FEATURE

Laboratory Evaluation of Anorectal Function and the Relationship to Biofeedback

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The laboratory evaluation of anorectal function includes several different diagnostic procedures that are routinely performed. These procedures are anorectal manometry, electromyography (EMG), pudendal nerve latency testing, water retention test, balloon expulsion test, defecography, and endoanal ultrasound. This article reviews these standard anorectal physiology evaluation techniques and explains how they are performed, what information can be gained by them, and finally how they can be utilized for biofeedback.

As with other areas of medicine, the evaluation of anorectal function in the laboratory setting has advanced in technology. There is a wide range of procedures that currently can be performed. These procedures confirm data on specific conditions allowing for precise diagnosis, providing information on possible surgical outcomes, and directing treatment plans. Most of these procedures were initially only used in research settings. However, over the past 25 years they have become more mainstream as anorectal physiology laboratories now exist across the United States. The goal of this article is to discuss standard anorectal physiology evaluation techniques, how they are performed, what information can be gained by them, and how they can be utilized for biofeedback. Facilities vary greatly in size and funding, which places limits on available equipment. Therefore not every procedure will be performed at all anorectal physiology laboratories.

Anorectal Physiology Procedures

There are several different diagnostic procedures that are routinely performed and will be discussed. They are (a) anorectal manometry, (b) rectal sensation and compliance study, (c) rectal elimination pressure profile, (d) electromyography of the pelvic floor, (e) pudendal nerve latency testing, (f) water retention testing, (g) balloon expulsion testing, (h) defecography-proctography, and (i) endoanal or transanal ultrasound.

The first three procedures listed are all performed utilizing the same equipment. However, they are separated in this discussion because each represents different aspects of functional physiology and each has separate procedural codes that are used when billing.

Anorectal Manometry

Manometry is the most frequently utilized procedure in the evaluation of anal sphincter function. Anal manometry is used to establish if there is any weakness of the pelvic floor sphincter muscles, allowing an objective measure of resting and squeeze pressures. This procedure also assesses the length of the high-pressure zone (Read & Bannister, 1985). Anal canal pressure is typically measured using either a water-perfused or solid-state catheter. There are advantages and disadvantages with each of these procedures, which have been previously described (Read & Bannister, 1985). One of the largest differences is in the cost of the catheters. The solid-state catheter's price is twice that of the water-perfused. However, the water-perfused catheter has the disadvantage—as the name indicates—of requiring water to be perfused through ports throughout the testing. This effect can produce a stimulus that some patients may detect, thereby altering the data being collected.

Anal canal pressures are typically measured in one of two ways, either with a station pull-through with measurements taken at 1-cm intervals throughout the anal canal or utilizing a continuous pull-through technique. Data typically recorded include resting pressure, squeeze pressures, maximum squeeze pressures, and squeeze duration. The pressure recordings are given in millimeters of mercury (mm Hg). Through personal discussions with other clinicians who perform these tests, the station pull-through technique appears to be the most commonly utilized. With the station pull-through method, measurements are recorded at 1-cm intervals beginning 5 cm from the anal verge and progressing distally. The order in which measurements are typically recorded is resting,

