Epidemiologic Trends and Diagnostic Evaluation of Fecal Incontinence

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Keywords
Fecal incontinence, high-resolution anorectal manometry, International Anorectal Physiology Working Group, London classification, translumbosacral anorectal magnetic stimulation

Abstract: Fecal incontinence (FI) is a prevalent condition that occurs in up to 15% of the Western population and significantly impairs quality of life. The current understanding of the epidemiology of FI is shifting because of an increasing recognition of FI in men, better appreciation for the impact of changing obstetric practices on FI in women, and comprehension of the effect of modifiable risk factors on the development of FI over time. The pathophysiology of FI is complex and multifactorial, which necessitates the use of multiple diagnostic tests, including tests of anorectal sensorimotor function, peripheral nerve function, and anatomic structure. Translumbosacral anorectal magnetic stimulation is an emerging noninvasive diagnostic test for assessing lumbosacral neuropathy. This article is not intended as a comprehensive recitation of the literature, but rather focuses on recent developments in the understanding of the epidemiology of FI, as well as on the diagnostic evaluation of this condition. This article aims to increase awareness of FI and to outline an initial diagnostic approach to affected patients.

Fecal incontinence (FI) is the recurrent unintended passage of mucus and/or liquid or solid stool for at least 3 months.[1] FI is present in 7% to 15% of the general Western population and is associated with a considerable impact on quality of life, which, in turn, is compounded by social stigma, leading to isolation and confinement to home.[2] Anal incontinence is the involuntary passage of gas or flatus in addition to FI. Incontinence of gas may occur in healthy individuals and is, therefore, excluded from the definition of FI. In clinical practice, providers may consider querying male patients about gas incontinence, as they often experience concurrent FI, associated with an impaired anorectal sampling mechanism. Similar to urinary incontinence, FI can be subtyped into passive incontinence, urge incontinence, or both. Passive incontinence occurs when patients unknowingly have stool leakage during the day or, particularly, the night. Urge incontinence is associated with a

strong urge to defecate with the inability to prevent leakage before reaching the toilet. FI also includes fecal seepage, the uncontrolled leakage of a small amount of stool after a normal bowel movement. Fecal seepage can also be associated with other conditions, such as poor hygiene, prolapsing hemorrhoids, or rectal prolapse.

The clinically significant threshold for frequency of FI episodes remains unclear. The most recent Rome criteria (Rome IV) suggest that FI should occur twice a month, compared to monthly in the Rome III criteria.[3] In a recent Internet-based survey of approximately 6000 responders in the United States, United Kingdom, and Canada, 16% reported FI. Of those, 70% had FI less than twice a month; nevertheless, these responders experienced a significant impairment on quality of life.[4]

This article focuses on recent developments in the understanding of the epidemiology of FI, as well as on its diagnostic evaluation. In addition, the article aims to heighten awareness of this condition and present new diagnostic approaches. Readers seeking knowledge on the management and treatment of FI are referred to comprehensive summaries elsewhere in the literature.[5-7]

Epidemiology and Predictive Factors

Age and Ethnicity

Increasing age is well established as the most common risk factor for FI, with prevalence rates exceeding 15% in adults older than 65 years.[8-11] FI is especially prevalent among adults admitted to the hospital and residing in nursing homes, with estimated rates up to 33% and 70%, respectively.[1] Due to mounting caregiver burden, FI is the second most frequent reason for referral to nursing home placement.[12] FI results in increased need for the caregiver's time, as well as in the health deterioration and emotional distress of the caregiver.[13-15] In institutionalized individuals, FI is also strongly associated with the increased prevalence and severity of decubitus ulcers compared to urinary incontinence alone or combined urinary incontinence and FI.[16]

In the National Gastrointestinal Survey, which consisted of more than 70,000 Americans, 1 in 7 responders had experienced FI in the past.[17] One in 20 responders reported FI episodes in the previous 7 days. Latino individuals were found to have the most severe and highest likelihood of FI among all ethnicities.[17] Multiple other studies have demonstrated that African-American women have lower prevalence rates compared to their white counterparts.[1]

Gender

Over the next 30 years, the prevalence of FI is estimated to increase by 60%, affecting up to 17 million American women.[18] However, accounting for FI prevalence only in women may lead to gross underestimation. FI in men is often underappreciated by providers, underreported by patients, and understudied by investigators. Multiple large-scale epidemiologic studies have demonstrated similar prevalence rates of FI between men and women.[8,9,11] Men experience more frequent FI episodes than women, likely due to inexperience with routine use of protective measures such as pads or diapers. This compounds the effect on quality of life, leading to an even greater impairment in activities of daily living.[17,19]

Shifts in obstetric practice have resulted in declining rates of cesarean sections, episiotomy, and instrument-assisted delivery techniques such as those involving a vacuum or forceps. These trends have correlated with a decline in the incidence of immediate postpartum FI from 13% to 8%.[20-22] Approximately 80% of sphincter defects are not recognized as obstetric anal sphincter injury at the time of first delivery.[23] The onset of FI related to anal sphincter injury experienced during childbirth may be more indolent. The median onset of FI in women is 55 years of age, frequently several decades removed from childbirth.[10] Eighteen percent of women with an external anal sphincter defect and 29% with an internal anal sphincter defect experience FI 15 to 24 years after first delivery.[23] The prevalence of FI in women peaks in the fifth decade of life at 22% and remains stable into the ninth decade.[24] These epidemiologic trends suggest a multiple-hit hypothesis for FI in women.[25] Obstetric anal sphincter injury may serve as the initial hit, likely followed by the development of pelvic neuropathy over time.[26] An alternate view of this hypothesis can be supported by an analysis of the National Health and Nutrition Examination Survey (NHANES). In surveys distributed between 2005 and 2006, the Pelvic Floor Disorders Network successfully petitioned to add questions to the NHANES to inquire about FI.[27] This survey showed a linear rise in FI prevalence among American women corresponding to increasing age, from 2.9% in those 20 to 39 years of age to 21.6% in those greater than 80 years of age.[27]

