crypts, known as cryptoglandular theory [12]. In the acute phase, the suppuration loculated in the potential space around the anus: *perianal* (or subanodermal), *intersphincteric*, *ischiorectal* (or ischioanal) and *supralelevator abscesses* [13, 14]. In the chronic phase, the suppuration takes a course between and through anal sphincter muscles to find the exit in the perianal skin. The most commonly used classification of the anorectal fistula is Park's classification [12, 15]: *intersphincteric fistula* (primary tract courses in the intersphincteric space down to the skin), *transsphincteric fistula* (primary tract traverses the EAS to enter the ischioanal fossa before exit at the skin), *suprasphincteric* (primary tract courses up within the intersphincteric plane above and over the puborectalis muscle before coursing back into ischioanal fossa downwards to the exit at the skin), *extrasphincteric fistula* (primary tract traverses levator ani to course through the ischioanal space without relation with IAS and EAS) [15]. Another additional subtype courses in the submucosa without traversing IAS or EAS is called *subcutaneous fistula* [15]. Perianal sepsis that arises from noncryptoglandular causes, such as Crohn's disease, tuberculosis, rectovaginal fistula, traumatic injury or in patients after previous anorectal surgery, may have more complex courses of the fistula and related abscess.

Preoperative imaging aims to reduce the risk of postoperative recurrences and fecal incontinence [16]. Endoanal ultrasound (EAUS) is a safe and reliable technique for the assessment of perianal sepsis [17]. With three-dimensional technology (3D-EAUS), the accuracy in identifying primary fistula type, internal opening, secondary tract and adjacent abscesses was improved from a two-dimensional view (2D-EAUS) [18]. Fistula and abscess are hypoechoic tracts or lesion within the anal wall [19]. From meta-analysis of the early studies, sensitivity and specificity for fistula detection of EAUS versus MRI were 87 versus 87% and 43 versus 69%, respectively [20]. In the identification of internal opening, sensitivity of EAUS versus MRI was 88–91% versus 19–97% and specificity of 41–100% versus 71–100% [20].

Injection of hydrogen peroxide into the external opening of the fistula has significantly improved the visualization of the fistula tract [16] as it would form into small air bubbles which show as bright hyperechoic (white) tracts [16]. The technique provided better detection of internal opening, fistula level, secondary tract and chronic fistula cavity [21, 22]. Addition of image-enhanced technology as volume rendering to the 3D-EAUS further improved the accuracy of preoperative fistula study [23, 24]. **Figure 3a** is an example of EAUS in demonstrating the horseshoe fistula using the 3D technique, hydrogen peroxide injection and volume render mode. **Figure 3b** compares the 3D-EAUS view with the rendered view of postanal space abscess.

The accuracy of EAUS in evaluation of the recurrent anorectal fistula did not significantly decrease compared to primary anorectal fistula [25]. Another useful information for planning the fistula operation, obtained during EAUS, is whether there is any anal sphincter defect(s) [25].

In Crohn-related anorectal fistula, there was no significant difference between 3D-EAUS versus MRI in detection of anorectal fistula: sensitivity, 98 versus 91%; specificity, 100 versus 100% and accuracy, 98 versus 92% [26]. While 3D-EAUS was preferable in the detection of the intersphincteric fistula, MRI was preferable in evaluation of suprasphincteric and extrasphincteric fistula [26]. EAUS technique is simple, inexpensive and well tolerated by the patient [27] and more available than MRI [28]. Thus, it is recommended as a modality for assessment of patients with occult anorectal abscess, complex anal fistula or perianal Crohn's disease [28, 29].

3.2. Endoanal ultrasound in fecal incontinence and anal sphincter injury

Fecal incontinence (FI) is a disturbing condition that greatly impacts the patient's quality of life. The anatomical causes are anal sphincter disruption or atrophy which could occur as a result of vaginal delivery, surgery, trauma or aging. EAUS is a gold standard and has an established role in defining anal sphincter anatomy and defect in the assessment of patients with FI [30–32]. Information from EAUS includes EAS/IAS/puborectalis muscle integrity, length and thickness. A comparison to the normative value may explain the possible cause(s) of incontinence [33, 34]. FI was found to be associated with anal sphincter length and thickness rather than volume [33]. IAS defect appears as a discontinuity of the hypoechoic band or localized thinning. There was a significant correlation between decreased maximal resting anal sphincter pressure and decreased IAS thickness or presence of IAS defect [35]. EAS defect appears as a discontinuity in the hyperechoic band of EAS. EAS defect or thinning was