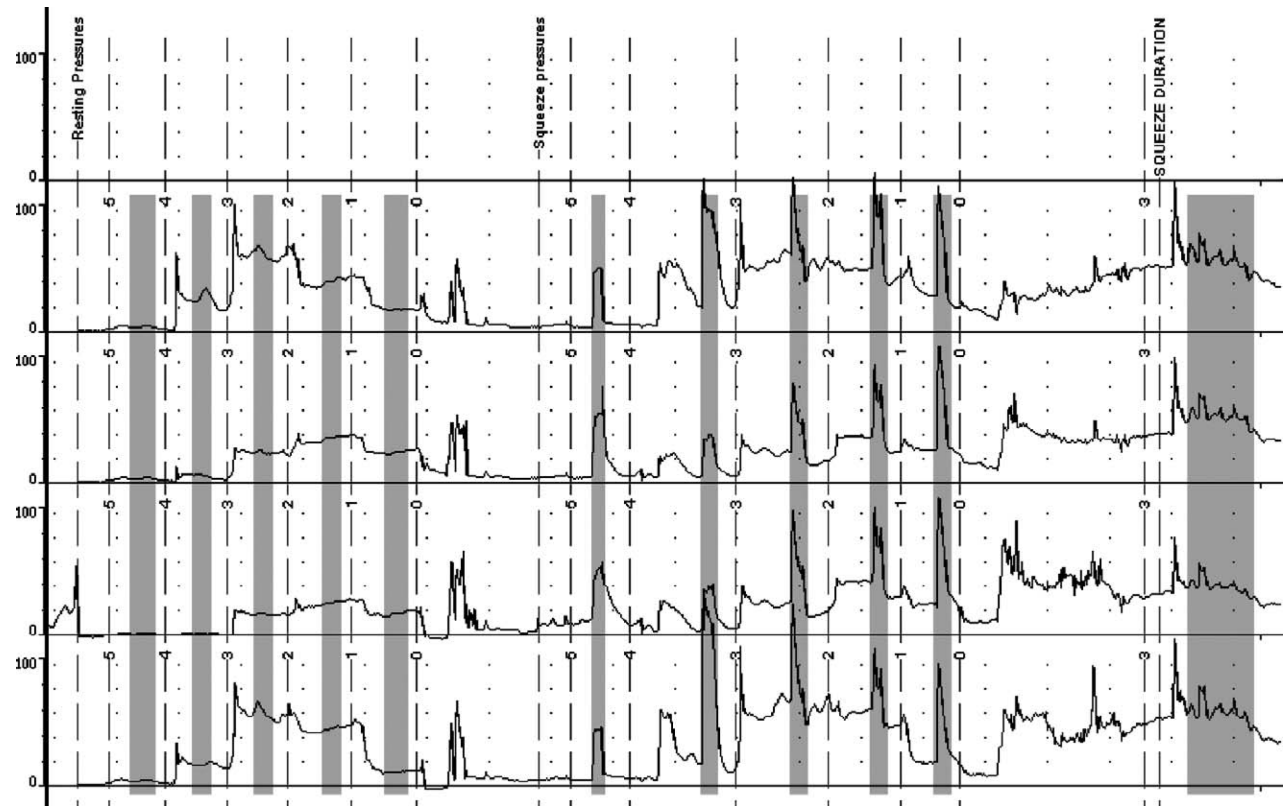

Figure 1. Resting pressure, squeeze pressure, and squeeze duration are all demonstrated. There are four channels listed with data representing the four quadrants recorded (in descending order): posterior, left, anterior, and right. Each has a scale of 0–100 mm Hg. Each activity was recorded at 1-cm intervals beginning 5 cm from the anal verge and progressing distally. A rise in the graph indicates a rise in pressure at that particular position.

then rapid squeeze, then squeeze duration. Resting measurements are viewed as an indicator of internal anal sphincter (IAS) function (Kaur, Gardiner, & Duthie, 2002), whereas squeeze pressure measurements represent external anal sphincter function (Cortesini, Paparozzi, Carassale, & Bechi, 1979). Initial squeeze measurements are taken during a quick contraction and are an indication of the pressure response of activating the fast-twitch fibers of the sphincter muscle complex. The squeeze duration is measured subsequently and represents the pressure that can be maintained for an extended period (approximately 20 seconds or more), giving an indication of slow-twitch fiber function (see Figure 1).

Biofeedback Applications

Manometry is often utilized for biofeedback. The patient lies in a lateral position, which allows him or her the ability to view the computer screen. There is an advantage with the manometry in that the clinician has the ability to choose whether to view information from all four quadrants of the sphincter muscles or just one. Also there is the option to vary the position of the catheter in the anal canal, hence providing information from different areas of the sphincter complex. This aspect therefore increases the sensitivity and variability of data that is available to both the patient and clinician.

Rectal Sensation and Compliance Testing

Rectal sensation and compliance testing accompanies basic manometric evaluations and utilizes the same equipment. The test is performed to provide information regarding sensory deficits and extensibility of the rectum. This procedure is performed by introducing air into a balloon, which is located at the end of the manometry catheter and positioned in the rectum. The typical measurements recorded during sensory testing are the point of first sensation, the point of urge to defecate, and the maximal tolerable volume. Rectal compliance testing challenges the rectum with increasing volumes of air looking for an adaptation of the rectum to these increas-