Lifestyle Modifications

Most epidemiologic studies on FI sample a population of individuals at one point in time, which does not provide longitudinal insight into the association of lifestyle changes. Studying more than 55,000 female respondents to the prospective Nurses' Health Study, investigators have examined the association of modifiable risk factors on FI over more than 20 years. Findings have suggested that hormone therapy is associated with an increased risk of FI, especially in postmenopausal women taking combined estrogen and progesterone therapy.[28] An 18% decreased FI incidence in women consuming greater than

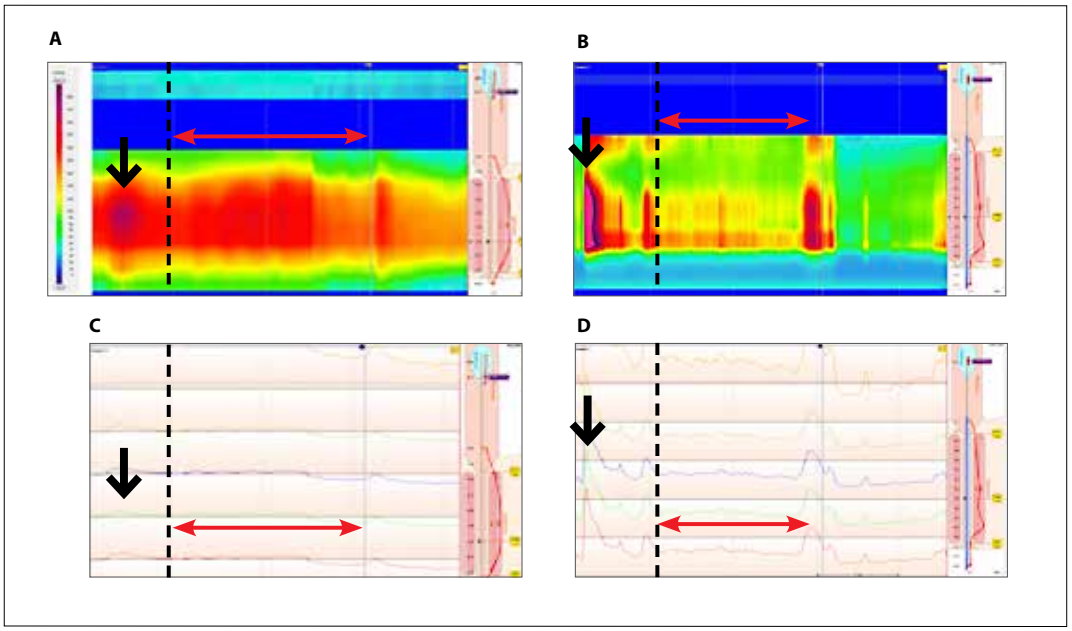

Figure 1. High-resolution anorectal manometry in an individual without fecal incontinence (**A**, **C**) and with fecal incontinence (**B**, **D**). Pressure topography plots are shown in **A** and **B**. Waveform plots are shown in **C** and **D**, with each line of the y-axis representing 0 to 100 mm Hg. The green line tracings in **C** and **D** represent the anal sphincter during the squeeze maneuver. Maximum squeeze pressure is shown by the black arrows, and sustained squeeze pressure is outlined by the red arrows. The black dotted lines demarcate the transition from maximum squeeze pressure to sustained squeeze pressure.

25 g of fiber per day was also observed.[29] Furthermore, a prospective cohort of older women had a 25% lower risk of developing FI when engaged in physical activity of greater than 27 metabolic equivalents of task per week.[30] Prior studies have shown mixed results in terms of the association of body mass index and FI.[9,31-33] In the Nurses' Health Study, the association of FI and body mass index attenuated after adjusting for confounders, particularly the amount of physical activity.[30]

Other Conditions

Iatrogenic causes of FI include hemorrhoidectomy associated with internal anal sphincter injury, lateral anal sphincterotomy in the treatment of anal fissures, surgical management of anorectal fistulas, and anal dilation.[34-36] FI is common in patients with ileoanal pouches, with prevalence rates up to 40%.[37] Perineal trauma and pelvic fracture are also associated with FI through direct anal sphincter injury.[38] Myopathies associated with FI include muscular dystrophy, myasthenia gravis, internal sphincter degeneration, and radiation exposure.[39-41] Central neuropathies such as multiple sclerosis, dementia, stroke, brain tumors, and spinal cord lesions can also be associated with FI.[42-44] High FI prevalence rates of up to 30% are seen in patients with multiple sclerosis.[39] One-quarter of cystic fibrosis patients are estimated to have stress FI that occurs with coughing, sneezing, or laughing.[45] Both diarrhea and constipation are associated with increased odds of FI, although FI with diarrhea is approximately 3 times more prevalent.[17] Patients with gastrointestinal conditions such as Crohn's disease, ulcerative colitis, celiac disease, and irritable bowel syndrome are more likely to have concurrent FI.[17]

Evaluation

FI is a diagnosis that can be made on clinical history alone; however, patient-reported symptoms are a poor indicator of underlying pathophysiology. Digital rectal examination (DRE) is useful and should be performed in the clinical evaluation of anorectal disorders.[46] DRE aids in the detection of anorectal incoordination or dyssynergic defecation as well as large rectoceles.[47-49] Detection of a gaping anus at rest or a scar from prior surgery or obstetric trauma while straining during DRE indicates low resting anal sphincter pressure and diminished anal squeeze pressure, respectively.[50] However, DRE itself is not well correlated with objective measures of resting anal sphincter tone or squeeze pressure.[51] Therefore, in addition to DRE, anorectal physiologic testing is required for thorough evaluation of anorectal function and to guide clinical management beyond conservative therapy.[52,53]