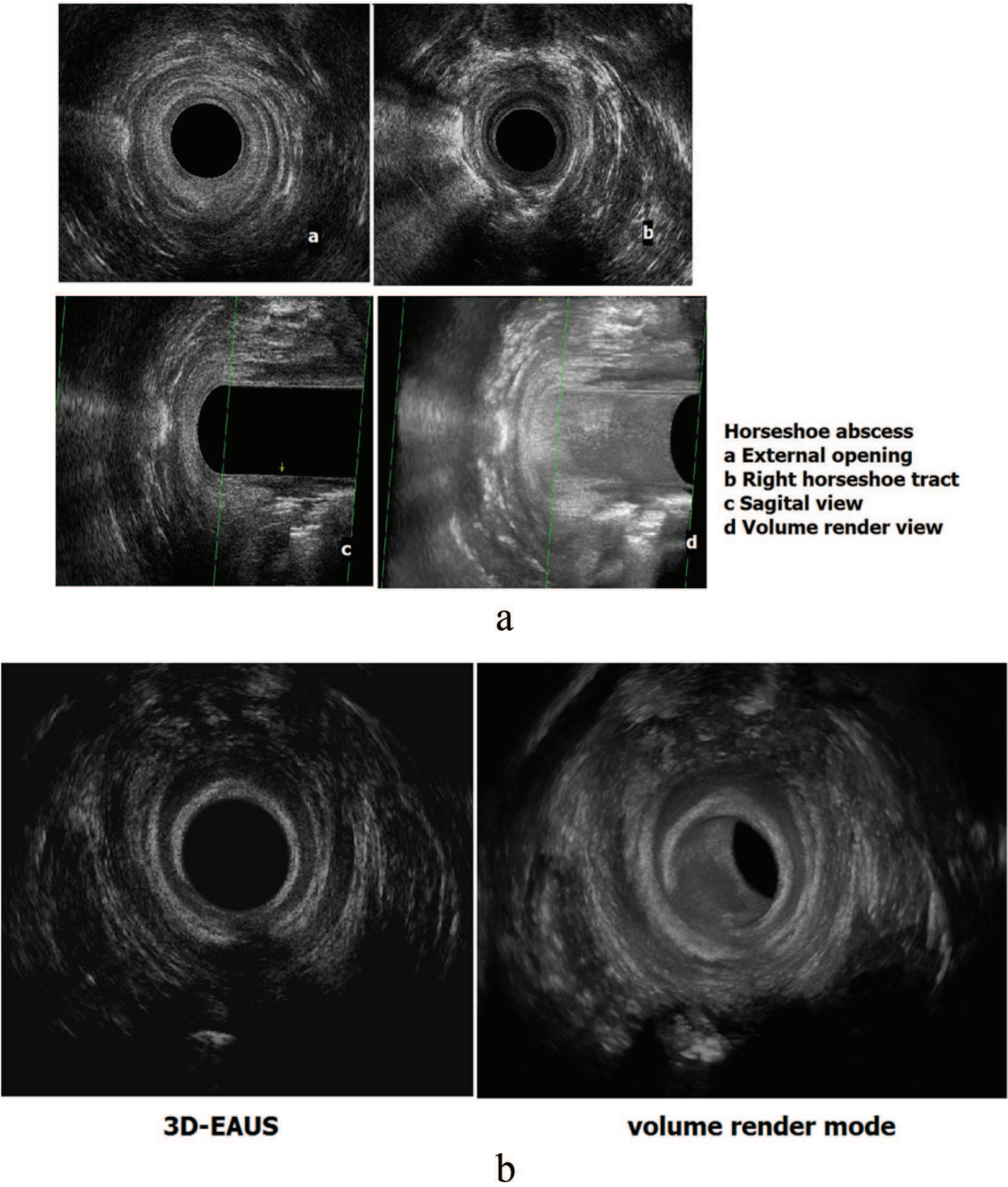


Figure 3. a. Endoanal ultrasound view of the right horseshoe fistula. b. 3D-EAUS view with the rendered view of postanal space abscess.