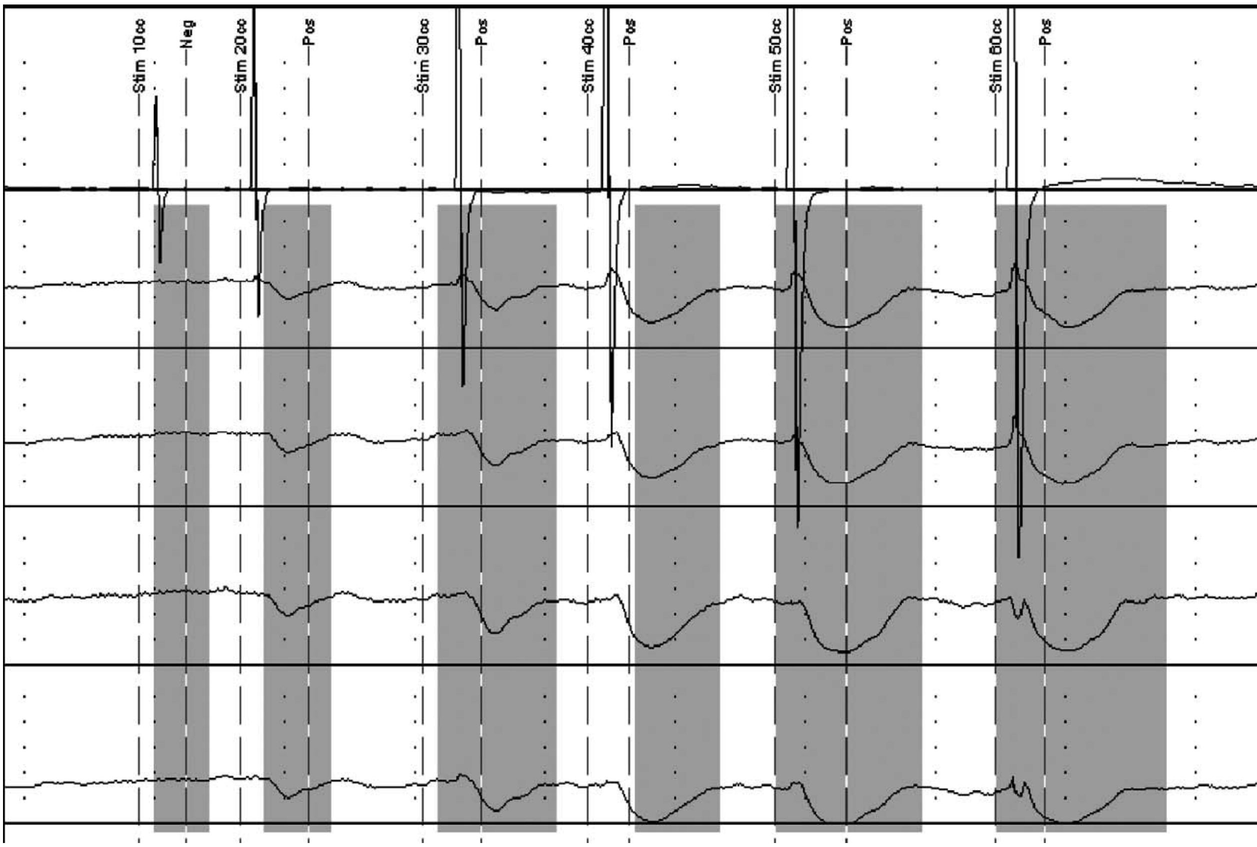

Figure 2. Recto-anal inhibitory reflex response graph. The top column represents the rectal balloon. The spikes are the response of air being rapidly introduced into the balloon and then rapidly withdrawn. The reflex is the drop in pressure following this challenge and represents a relaxation of the internal anal sphincter. All four quadrants are represented again from row two down in the following sequence: posterior, left, anterior, and right. This measurement is typically taken at the high-pressure zone station within the anal canal.

es. A normal compliant rectum would expand with the increase in volume allowing the pressure reading to remain relatively steady. A noncompliant rectum would not adapt as the balloon volume increased and a rise in rectal pressure would be noted.

Another component of the sensory study is the evaluation of the recto-anal inhibitory reflex, which is commonly called the RAIR response. The RAIR was first described in 1877 by Gowers and confirmed in 1935 by Denny-Brown and Robertson. The RAIR is a transient relaxation of the IAS in response to rectal distention. The concept of the RAIR reflecting a sampling mechanism and allowing the upper anal canal to discriminate between flatus and feces was proposed by Duthie and Bennett (1963). This reflex requires the presence of an intact intramural neural plexus (Lubowshi, Nichols, Swash, & Jordan, 1987) and is absent in Hirschsprung's disease. RAIR evaluation is done by challenging the rectum with progressive increases in volumes of air and recording anal canal pressure responses (see Figure 2). A normal response to rapid volume increase in the rectum is a relaxation in the internal sphincter muscle, which is demonstrated by a decrease in anal canal pressure. As the challenge increases, the response should also increase. A false-negative reflex may be obtained if the basal pressure is too low or if an insufficient volume is used in a patient with a megarectum. Most anorectal laboratories report the RAIR as either being present or absent and state the volume of air required to elicit the reflex. Because the RAIR is a reflex, it cannot be trained with biofeedback.