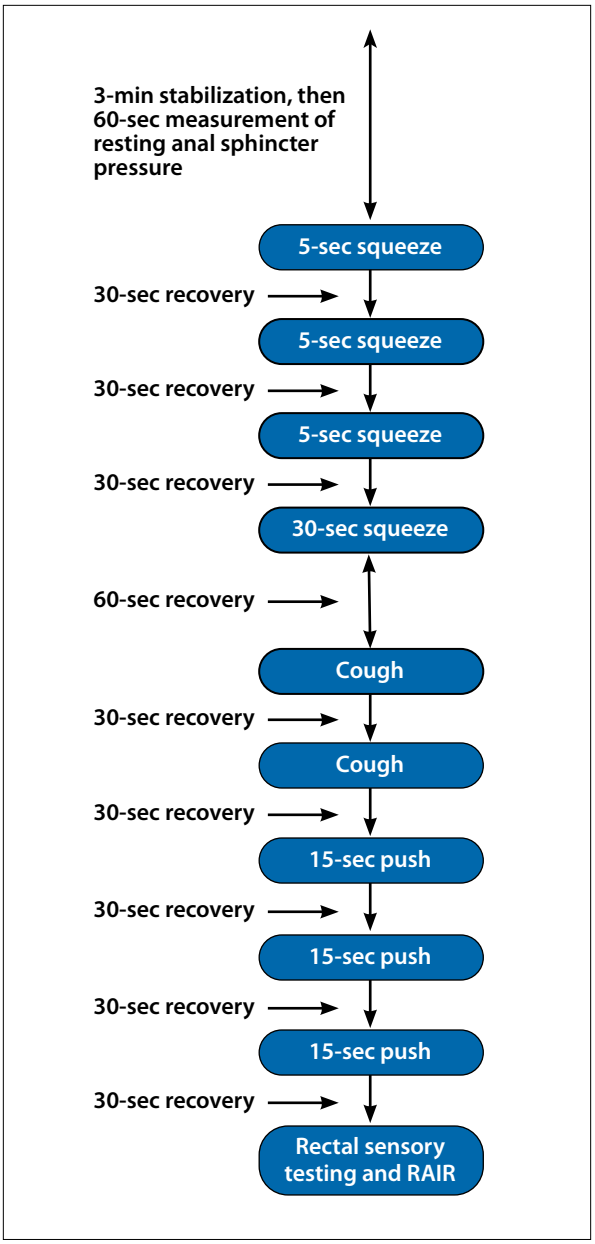

Figure 2. The International Anorectal Physiology Working Group standardized protocol for anorectal manometry evaluation in the assessment of anorectal disorders.

RAIR, rectoanal inhibitory reflex.

Tests of Sensorimotor Dysfunction

Anorectal manometry for FI should include concomitant rectal sensory and compliance testing. Thirty percent of FI cases can be attributed to delayed rectal sensation, or rectal hyposensitivity, which can be corrected with sensory retraining.[54] The high-pressure zone of the anal canal comprises the puborectalis and the internal and external anal sphincters. Anorectal manometry studies have demonstrated that 60% of the resting anal tone is provided by the internal anal sphincter smooth muscle fibers and less than 30% is attributed to the striated external anal sphincter, which further decreases its contribution during sleep.[55-57] Low resting and maximum squeeze anal sphincter pressures can be seen in FI patients.[51,58,59] Sustained squeeze pressure assesses the duration of squeeze and allows for evaluation of anal sphincter muscle fatigue (Figure 1). Although expensive, fragile, and requiring regular maintenance for reuse, high-resolution and high-definition anorectal manometry catheters have replaced conventional water-perfused, air-charged, or solid-state probes with unidirectional sensors in the last decade. High-resolution and high-definition anorectal manometry provide better spatial resolution of the anal sphincter pressure profile, eliminate the need for station pull-through limited by motion artifact, are much easier to calibrate, and are more accurate in detecting anal hypocontractility in FI compared to conventional probes.[60,61] High-definition anorectal manometry with 3-dimensional reconstruction of the high-pressure zone via 256 circumferentially arranged sensors is also able to detect excessive perineal descent, rectal mucosal intussusception, rectoceles, and anal sphincter defects.[62] In an attempt to address wide variability in anorectal manometry practice, the International Anorectal Physiology Working Group outlined a standardized protocol consisting of 3-minute stabilization after probe placement, a 60-second rest period, 3 5-second squeezes with 30-second intermittent recovery periods, a 30-second squeeze with 60-second recovery for FI, 2 coughs and 3 15-second pushes or bear downs with 30-second intermittent recovery periods, and finally rectal sensory testing and rectoanal inhibitory reflex assessment (Figure 2).[63] It is estimated that the entire standardized protocol can be completed in 12 minutes, although this estimate seems to lack feasibility in clinical practice. The International Anorectal Physiology Working Group also outlines disorders of anal tone and contractility within the London classification (part II) to characterize high-resolution anorectal manometry findings of FI as major or minor disturbances (Figure 3).[63] Further validation of these disorders is warranted prior to widespread adoption in clinical practice.