significantly correlated with maximal squeeze pressure [36]. In females, perineal body thickness measurement should be performed. The thickness of 10 mm or less is considered abnormal [37]. **Figure 4a** shows the EAUS view of anterior anal sphincter defect (most commonly found in obstetric injury) and **Figure 4b** demonstrates the perineal body measurement by

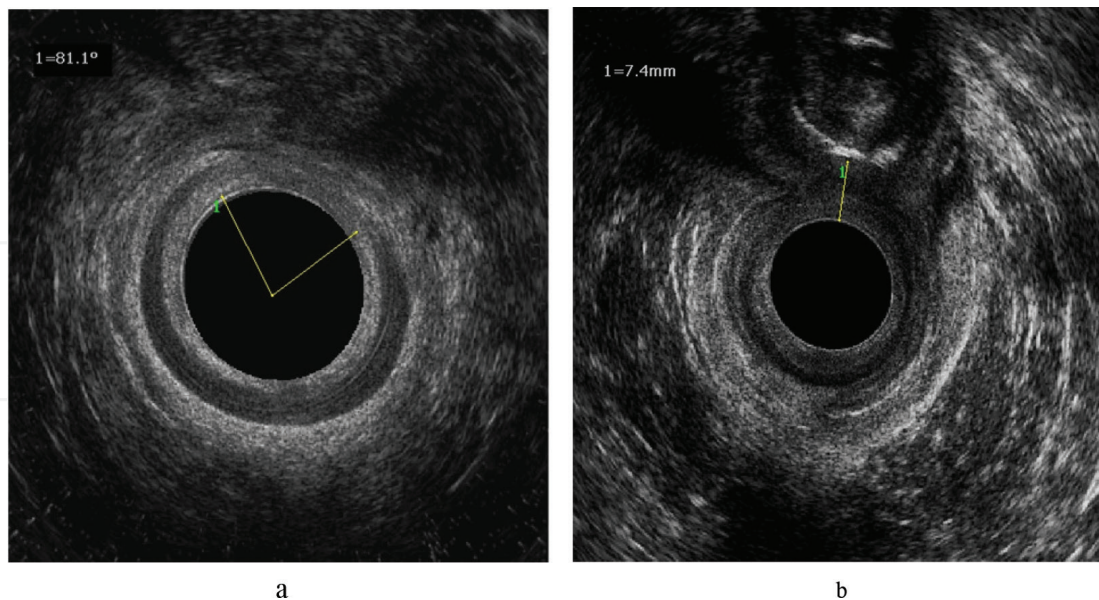


Figure 4. a. Endoanal ultrasound view of anterior anal sphincter defect; IAS defect seen as the discontinuity of the hypoechoic (dark) ring and EAS defect seen as the discontinuity of the hyperechoic (white) ring. b. Perineal body measurement; the hyperechoic shadow is the examiner's index finger that presses against the patient's posterior vaginal wall.

inserting the examiner's index finger into the patient's vagina and gently pressing on the posterior wall. Compared to MRI, 3D-EAUS can also be used to detect EAS atrophy and defects [38]. By MRI, EAS atrophy is defined as diffuse thinning of EAS or diffuse replacement of EAS by fat [38]. By EAUS, EAS atrophy is defined by the visibility of the outer interface between EAS border and subadventitial fat, reflection pattern and length [38]. The atrophic EAS could not be clearly differentiated from the subadventitial fat, has a hyperechogenic reflection, and is short [38].

In the patient who has sustained anorectal and perineal trauma, a thorough assessment of anorectal anatomy and function should be performed after the patient recovers and regains the ability to go to the toilet [39]. The preferred anorectal imaging is EAUS as the sensitivity for evaluation of anal sphincter defect is nearly 100%, better identification of IAS injury than MRI, less time-consuming and less expensive than MRI [39]. Together with the information from anorectal manometry and pudendal terminal motor latency test, a definitive treatment can be planned [30, 39].