Biofeedback Applications

Sensory testing and compliance are both biofeedback tools that can be utilized and have been demonstrated to be successful (Chiarioni, Bassotti, Stegagnini, Vantini, & Whitehead, 2002; Wald, 1981). An example would be a patient who presents with a premature urge to defecate

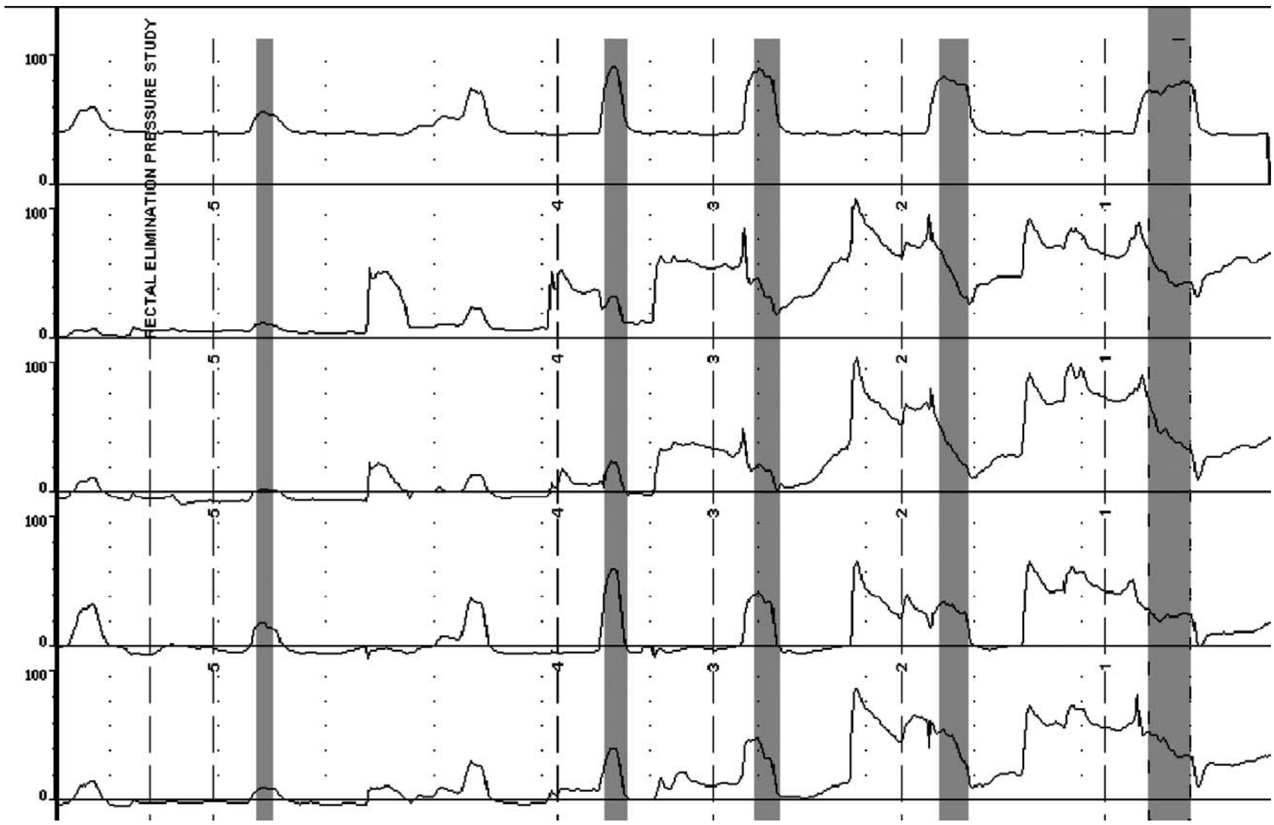

Figure 3. Rectal elimination pressure study. The top column is the pressure in the rectum. The remaining columns following downward on the graph represent the posterior, left, anterior, and right quadrants. The baseline pressure is created by the balloon to simulate the presence of stool in the rectum. The patient is asked to push as if he or she were attempting to have a bowel movement, and the pressure changes are measured in both the rectum and anal canal. Responses vary to this activity from a concomitant increase in anal canal pressure with rectal pressure during straining to a rapid simultaneous decline in anal canal pressure during staining when compared with rectal pressure. These are taken 5 cm from the anal verge and progress distally at 1-cm intervals.