Use of emerging technologies such as functional luminal impedance topography (endoluminal functional lumen imaging probe [EndoFLIP, Medtronic]) and Fecobionics may provide additional insight into anorectal disorders. EndoFLIP is a catheter that includes a distensible bag without inherent resistance itself that measures the true distensibility of sphincteric regions throughout the gastrointestinal tract. This instrument may be useful in conditions associated with hypertensive anal sphincters, which are generally seen in constipation. Its utility in FI

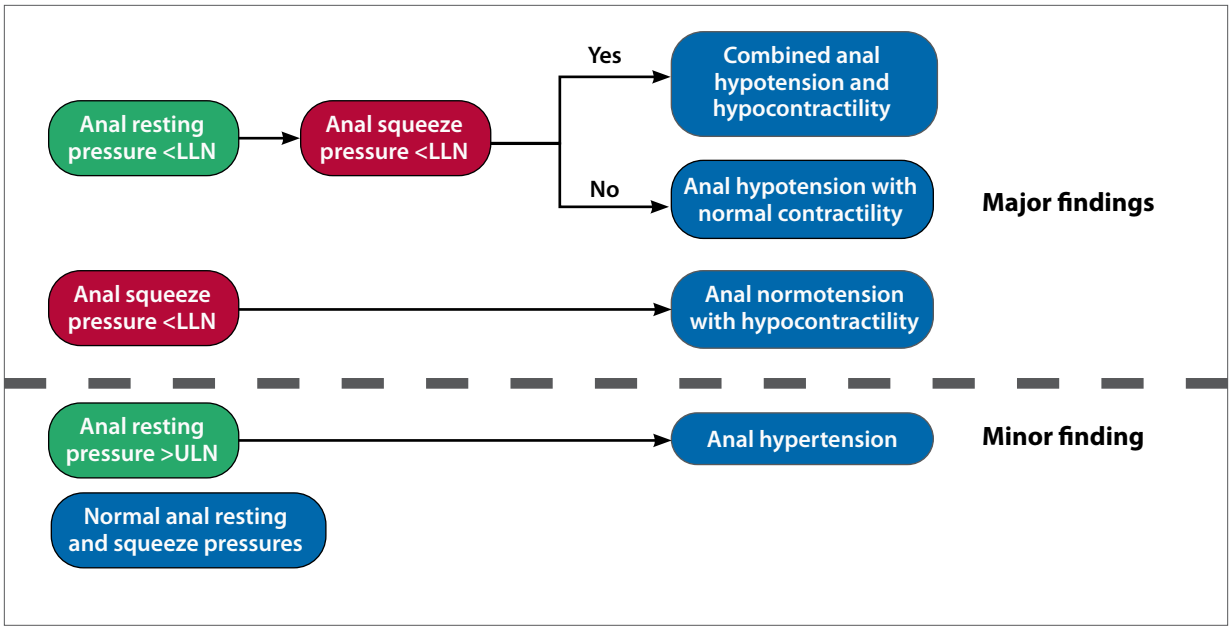

Figure 3. London classification part II: disorders of anal tone and contractility.

LLN, lower limit of normal; ULN, upper limit of normal.

remains to be demonstrated. Fecobionics is simulated artificial stool (10 cm in length and 12 mm in width) that is aided by impedance to provide more physiologic information, such as axial pressure signatures, anorectal angle, and geometric mapping during defecation.[64] This technology may also be useful in providing mechanistic understanding of anorectal incoordination or dyssynergic defecation in constipated patients.

Tests for Peripheral Neuropathy

Peripheral spinoanal and rectal neuropathy has been demonstrated by novel brain-gut testing to play a major role in the pathophysiology of FI when compared to healthy controls.[65] The spinoanal reflex arc can be assessed by eliciting the anocutaneous reflex during physical examination. To evoke the anocutaneous reflex, the examiner uses a cotton swab to centripetally and gently stroke the perianal region in all 4 quadrants, eliciting a brisk contraction of the perianal skin and underlying external anal sphincter. The spinoanal reflex can also be assessed during high-resolution anorectal manometry, when patients cough or blow air into a party balloon to elicit an increase in intra-abdominal pressure, in response to which the external anal sphincter should simultaneously contract.[66-68] A central neurologic lesion above the cauda equina is suspected when the reflex is present but patients lack the ability to generate any significant voluntary anal squeeze pressure, whereas peripheral neuropathy below the cauda equina may be present if the reflex is absent.[69]

Anal electromyography and pudendal nerve terminal motor latency testing can assess nerve function between the terminal portion of the pudendal nerve and the anal sphincter. However, these tests carry significant limitations.[69] The American Gastroenterological Association technical review determined that pudendal nerve terminal motor latency testing cannot be recommended for patients with FI due to poor correlation with clinical symptoms and histologic findings, poor sensitivity and specificity, operator dependence, and inability to predict surgical outcome.[70] Alternatively, newly developed translumbosacral anorectal magnetic stimulation (TAMS) is a safe and well-tolerated method to more accurately assess nerve function in FI (Figure 4).[71] By using a magnetic coil to stimulate the bilateral plexi at L2 to L3 (lumbar) and S2 to S3 (sacral) regions with single pulses, motor-evoked potentials can be recorded with a specially designed electromyography probe in the anorectum. In a prospective observational study of 30 FI patients and 20 healthy controls, TAMS was superior to pudendal nerve terminal motor latency, with a significantly higher yield of neuropathy (87% vs 63%) and 63% positive agreement.[71] TAMS studies of an FI patient and a healthy individual are shown in Figure 4.

Tests of Anatomic Defects

Anal ultrasound or endosonography can closely examine anal sphincter morphology in the hands of experienced operators. Pathology such as scars, thinning or