3.3. Endoanal ultrasound in the assessment of anorectal dysfunction

3D-EAUS can be used to evaluate patients with obstructed defecation by steps of scan described by Murad-Regadas, called "echodefecography" [40]. Using this technique, anismus, anorectocele and rectal intussusception can be identified with moderate to high agreement with defecography [40]. Recent studies showed that echocardiography alone [41] or in combination with transvaginal and transperineal ultrasound is an effective and useful non-invasive test in evaluation of the patients with pelvic floor dysfunction including obstructed defecation and pelvic organ prolapse [42, 43].

3.4. Endorectal ultrasound in rectal cancer

Evaluation of rectal tumor is essential for planning the treatment. Carcinoma is seen as a hypoechoic lesion disrupting or penetrating through the rectal wall layers [11]. Villous adenoma can be classified as **uT0** lesion which does not penetrate the submucosa [11]. In situ, carcinoma (pTis) could not be differentiated from the benign adenoma using the ultrasound imaging alone [11]. A **uT1** tumor invades the submucosal layer and may be divided into uT1-slight, if only slight irregularity of the submucosa is seen, and uT1-massive, if massive irregularity of the submucosa is seen. A **uT2** tumor invades the outer hypoechoic muscular layer but with intact perirectal fat interface. A **uT3** tumor infiltrates the submucosal layer and presents as irregularity of the outer hyperechoic layer. A **uT4** tumor invades the adjacent organs such as bladder, uterus, cervix, vagina, prostate and seminal vesicles. Perirectal lymph nodes that are likely involved by the malignant cells are greater than 5 mm in size, have mixed echogenicity, irregular margins and are spherical rather than ovoid or flat [11]. **Figure 5a** demonstrates ERUS view of villous adenoma which shows no invasion of the hyperechoic middle submucosal layer. **Figure 5b** and **c** shows uT1 and uT3N1 lesions, respectively. This preoperative locoregional staging information can be used in treatment planning, whether local excision, oncologic resection or preoperative chemoradiotherapy would be appropriate.

In grossly benign rectal adenoma planning for local removal, additional ERUS may detect up to 81% of focal invasive carcinoma [44]. If the routine use of ERUS for biopsy-negative rectal adenomas is applied, the false-negative rate would be decreased from 24 to 5% and would allow better operative planning [44]. The accuracy of uT0 was 87% [45]. For other T-stages, the accuracy of preoperative uT staging is 94, 77 and 83% for T2, T3, T4, respectively [46]. From meta-analysis and a recent study [47, 48], the sensitivity and specificity for each T stages are as follows:

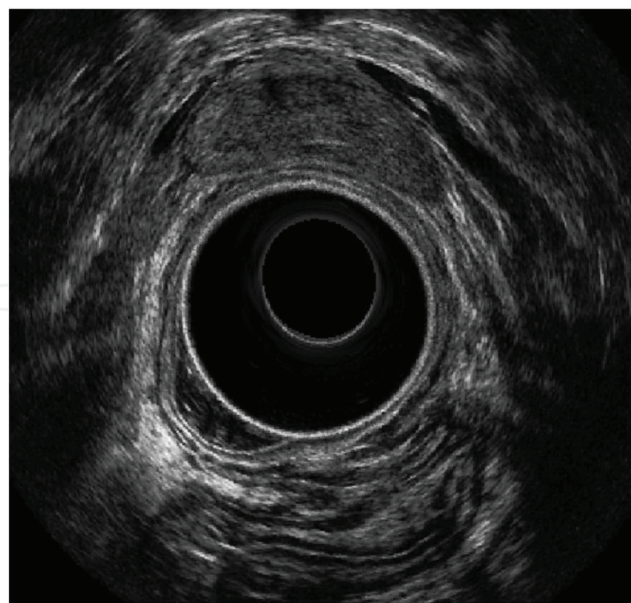
Sensitivity: 96, 88, 81, 96 and 95% for T0, T1, T2, T3 and T4, respectively.

Specificity: 87, 93, 96, 91 and 98% for T0, T1, T2, T3 and T4, respectively.

The concern of ERUS is that the overstaging of 18% and understaging of 13% has been reported [45]. With three-dimensional ERUS (3D-ERUS), the examiner can evaluate the arbitrary planes from any direction [49]. This improves the sensitivity, specificity and accuracy of the test [50]. For example, the sensitivity for detection of T4 is up to 100% and the specificity for T1 was 97% [50]. The total overstaging and understaging were reduced to 4.5 and 6.8%, respectively [50].

