Balloon Sphincterography

Clinical Findings After 200 Patients

CHRISTOPHER J. LAHR, M.D., DAVID A. CHERRY, M.D., LINDA L. JENSEN, R.N., DAVID A. ROTHENBERGER, M.D.

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There are two muscular mechanisms of fecal continence. The anal sphincter squeezes the anal canal, thus lengthening it and increasing its resistance. The puborectalis kinks the distal rectum, preventing the transmission of intra-abdominal pressures into the anal canal. Balloon sphincterography simultaneously records the shape of the anal canal and distal rectum and measures the strength of the puborectalis and anal sphincter muscles. This allows the physician to evaluate the function of these important muscles in patients with symptomatic defecation disorders such as constipation, incontinence, and rectal prolapse. A cylindrical balloon is connected by a hose to a fluid reservoir filled with liquid barium. The deflated balloon is placed into the anal canal and inflated by raising the fluid reservoir in increments. Fluoroscopy visualizes the balloon's shape and video records the results. Quantitative sphincterogram measurements in patients with defecation disorders include (the three measurements in each category refer respectively to incontinent patients [N = 87], prolapse patients without incontinence [N = 26], and constipated patients [N = 65]); anorectal angle (degrees + S.D.):114 + 28, 103 + 18, 95 + 19; anal canal length (mm + S.D.): 33 + 11, 38 + 10, 39 + 10; squeeze pressure (cm H_2O + S.D.):68 + 23, 80 + 16, 91 + 22, and opening pressure (cm H_2O + S.D.):52 + 25, 67 + 22, 81 + 24. The method is useful in identifying specific defects, such as paradoxic puborectalis contractions, that can cause constipation, and injuries to the sphincters that can cause incontinence. In over 280 patients with a wide variety of defecation disorders, sphincterography has yielded information not available by standard manometric techniques. It augments the findings of defecography. **[Key words: Balloon sphincterography; Fecal incontinence; Rectal prolapse; Anorectal angle; Anal canal length; Paradoxic puborectalis; Stiff perineum; Anal manometry; Defecography]**

From the Division of Colon and Rectal Surgery, United States Air Force Medical Center, Scott AFB, Illinois, and the Department of Surgery, Division of Colon and Rectal Surgery, University of Minnesota, and Colon and Rectal Surgery, Ltd., Minneapolis, Minnesota

BALLOON SPHINCTEROGRAPHY[1] is a fluoroscopic technique for watching and recording the shape of the anal canal and rectum. It shows how the pelvic and sphincter muscles contract and relax against controlled resistance. This report describes the technique and some of the authors' findings. It offers current opinions regarding use and limitations in clinical situations.

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Address reprint requests to Dr. Lahr: 57 Concord Drive, Fairview Heights, Illinois 62208.

Materials and Methods

Balloon sphincterography was performed on over 300 patients with a wide variety of evacuation disorders. This study includes the first 280 consecutive patients referred for physiologic anal evaluation. Symptomatic complaints included anal pain, constipation, diarrhea, incontinence, and procidentia.

The sphincterogram balloon consists of a cylindrical balloon connected by a hose to a bag of x-ray dye. The pressure in the balloon is equal to the height of the fluid in the bag above the balloon. The higher the bag, the higher the pressure in the balloon. The pressure in the balloon inside the patient can be controlled by raising or lowering the bag of dye.

The shape of the flexible, dye-filled balloon within the anal canal and rectum is visualized with fluoroscopy or plain x-rays. The curve of the balloon as it passes through the anal canal and anorectal angle can be observed during the voluntary contraction and relaxation of the puborectalis and during defecation. The investigator can see