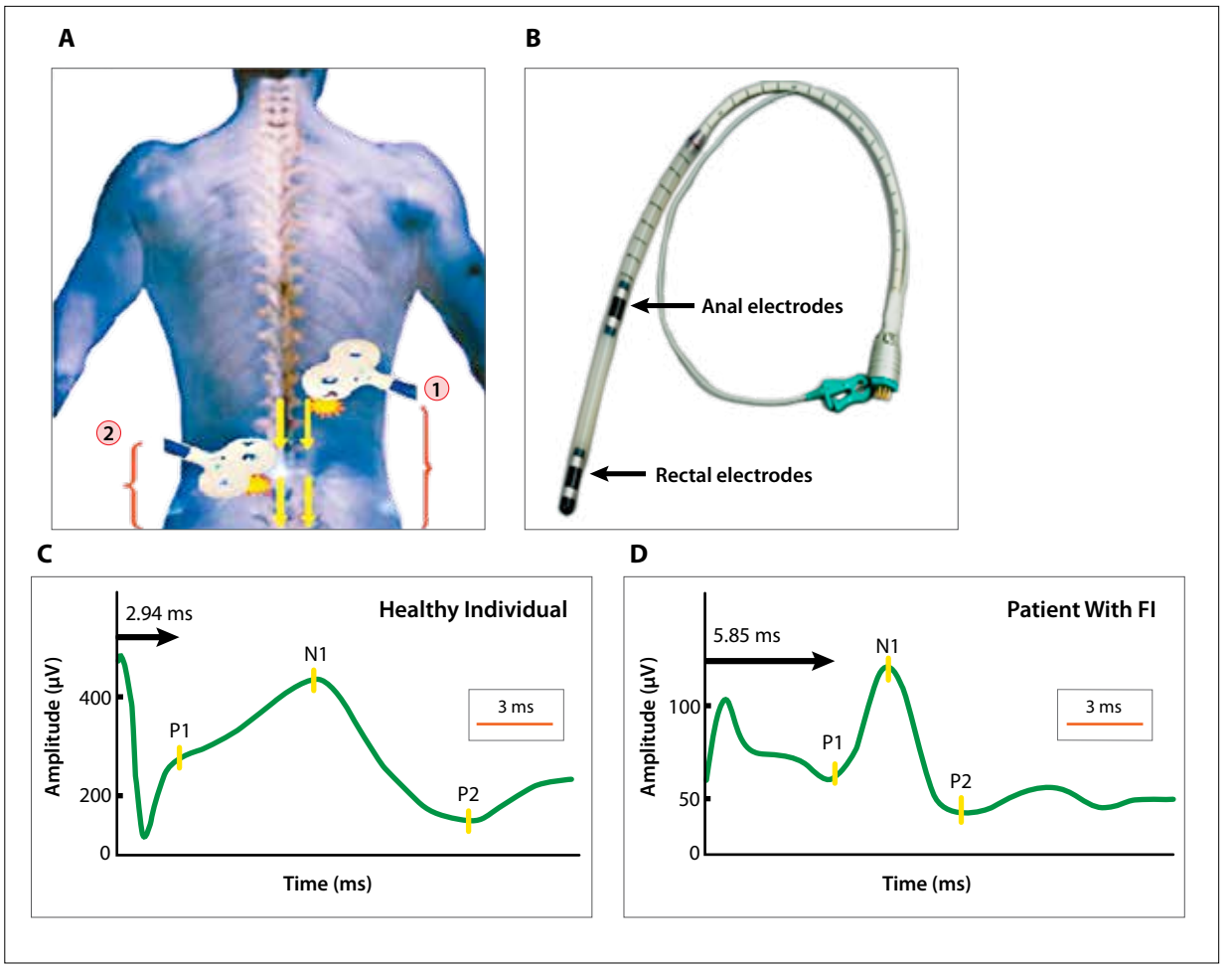

Figure 4. A: TAMS testing is performed with single-pulse stimulations delivered at bilateral L2 to L3 (lumbar) locations (1) and bilateral S2 to S3 (sacral) locations (2) via a magnetic coil. **B:** MEPs are recorded with an anorectal EMG probe that has rectal and anal electrodes. **C:** A classic MEP recording of a healthy individual with normal latency (2.94 ms). **D:** A representative MEP recording of an FI patient with prolonged latency (5.85 ms).

EMG, electromyography; FI, fecal incontinence; MEP, motor-evoked potential; ms, millisecond; TAMS, translumbosacral anorectal magnetic stimulation; μV, microvolts.

hypertrophy of anal sphincters, and sphincter defects, and prior surgical interventions such as episiotomy and anal sphincteroplasty can be observed (Figure 5).[69,72] High-frequency ultrasound probes have dramatically improved resolution of obtained images.[73] Examination of internal and external anal sphincters by 2-dimensional anal ultrasound results in good interobserver agreement for sphincter defects (κ=0.8).[74] Anal sphincter and defect volumes can be measured by 3-dimensional anal endosonography. Although further studies are needed to investigate clinical utility of 3-dimensional anal endosonography, 2-dimensional anal ultrasound is widely used in clinical practice to evaluate anal sphincter morphology with normative data in the absence of sphincteroplasty. Using a specifically designed endoanal coil, endoanal magnetic resonance imaging can precisely measure anal sphincter morphology, and this technology has led to recognition of external sphincter atrophy as a contributor to FI.[73] Expense and availability of endoanal magnetic resonance imaging remain a major limitation for widespread adoption.

Conclusion

FI is a common problem that significantly impacts quality of life. Health care providers should strongly consider screening for this condition in both male and female patients over 55 years of age. FI in men is underreported and grossly underestimated. FI episodes occurring less frequently than in the diagnostic Rome IV criteria may still have a significant impact on quality of life.