For lymph node staging, the accuracy of ERUS had been reported from 68 to 79% [45, 51]. Sensitivity and specificity were between 71 and 80% and 63 and 79%, respectively [52]. With 3D-ERUS, the accuracy improved up to 85–96% [53, 54]. Recent meta-analysis, including both 2D- and 3D-techniques, reveals sensitivity and specificity of 95 and 80%, respectively [55]. The diagnostic accuracy of ERUS for N-stage is comparable to CT and MRI [56]. Nothing is reliable in the evaluation of lymph node metastasis.

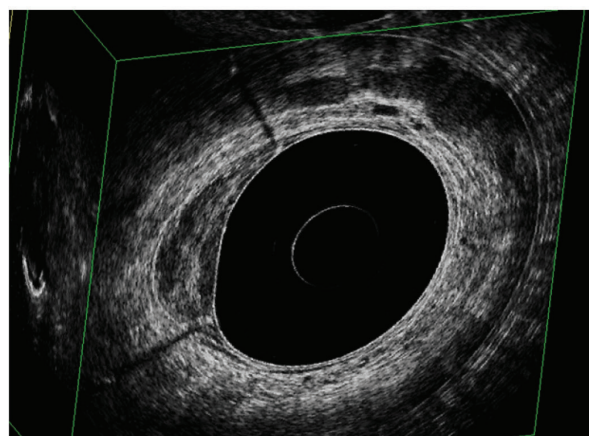
ERUS has substantial agreement with MRI and surgical pathology in predicting the radial tumor-mesorectal margin [56, 57]. From the available data, a combination of ERUS and MRI is recommended for pretreatment assessment of rectal cancer [58–60]. For postneoadjuvant chemoradiotherapy (CRT) evaluation, the accuracy to assess complete tumor response of



Villous adenoma

Expansion of inner hypoechoic layer (mucosa) with intact middle hyperechoic layer

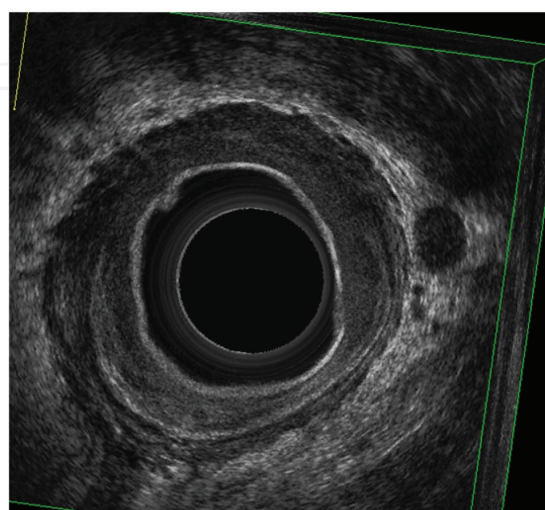
a



uT1 cancer

Submucosa (middle hyperechoic layer) is invaded but the muscularis propria (outer hypoechoic layer) is still intact

b



uT3N1 cancer

Perirectal fat (outer hyperechoic layer) infiltration (breaching) is seen with enlarged round hypoechoic lymph node

c

Figure 5. a. Villous adenoma, b. uT1 rectal cancer, and c. uT3N1 lesions.

ERUS, MRI and CT was 82, 75 and 83%, respectively [61]. The accuracy to detect T4 tumors with invasion to the circumferential margin was 94 and 88% for ERUS and MRI, respectively [61]. The accuracy for lymph node restaging was 72, 72 and 65% for ERUS, MRI and CT, respectively [61]. These are considered low and with no clinical relevance [61]. However, ERUS, if sequentially performed before, during and at 6–8 weeks after CRT, may predict therapeutic efficacy for locally advanced rectal cancer [62].

3.5. Endoanal-endorectal ultrasound for anal cancer

EAUS/ERUS evaluation of anal carcinoma has not been included in the major clinical guidelines [63, 64]. However, the technique is inexpensive, safe, well tolerated and repeatable for assessment of local disease [65]. EAUS staging of anal carcinoma had been proposed using the depth of invasion (**Table 2**) [65]. However, this is not correlated with the size criteria of tumor-node-metastasis (TNM) staging [66]. The exception is for T4 that the involvement of pelvic organ can be assessed. For lymph node evaluation, ERUS should be added to visualize the perirectal lymph node and any suspected lymph node should be considered as metastatic [67].