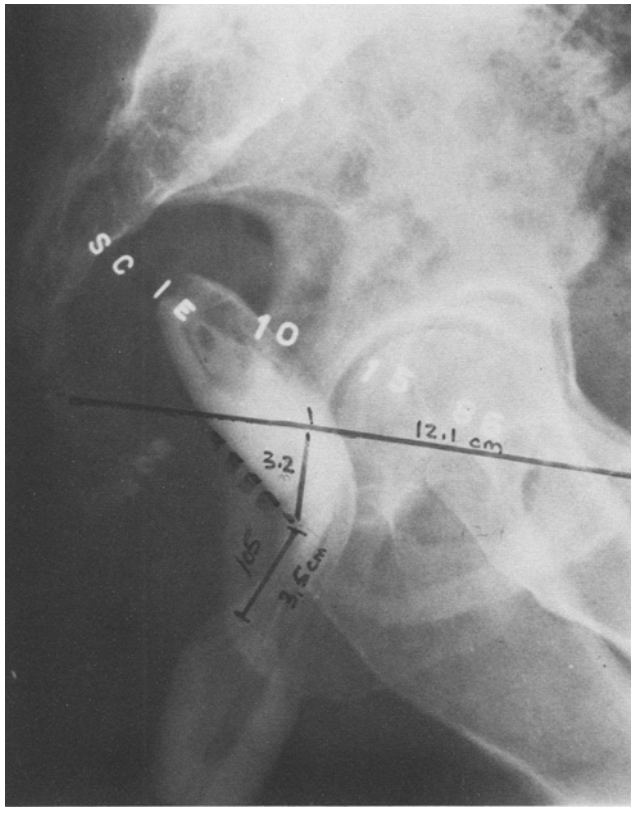

FIG. 1. Sphincterogram of normal subject at rest with hips slightly flexed and the balloon inflated to 40 cm H_2O.

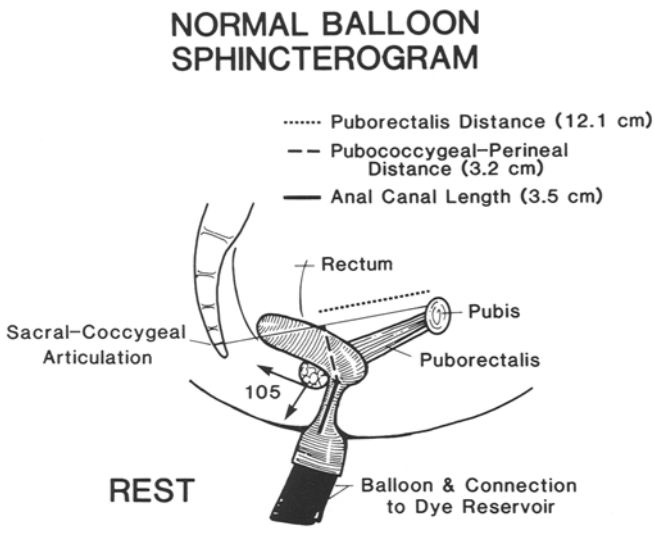

FIG. 2. Diagram of Fig. 1 identifying the measurements that can be made on each sphincterogram.

whether the balloon is expanded or collapsed at any given pressure. The highest pressure at which the squeezing sphincter muscle can collapse the balloon is the maximum squeeze pressure. The lowest balloon pressure at which the balloon expands within the resting anal canal is the opening pressure.

The maximum pressure within the balloon can be no greater than the maximum height of the dye bag, which is approximately 150 cm. There are no rigid components of the balloon, so impalement injury is unlikely. Because the balloon is disposable, there is no risk of disease transmission. Fluoroscopy exposure time is approximately 60 to 90 seconds.

Sphincterography is performed using a commercially available disposable kit. To set up the device, fill the premeasured barium bag with water to a level of 1500 cc and mix thoroughly. Secure the nylon cord to the top of the bag and pass the cord through the eye of an intravenous stand. Raise the intravenous stand to its maximum height. Raise and lower the bag by pulling and releasing the cord to assure smooth function.

Attach the calibrated measuring tape to the intravenous stand so that the lowest mark on the tape is level with the patient's anal canal (approximately 6 to 8 inches above the x-ray table). Holding the balloon below the bag, manually squeeze the balloon and allow it to fill with barium. Repeat this until there are no large bubbles in the balloon or tubing.

To perform the procedure, direct the patient to lie on the left side with hips and knees flexed. Insert the lubricated balloon into the anal canal until only 2 or 3 inches of the balloon remain outside the patient. Rest the connecting hose on an upsidedown disposable plastic washing pan. Keep the base in place by resting a lead glove on it. Center the x-ray unit. Make certain that the patient's hips are aligned perpendicular to the table. With the patient at rest, pull the nylon cord raising the bag until the balloon inflates inside the anal canal. Check the height of the bag against the measuring tape and record this as the anal canal opening pressure. Multiply the barium column height by 1.07 to obtain the cm H_2O.

Have the patient squeeze the balloon and raise the bag until the balloon inflates again. Record this bag height as the estimated sphincter squeeze pressure. Have the patient relax and lower the bag to zero on the tape measure. Now raise the bag to a point just below the estimated squeeze pressure. Have the patient squeeze. If the balloon does not compress, then the estimated value is too high. Have the patient relax and lower the bag to zero, then raise the bag to a point just above the estimated sphincter squeeze pressure. Have the patient squeeze. If the balloon does not remain inflated then the estimated value is too low. Repeat this process until the sphincter squeeze pressure is accurately determined.

Fluoroscopic or plain film x-ray recordings are made of the anal canal at 40 cm H_2O during rest (Figs. 1 and 2) and squeeze (Fig. 2). X-ray recording is also made at 40 cm H_2O during squeeze with the hips and back straight.