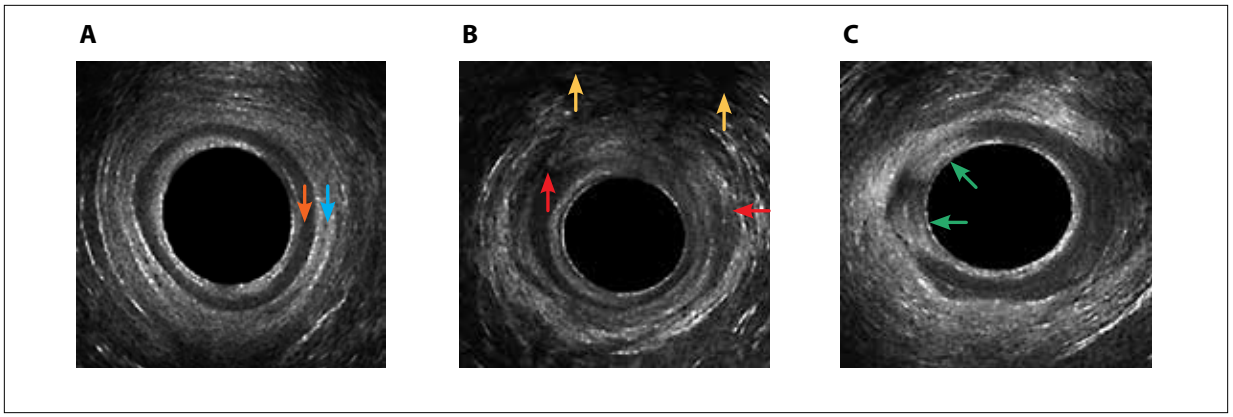

Figure 5. Anal endosonography images. **A** shows a healthy individual with a hypoechoic internal anal sphincter (orange arrow) and mixed hypo- and hyperechoic external anal sphincter (blue arrow). **B** shows an FI patient with both internal and external anal sphincter defects (between the red arrows) and hemicircumferential anal sphincteroplasty (between the yellow arrows). **C** shows an FI patient with lateral anal sphincterotomies (green arrows).

FI, fecal incontinence.

Modifiable risk factors should be identified, and, when possible, changes in hormonal therapy, increased fiber intake, and regular exercise should be encouraged. A recently validated FI stool application could improve diagnosis and disease monitoring.[75] DRE should be performed in the evaluation of FI to assess for coexisting dyssynergic defecation, large rectoceles, gaping anus, or prior surgeries. Further diagnostic evaluation assessing anorectal sensorimotor function, nerve function, and anatomy aids in the understanding of multifactorial pathologic insults in FI and can be used to guide management. TAMS, an emerging diagnostic test for anorectal neuropathy, should be considered in the evaluation of FI.

Dr Sharma has no relevant conflicts of interest to disclose. Dr Rao serves on the advisory board for, and has received stock options from, InTone MV.

References

1. Rao SS, Bharucha AE, Chiarioni G, et al. Anorectal disorders. *Gastroenterology.* 2016;150(6):1430-1442.e4.
2. Bharucha AE, Dunivan G, Goode PS, et al. Epidemiology, pathophysiology, and classification of fecal incontinence: state of the science summary for the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) workshop. *Am J Gastroenterol.* 2015;110(1):127-136.
3. Simren M, Palsson OS, Whitehead WE. Update on Rome IV criteria for colorectal disorders: implications for clinical practice. *Curr Gastroenterol Rep.* 2017;19(4):15.
4. Whitehead WE, Simren M, Busby-Whitehead J, et al. Fecal incontinence diagnosed by the Rome IV criteria in the United States, Canada, and the United Kingdom. *Clin Gastroenterol Hepatol.* 2020;18(2):385-391.
5. Whitehead WE, Rao SS, Lowry A, et al. Treatment of fecal incontinence: state of the science summary for the National Institute of Diabetes and Digestive and Kidney Diseases workshop. *Am J Gastroenterol.* 2015;110(1):138-146.
6. Bharucha AE, Rao SSC, Shin AS. Surgical interventions and the use of device-aided therapy for the treatment of fecal incontinence and defecatory disorders. *Clin Gastroenterol Hepatol.* 2017;15(12):1844-1854.
7. Ozturk R, Niazi S, Stessman M, Rao SS. Long-term outcome and objective changes of anorectal function after biofeedback therapy for faecal incontinence. *Aliment Pharmacol Ther.* 2004;20(6):667-674.
8. Ditah I, Devaki P, Luma HN, et al. Prevalence, trends, and risk factors for fecal incontinence in United States adults, 2005-2010. *Clin Gastroenterol Hepatol.* 2014;12(4):636-643.e1-e2.
9. Whitehead WE, Borrud L, Goode PS, et al. Fecal incontinence in US adults: epidemiology and risk factors. *Gastroenterology.* 2009;137(2):512-517, 517.e1-e2.
10. Bharucha AE, Zinsmeister AR, Locke GR, et al. Risk factors for fecal incontinence: a population-based study in women. *Am J Gastroenterol.* 2006;101(6):1305-1312.
11. Kalantar JS, Howell S, Talley NJ. Prevalence of faecal incontinence and associated risk factors; an underdiagnosed problem in the Australian community? *Med J Aust.* 2002;176(2):54-57.
12. Talley NJ, O'Keefe EA, Zinsmeister AR, Melton LJ III. Prevalence of gastrointestinal symptoms in the elderly: a population-based study. *Gastroenterology.* 1992;102(3):895-901.
13. Finne-Soveri H, Sørbye LW, Jonsson PV, Carpenter GI, Bernabei R. Increased work-load associated with faecal incontinence among home care patients in 11 European countries. *Eur J Public Health.* 2008;18(3):323-328.
14. Noelker LS. Incontinence in elderly cared for by family. *Gerontologist.* 1987;27(2):194-200.
15. Ouslander JG, Zarit SH, Orr NK, Muira SA. Incontinence among elderly community-dwelling dementia patients. Characteristics, management, and impact on caregivers. *J Am Geriatr Soc.* 1990;38(4):440-445.
16. Lachenbruch C, Ribble D, Emmons K, VanGilder C. Pressure ulcer risk in the incontinent patient: analysis of incontinence and hospital-acquired pressure ulcers from the International Pressure Ulcer Prevalence™ survey. *J Wound Ostomy Continence Nurs.* 2016;43(3):235-241.
17. Menees SB, Almario CV, Spiegel BMR, Chey WD. Prevalence of and factors associated with fecal incontinence: results from a population-based survey. *Gastroenterology.* 2018;154(6):1672-1681.e3.
18. Wu JM, Hundley AF, Fulton RG, Myers ER. Forecasting the prevalence of pelvic floor disorders in U.S. women: 2010 to 2050. *Obstet Gynecol.* 2009;114(6):1278-1283.
19. Bliss DZ, Lewis J, Hasselman K, Savik K, Lowry A, Whitebird R. Use and evaluation of disposable absorbent products for managing fecal incontinence by community-living people. *J Wound Ostomy Continence Nurs.* 2011;38(3):289-297.
20. Gee RR, Blea I. Does cesarean delivery protect against pelvic floor dysfunction at 6 months postpartum? *Female Pelvic Med Reconstr Surg.* 2012;18:S73.
21. Sultan AH, Kamm MA, Hudson CN, Thomas JM, Bartram CI. Anal-sphincter disruption during vaginal delivery. *N Engl J Med.* 1993;329(26):1905-1911.
22. Merriam AA, Ananth CV, Wright JD, Siddiq Z, D'Alton ME, Friedman AM.