and/or a slightly noncompliant rectum that is referred secondary to a complaint of fecal incontinence. Incontinence patients tend to increase their sensitivity to having bowel movements because of the likelihood of them leaking stool. Repeated incontinent episodes then can slowly decrease the patient's threshold for the urge to defecate, to a point that the slightest stimulus produces the call to stool. This premature urge to defecate would therefore be a learned response and not a true sensory deficit, which lends itself easily to biofeedback retraining. The patient would undergo biofeedback retraining through the utilization of the manometry balloon. By slowly and repeatedly increasing or challenging the rectum to larger volumes, patients can frequently increase their defecatory urge threshold to a more normal level. A similar procedure can be performed for patients who present with a noncompliant rectum. Repeated challenges, which slowly increase in volume, can with time alter rectal compliance for some patient populations. The opposite can be performed on patients with constipation who present with delayed first sense. Again, the balloon manometry is utilized but in the reverse manner. The patient learns to sense smaller and smaller volumes with the goal being to approach normal sensation. There are certain conditions for which this procedure is ineffective, such as megarectum syndrome. However, if the condition is acquired, it presents with the opportunity to be changed.

Rectal Elimination Pressure Study

The next procedure has been described many different ways and seems to have a variety of names: push studies, straining studies, or rectal voiding studies. For the purpose of this article it will be referred to as a rectal elimination pressure study. This test is performed by having the patient strain as if he or she were having a bowel movement, at which time a reading of both the anal canal pressure and the pressure being generated inside the rectum are recorded (see Figure 3). This is