Following chemoradiotherapy, EAUS can be repeated to determine the response and used for surveillance. Although it is difficult to differentiate between post radiation change (edema, fibrosis) and tumor, tumors tend to be more hypoechogenic than scar (more mixed echogenic) [63]. It has been suggested that EAUS should not be performed within 45 days after the last radiotherapy but should be delayed until 16–20 weeks [63]. Serial examination and addition of color doppler to determine vascularity may increase the specificity in detecting local recurrence [65]. In some institutes, EAUS may be used to guide brachytherapy for anal cancer [64].

3.6. Endoanal ultrasound in anorectal pain

Endoanal ultrasound can be used in patients with chronic proctalgia to look for the possible causes, that is, chronic anorectal sepsis, IAS hypertrophy and anal sphincter defect [68, 69].

EAUS* stage	Definition
uT1	Involvement of the mucosa and submucosa without infiltration of the IAS [§]
uT2	Involvement of the IAS [§] with sparing of the EAS ^{§§}
uT3	Involvement of the EAS ^{§§}
uT4	Involvement of a pelvic organ
N0	No suspicious perirectal lymph nodes
N+	Perirectal lymph nodes suspicious for metastasis

*EAUS: endoanal ultrasound.

[§]IAS: internal anal sphincter.

^{§§}EAS: external anal sphincter.

Table 2. Endoanal ultrasound staging for anal carcinoma.

Recent EAUS study found that paradoxical anal sphincter puborectalis muscle (PR) contraction during straining and increased PR thickness is more common in these patients than normal subjects [70]. This information is useful for the management plan.

3.7. Other usage

EAUS and ERUS have been used to evaluate the pathologic process around the anorectal area such as bladder lesion, ovarian tumor and retrorectal tumor [71, 72]. However, it has not been popularized and is usually used as an adjunct to other imaging modality [73].

3.8. Personal experience

Our institute, King Chulalongkorn Memorial Hospital, is a tertiary center with a colorectal surgery fellowship program. We have adopted endoanal ultrasound in our practice since 2008. By that time, the 2D-technology was used, and we had compared the data from 2D-EAUS (with selective use of peroxide enhancement) with the data from examination under anesthesia (EUA) by our most experienced surgeon, Rojanasakul A. For acute anorectal abscess, fistula-in-ano and recurrent fistula, EAUS and EUA had 67, 91 and 100% agreement in identification of internal openings, respectively (Poster presentation in the 71st colon and rectal surgery: current principles and practice 2008, Minneapolis, MN). The results are comparable to the early 2D-EAUS report [21, 74, 75]. Later, the 3D-technology was launched. We had established the normative values of the anal sphincter anatomical component [34]. The mean IAS and EAS thickness in male versus female were 1.7 ± 0.4 versus 1.8 ± 0.3 mm and 8.1 ± 1.3 versus 6.9 ± 0.9 mm, respectively [34]. The mean anal canal length in male and female was 38.6 and 34.0 mm, respectively [34]. These findings were comparable with the previous study [34, 76]. We have used intraoperative EAUS in acute anorectal abscess to guide drainage, preoperative assessment of fistula-in-ano, assessment of anal sphincter defect in patients with fecal incontinence or anal sphincter injury. ERUS has been used for assessment of rectal tumor which clinically suitable for surgery and advanced rectal cancer (preoperative staging, follow-up). Additionally, MRI is selectively used in complex cases that need further information for the multidisciplinary team and academic discussion. In our experience, EAUS and ERUS are effective, informative, inexpensive and readily available technologies for colorectal surgeons.

4. Conclusion

Endoanal-endorectal ultrasound is a useful tool for assessment of various anorectal disorders. In a static view, the anal sphincter complex can be evaluated for integrity, thickness and length as well as local staging of anorectal cancer. In a dynamic view, anorectal dysfunction and structural defects related to pelvic floor disorder can be appreciated. The technique is noninvasive, well tolerated, inexpensive and widely available. The main drawback is that the interpretation depends largely on the experience of the operator.

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Conflict of interest

No conflict of interest

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