Trends in operative vaginal delivery, 2005-2013: a population-based study. *BJOG.* 2017;124(9):1365-1372.
23. Guzmán Rojas RA, Salvesen KÅ, Volløyhaug I. Anal sphincter defects and fecal incontinence 15-24 years after first delivery: a cross-sectional study. *Ultrasound Obstet Gynecol.* 2018;51(5):677-683.
24. Bharucha AE, Seide BM, Zinsmeister AR, Melton LJ III. Relation of bowel habits to fecal incontinence in women. *Am J Gastroenterol.* 2008;103(6):1470-1475.
25. Bharucha AE. Fecal incontinence. *Gastroenterology.* 2003;124(6):1672-1685.
26. Rao SS. Pathophysiology of adult fecal incontinence. *Gastroenterology.* 2004;126(1)(suppl 1):S14-S22.
27. Nygaard I, Barber MD, Burgio KL, et al; Pelvic Floor Disorders Network. Prevalence of symptomatic pelvic floor disorders in US women. *JAMA.* 2008;300(11):1311-1316.
28. Staller K, Townsend MK, Khalili H, et al. Menopausal hormone therapy is associated with increased risk of fecal incontinence in women after menopause. *Gastroenterology.* 2017;152(8):1915-1921.e1.
29. Staller K, Song M, Grodstein F, et al. Increased long-term dietary fiber intake is associated with a decreased risk of fecal incontinence in older women. *Gastroenterology.* 2018;155(3):661-667.e1.
30. Staller K, Song M, Grodstein F, et al. Physical activity, BMI, and risk of fecal incontinence in the Nurses' Health Study. *Clin Transl Gastroenterol.* 2018;9(10):200.
31. Rømmen K, Schei B, Rydning A, Sultan AH, Mørkved S. Prevalence of anal incontinence among Norwegian women: a cross-sectional study. *BMJ Open.* 2012;2(4):e001257.
32. Varma MG, Brown JS, Creasman JM, et al; Reproductive Risks for Incontinence Study at Kaiser (RRISK) Research Group. Fecal incontinence in females older than aged 40 years: who is at risk? *Dis Colon Rectum.* 2006;49(6):841-851.
33. Markland AD, Goode PS, Burgio KL, et al. Incidence and risk factors for fecal incontinence in black and white older adults: a population-based study. *J Am Geriatr Soc.* 2010;58(7):1341-1346.
34. Abbasakoor F, Nelson M, Beynon J, Patel B, Carr ND. Anal endosonography in patients with anorectal symptoms after haemorrhoidectomy. *Br J Surg.* 1998;85(11):1522-1524.
35. Snooks S, Henry MM, Swash M. Faecal incontinence after anal dilatation. *Br J Surg.* 1984;71(8):617-618.
36. Speakman CT, Burnett SJ, Kamm MA, Bartram CI. Sphincter injury after anal dilatation demonstrated by anal endosonography. *Br J Surg.* 1991;78(12):1429-1430.
37. Levitt MD, Kamm MA, van der Sijp JR, Nicholls RJ. Ambulatory pouch and anal motility in patients with ileo-anal reservoirs. *Int J Colorectal Dis.* 1994;9(1):40-44.
38. Engel AF, Kamm MA, Hawley PR. Civilian and war injuries of the perineum and anal sphincters. *Br J Surg.* 1994;81(7):1069-1073.
39. Caruana BJ, Wald A, Hinds JP, Eidelman BH. Anorectal sensory and motor function in neurogenic fecal incontinence. Comparison between multiple sclerosis and diabetes mellitus. *Gastroenterology.* 1991;100(2):465-470.
40. Varma JS, Smith AN, Busuttil A. Function of the anal sphincters after chronic radiation injury. *Gut.* 1986;27(5):528-533.
41. Vaizey CJ, Kamm MA, Bartram CI. Primary degeneration of the internal anal sphincter as a cause of passive faecal incontinence. *Lancet.* 1997;349(9052):612-615.
42. Glickman S, Kamm MA. Bowel dysfunction in spinal-cord-injury patients. *Lancet.* 1996;347(9016):1651-1653.
43. Krogh K, Nielsen J, Djurhuus JC, Mosdal C, Sabroe S, Laurberg S. Colorectal function in patients with spinal cord lesions. *Dis Colon Rectum.* 1997;40(10):1233-1239.
44. Brittain KR, Peet SM, Castleden CM. Stroke and incontinence. *Stroke.* 1998;29(2):524-528.
45. Benezech A, Desmazes-Dufeu N, Baumstarck K, et al. Prevalence of fecal incontinence in adults with cystic fibrosis. *Dig Dis Sci.* 2018;63(4):982-988.
46. Rao SSC. Rectal exam: Yes, it can and should be done in a busy practice! *Am J Gastroenterol.* 2018;113(5):635-638.
47. Tantiphlachiva K, Rao P, Attaluri A, Rao SS. Digital rectal examination is a useful tool for identifying patients with dyssynergia. *Clin Gastroenterol Hepatol.* 2010;8(11):955-960.
48. Soh JS, Lee HJ, Jung KW, et al. The diagnostic value of a digital rectal examination compared with high-resolution anorectal manometry in patients with chronic constipation and fecal incontinence. *Am J Gastroenterol.* 2015;110(8):1197-1204.
49. Rachaneni S, Atan IK, Shek KL, Dietz HP. Digital rectal examination in the evaluation of rectovaginal septal defects. *Int Urogynecol J.* 2017;28(9):1401-1405.