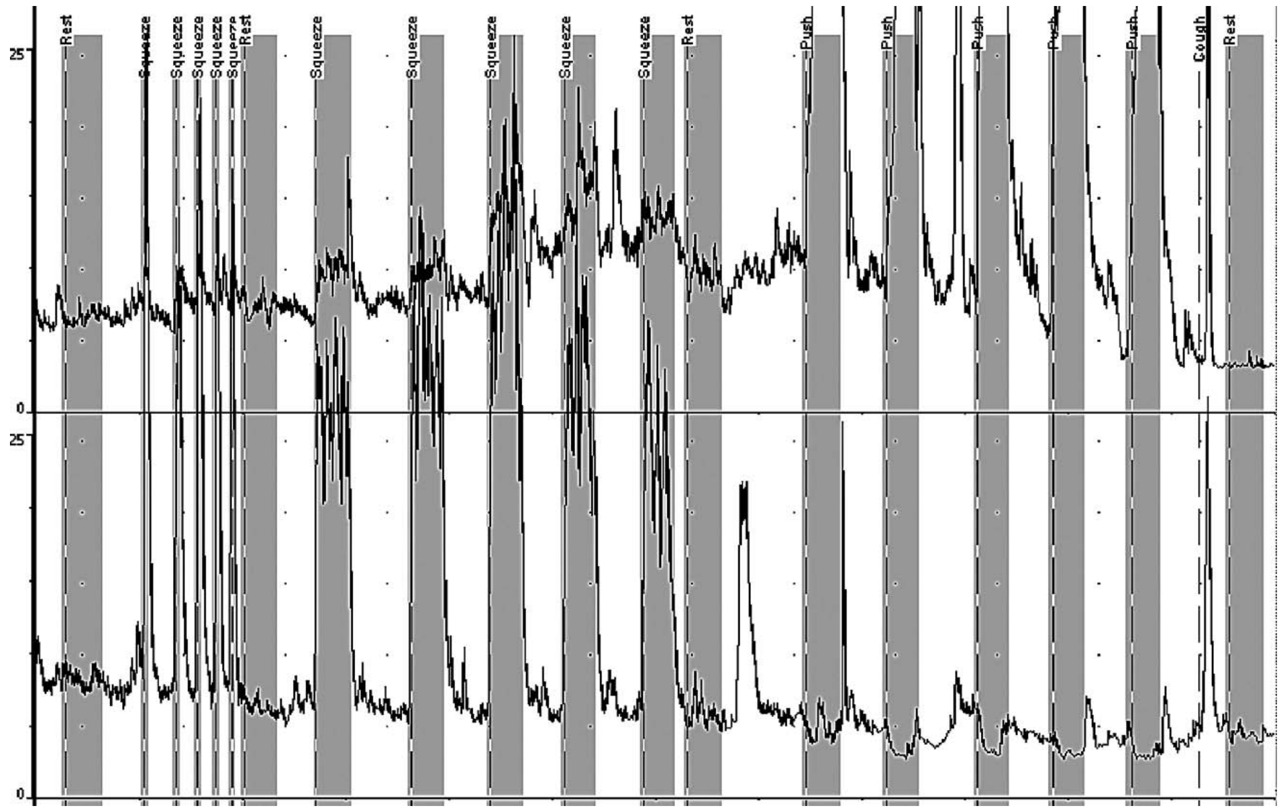

Figure 4. Electromyography (EMG) graph. Basic EMG evaluation of the pelvic floor utilizing a rectal plug. Resting activity is demonstrated at various positions in the examination. Volitional contractions are divided into first phasic contractions followed by tonic contractions of the sphincter complex. The graph demonstrates a very strong motor response to both activities. There is slight abdominal recruitment noted during sphincter squeezing. Straining maneuvers are performed last and listed under push above. The abdominal response is extremely strong, and it is notable that during straining there is a visible decrease in sphincter motor activity. The last check performed is for the cough reflex, which is present in the patient.

again done at 5 cm from the anal verge and progresses distally at 1-cm increments throughout the anal canal. Normal function would be that rectal pressure should exceed anal canal pressure during activities of straining. An abnormal result would demonstrate rectal pressure generated being below that of anal canal pressure. There are an obvious number of combinations that can occur: a deficit response in the patient's ability to increase rectal pressure, a concomitant rise in anal canal pressure with the rise in rectal pressure, or a sharp rise in anal canal pressure with little accompanied rectal response. This test is commonly positive on constipation patients and overflow incontinence and allows the physician to differentiate between an outlet obstruction producing the problem or an inability of the patient to generate adequate rectal pressure above that of the anal canal. An example of that would be a patient who presents with constipation, has a known rectocele, and complains of an inability to pass stool. (A rectocele is a bulge or herniation of the front wall of the rectum into the vagina.) The cause could be a paradoxical sphincter contraction, a hypertonic sphincter (anal stenosis), or a deficient straining maneuver. Often the latter is ignored and the patient is given relaxation exercises or is down-trained with the goal to decrease sphincter activity. The problem arises when sphincter activity is normal.

Biofeedback Applications

From a biofeedback standpoint, rectal elimination pressure studies can be utilized for guided retraining for two different conditions. The first case involves paradoxical sphincter contractions, which occur during straining maneuvers. The patients would have the opportunity to view the data coming across the screen and make appropriate adjustments while attempting a Valsalva maneuver. (A Valsalva maneuver is performed by having a subject carry out a maximal, forced expiration with the mouth closed and the nostrils pinched shut, and holding this for at least 10 seconds.) The second condition occurs when rectal pressure is not sufficient to overcome anal canal pressure during straining maneuvers. In this condition, sphincter pressures are within normal limits. Again the patient could undergo biofeedback retraining with the goal to learn to produce greater rectal pressure while attempting to have a bowel movement. Both of these conditions produce constipation, but with different causative factors. The down side of biofeedback utilizing the manometry probe remains that the patient is lying on his or her side and is not in a normal position for defecation.

Electromyography

Electromyography (EMG) is probably the most utilized method for both evaluation and biofeedback training for pelvic floor muscle dysfunction. EMG of the pelvic floor muscles can be performed using a needle electrode, a surface electrode on the perianal skin, or an anal plug (Gee, Jones, & Durdey, 2000). The majority of pelvic floor EMG evaluations are performed using the anal plug, with the occasional use of a vaginal plug. This procedure provides the ability to assess the neuromuscular integrity of the anal canal by recording the motor unit action potentials generated by the sphincter complex during rest, volitional contractions, evacuation maneuvers, and in response to various reflexes (Cheong, Vaccaro, & Salanga, 1995; see Figure 4).