50. Dobben AC, Terra MP, Deutekom M, et al. Anal inspection and digital rectal examination compared to anorectal physiology tests and endoanal ultrasonography in evaluating fecal incontinence. *Int J Colorectal Dis.* 2007;22(7):783-790.
51. Read NW, Harford WV, Schmulen AC, Read MG, Santa Ana C, Fordtran JS. A clinical study of patients with fecal incontinence and diarrhea. *Gastroenterology.* 1979;76(4):747-756.
52. Townsend DC, Carrington EV, Grossi U, et al. Pathophysiology of fecal incontinence differs between men and women: a case-matched study in 200 patients. *Neurogastroenterol Motil.* 2016;28(10):1580-1588.
53. Carrington EV, Scott SM, Bharucha A, et al; International Anorectal Physiology Working Group and the International Working Group for Disorders of Gastrointestinal Motility and Function. Expert consensus document: advances in the evaluation of anorectal function. *Nat Rev Gastroenterol Hepatol.* 2018;15(5):309-323.
54. Buser WD, Miner PB Jr. Delayed rectal sensation with fecal incontinence. Successful treatment using anorectal manometry. *Gastroenterology.* 1986;91(5):1186-1191.
55. Lestar B, Penninckx F, Kerremans R. The composition of anal basal pressure. An in vivo and in vitro study in man. *Int J Colorectal Dis.* 1989;4(2):118-122.
56. Frenckner B, Euler CV. Influence of pudendal block on the function of the anal sphincters. *Gut.* 1975;16(6):482-489.
57. Floyd WF, Walls EW. Electromyography of the sphincter ani externus in man. *J Physiol.* 1953;122(3):599-609.
58. Felt-Bersma RJ, Klinkenberg-Knol EC, Meuwissen SG. Investigation of anorectal function. *Br J Surg.* 1988;75(1):53-55.
59. Read NW, Bartolo DC, Read MG. Differences in anal function in patients with incontinence to solids and in patients with incontinence to liquids. *Br J Surg.* 1984;71(1):39-42.
60. Basilisco G, Bharucha AE. High-resolution anorectal manometry: an expensive hobby or worth every penny? *Neurogastroenterol Motil.* 2017;29(8):e13125.
61. Carrington EV, Knowles CH, Grossi U, Scott SM. High-resolution anorectal manometry measures are more accurate than conventional measures in detecting anal hypocontractility in women with fecal incontinence. *Clin Gastroenterol Hepatol.* 2019;17(3):477-485.e9.
62. Lee YY, Erdogan A, Rao SS. High resolution and high definition anorectal manometry and pressure topography: diagnostic advance or a new kid on the block? *Curr Gastroenterol Rep.* 2013;15(12):360.
63. Carrington EV, Heinrich H, Knowles CH, et al; International Anorectal Physiology Working Group. The International Anorectal Physiology Working Group (IAPWG) recommendations: standardized testing protocol and the London classification for disorders of anorectal function. *Neurogastroenterol Motil.* 2020;32(1):e13679.
64. Gregersen H, Krogh K, Liao D. Fecobionics: integrating anorectal function measurements. *Clin Gastroenterol Hepatol.* 2018;16(6):981-983.
65. Xiang X, Patcharatrakul T, Sharma A, Parr R, Hamdy S, Rao SSC. Cortico-anorectal, spino-anorectal, and cortico-spinal nerve conduction and locus of neuronal injury in patients with fecal incontinence. *Clin Gastroenterol Hepatol.* 2019;17(6):1130-1137.e2.
66. Rao SS, Sun WM. Current techniques of assessing defecation dynamics. *Dig Dis.* 1997;15(suppl 1):64-77.
67. Rao SSC, Hatfield R, Soffer E, Rao S, Beaty J, Conklin JL. Manometric tests of anorectal function in healthy adults. *Am J Gastroenterol.* 1999;94(3):773-783.
68. Rao SS. Manometric evaluation of defecation disorders: part II. Fecal incontinence. *Gastroenterologist.* 1997;5(2):99-111.
69. Rao SS; American College of Gastroenterology Practice Parameters Committee. Diagnosis and management of fecal incontinence. *Am J Gastroenterol.* 2004;99(8):1585-1604.
70. Diamant NE, Kamm MA, Wald A, Whitehead WE. AGA technical review on anorectal testing techniques. *Gastroenterology.* 1999;116(3):735-760.
71. Rao SS, Coss-Adame E, Tantiphlachiva K, Attaluri A, Remes-Troche J. Translumbar and transsacral magnetic neurostimulation for the assessment of neuropathy in fecal incontinence. *Dis Colon Rectum.* 2014;57(5):645-652.
72. Law PJ, Kamm MA, Bartram CI. Anal endosonography in the investigation of faecal incontinence. *Br J Surg.* 1991;78(3):312-314.
73. Bartram C. Radiologic evaluation of anorectal disorders. *Gastroenterol Clin North Am.* 2001;30(1):55-75.
74. Gold DM, Halligan S, Kmiot WA, Bartram CI. Intraobserver and interobserver agreement in anal endosonography. *Br J Surg.* 1999;86(3):371-375.
75. Jimenez E, Yan Y, Sharma A, et al. Sa1681 Fecal incontinence (FI) stool app is a reliable and valid instrument for leakage assessment: RCT in FI and healthy subjects. *Gastroenterology*. 2020;158(6):S-380.