EMG-guided biofeedback of the pelvic floor remains the least invasive and possibly the most useful tool. The advantages are that one can assess both static and dynamic activities. For example, functional recovery from fecal incontinence requires a patient to be able to not only sit while performing volitional contractions but also to be able to stand and ambulate. The use of the anal plug provides the physician the ability to both evaluate and perform biofeedback in all three of these positions. Pelvic floor EMG is usually paired with abdominal surface reading for the purpose of evaluating and treating abdominal pelvic dissociation disorders (APDD), which are common in incontinence patients. (These disorders will be clarified and discussed later in this article.) On occasion, surface leads are placed on other areas to assess for misguided contraction by patients while they attempt to squeeze the sphincter muscles. EMG biofeedback is used to down-train hypertonic muscles as seen in patients presenting with levator ani syndrome or a spastic anal sphincter. It is also utilized to assist with the normalization of pelvic floor instability as seen in patients with vulvodynia or vaginismus. (Vaginismus is an involuntary spasm of the muscles surrounding the vagina, closing the vagina, and blocking penetration. Vulvodynia refers to pain in the vaginal area.) By utilizing the information provided during a biofeedback session, patients learn to lower their resting muscle tension levels and/or reduce muscle instability with the goal of pain reduction (Glazer, Rodke, Swencionis, Hertz, & Young, 1995).

Biofeedback Applications

EMG-guided retraining is utilized with incontinence patients (Kamm, 2003; Palsson, Heymen, & Whitehead, 2004; Whitehead & Drossman, 1996) to demonstrate and reinforce to them how to produce an effective sphincter and pelvic floor muscle contraction to prevent leakage. This procedure is also used in treating constipated patients who demonstrate paradoxical sphincter contractions when straining (Heymen, Jones, Scarlett, & Whitehead, 2003). Additionally, EMG-guided retraining is employed or utilized for those patients who inappropriately co-contract their abdominal obliques or rectus abdominal muscles along with their sphincter complex (Whitehead & Drossman, 1996; Heymen et al., 2003). These conditions can be termed abdominal pelvic dissociation disorders; EMG biofeedback can be used to correct the maladaptive muscular patterns and decrease symptoms.

Pudendal Nerve Motor Latency

Pudendal nerve motor latency (PNML) testing addresses the motor innervation of the sphincter complex. The puborectalis and external anal sphincter muscles receive innervation from the pudendal nerve (Shafik, el-Sherif, Youssef, & Olfat, 1995). It had previously been accepted that the levator ani also had innervation by the pudendal nerve (Wall, 1993; Wester & Brubaker, 1998); however, recent evidence suggests that the levator ani does not receive pudendal input (Barber, Bremer, Thor, Dolber, Kuehl, & Coates, 2002; Juenemann, Lue, Schmidt, & Tanagho, 1988; Percy, Neill, Swash, & Parks, 1981; Snooks & Swash, 1986). However, all three of these areas do have some form of dual innervation from other sacral nerves, and this aspect should be noted when assessing the value of this test (Delancey, 1997; Retzky, Rogers, & Richardson, 1996; Wall, 1993).

PNML is performed by stimulating the pudendal nerves through the wall of the rectum. The nerve is stimulated with the use of a St. Mark's electrode. The electrode is designed to be attached to the examiner's glove. It has a stimulation electrode, which is secured to the examiner's fingertip, and a receiving electrode at the base of the examiner's finger. A pulsed stimulus is sent through the electrode, and the time (or latency) for the sphincter muscle to respond is recorded. The normal delay between stimulus and recording is <2.3 ms (Snooks & Swash, 1985). A longer delay is considered indicative of damage to the pudendal nerve.

Research has demonstrated that a prolonged PNML is not pathognomonic of poor functional integrity, and this finding creates some questions regarding its utilization. Studies have indicated that 31% of patients with bilateral prolonged PNML have squeeze pressures in the normal range and that 49% of those with normal PNML have squeeze pressures below the normal range (Hill, Hosker, & Kiff, 2002). Therefore, the use of this test to manage pelvic floor functional disorders is in question. Nevertheless, it seems to have strong prognostic value when surgical treatment is being considered. Surgical sphincter repair in the presence of pudendal neuropathy has only a 10% chance of success compared with an 80% chance in the absence of a neuropathy (Laurberg, Swash, & Henry, 1988). Pudendal nerve testing has no biofeedback capabilities.

Water Retention Test or Saline Continence Test

Water retention or saline continence test is a conventional and simple test that provides objective evidence of incontinence. In this procedure the patient can be placed either in a left lateral (sims) or prone (jackknife) position, and saline is infused at a constant rate of 60 ml/minute into the rectum. It is generally believed that healthy individuals are able to retain 1500 ml, whereas most incontinent patients leak after the instillation of <500 ml (Leigh & Turnberg, 1982). It is then relatively safe to say that if a patient can hold more than 500 ml without leakage for between 3 and 5 minutes, then he or she passes the test. This test is useful in predicting functional outcomes in patients being considered for stoma closure following an ileostomy or colostomy reversal. (The ileostomy procedure attaches the ileum or small intestine to a new stoma or opening in the abdomen in order to allow feces to pass from the body into an external reservoir. The colostomy attaches the colon to a new stoma or opening. The reversal of either involves closing the artificial stoma and restoring the original intestinal circuit.)

Balloon Expulsion Test

The balloon expulsion test is performed to evaluate the patient's defecatory ability. In this procedure a catheter with a dilation balloon attached is passed into the rectum, and 50-60 ml of saline is introduced into the balloon to simulate the presence of stool in the rectum. The patient is then asked to attempt to pass the balloon in the same manner he or she would during a bowel movement. Patients with outlet obstruction or those who are unable to produce sufficient rectal pressure above that of resting anal canal pressure cannot pass the balloon. This test is an objective measure of defecation.

Defecography-Proctography

Defecography, radiographic imaging of the process of evacuation, provides a static evaluation of anorectal anatomy and a dynamic assessment of anorectal function. The technique requires filling the rectum with 50 ml of liquid barium, followed by 100–200 ml of a barium paste, which is a mixture of barium and psyllium the consistency of soft stool. The patient is seated on a translucent commode and lateral x-rays are then taken of the anal canal and rectum at rest, during squeezing, and as the patent strains. This provides measurements of the length of the anal canal, the anorectal angle, and the degree of perianal descent. This is followed by video fluoroscopy of the anorectum during evacuation. This dynamic recording of rectal emptying provides a better evaluation of anatomical abnormalities such as a rectocele or a rectal prolapse (Shorvon & Henry, 1991). (A rectal prolapse involves an abnormal protusion of the interior rectal wall through the rectum.) Fluoroscopy also provides information about functional abnormalities. An example would be that during straining and evacuation the angle between the rectum and the anal canal should straighten and become more obtuse as the puborectalis muscle relaxes. If the puborectalis fails to release significantly, pelvic floor dyssynergia is indicated. (Pelvic floor dyssynergia presents in the form of chronic constipation due to an outlet obstruction resulting from inappropriate use of the muscles of the pelvic floor.) Therefore defecography provides both anatomical and functional information. However, it has no value as a biofeedback modality.

Endoanal or Transanal Ultrasound

Endoanal ultrasound provides high-resolution ultrasound images of the internal and external anal sphincter. A balloon is inserted into the rectum and is inflated with air. Next a rotating endoprobe is inserted, which provides a 360° evaluation of the anal canal. The procedure does not require sedation and is usually well tolerated by the patient. This procedure is considered the gold standard for diagnosing with extremely high accuracy sphincter defects such as tears and scarring (Sentovich, Wong, & Blatchford, 1998). Thus endoanal ultrasound is valuable for assessing whether a patient is a surgical candidate for a sphinctero-plasty. Regarding biofeedback this procedure is of little value. However, knowing the amount of damage to the sphincter complex can assist in clinical decision making when attempting to make gains in motor response on an EMG and correlating that with symptomatic presentations. The patient may demonstrate an improvement during EMG-guided biofeedback yet remain symptomatic because of the severity of the sphincter defect. Therefore endoanal ultrasound can be indirectly useful in biofeedback assessment and treatment.

Conclusion

All of the above tests can be beneficial when treating patients with pelvic floor dysfunction. The process of diagnosing their condition may encompass many of the tests mentioned. Choosing which of these to utilize for the purpose of biofeedback then becomes the clinically important choice. The goal is to pick the modality that shows the most promise for success for each individual patient. Often this means the procedure the patient seems to tolerate the best or the method the patient seemed to understand the best. Whatever modality is chosen, it must provide meaningful information regarding the patient's condition. The clinical decisions should be made prudently as they can have a great effect on outcome. A patient example illustrates this point.

Case Example

EMG assessment demonstrates that a patient has a very poor motor response during both tonic and phasic contractions. This response is very evident to both the clinician and patient. The patient attempts to increase the ability to produce a contraction while viewing the EMG data screen but has no success on repeated attempts. This patient may be one who is just unable to make the appropriate changes when provided with visual biofeedback. Possibly, this patient requires a different sensory input to change motor recruitment responses. An alternative would be to utilize an electric stimulation probe to increase the his or her sensation in the area and/or to offer a variety of visual images designed to enhance the appropriate response. These essential clinical decisions are made both at intake and throughout the patient's course of treatment. A wide assortment of procedures available to the clinician increases these clinical choices and can improve clinical outcomes.

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