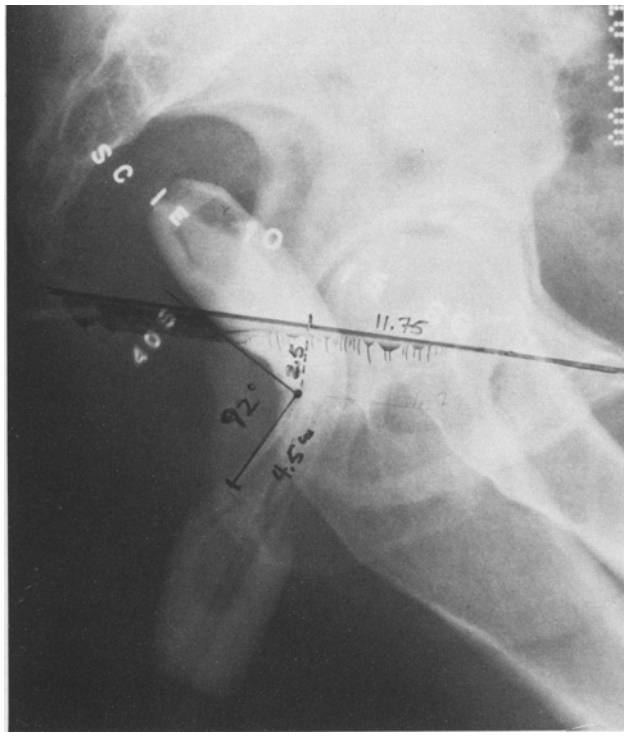

FIG. 3. Sphincterogram showing the changes that occur in a normal subject when he or she squeezes the pelvic muscles to maintain continence. The anal canal lengthens, the anorectal angle sharpens, and the puborectalis shortens.

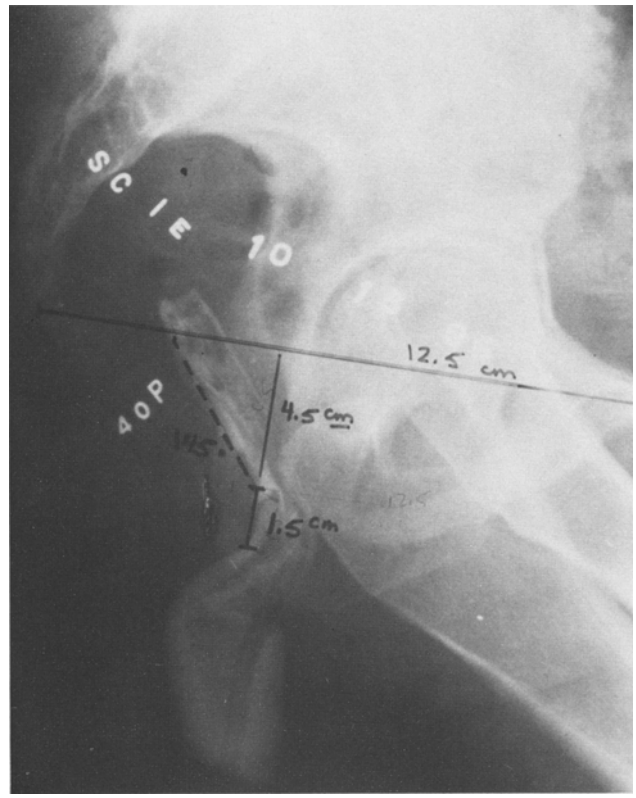

FIG. 4. Sphincterogram of normal subject showing the changes that occur during evacuation. The puborectalis and anal sphincters relax, producing a flattened anorectal angle and a short anal canal. Increased intra-abdominal pressure collapses the balloon within the rectum.

At 20 cm H_2O below maximum squeeze have the patient repetitively squeeze and relax until the balloon can no longer be collapsed. Record the number of squeezes performed. This is a measure of sphincter fatigue.

With the balloon pressure 40 cm H_2O and the hips and back again flexed, radiographically record the balloon shape as the patient tries to defecate (Fig. 4). Remove the balloon.

Results

Over 280 patients were evaluated with balloon sphincterography and anal manometry. There were no patient injuries or cases of disease transmission.

During defecation the anal sphincter relaxes and the anal canal shortens. The puborectalis relaxes, the distal rectum moves posteriorly, and the anorectal angle flattens. Increased intra-abdominal pressure compresses the rectum against the sacrum, squeezing stool out past the straightened anorectal angle and through the shortened, relaxed anal canal. In most patients with fecal incontinence (Fig. 5), the anorectal angle is flat, the anal canal is short, and the pressure within the anal canal is low both at rest and during squeeze. With voluntary squeeze, the anorectal angle sharpens and the anal canal lengthens. Because of the limits of the balloon, it is not always possible to reach the maximum squeeze pressure in patients with normal or high pressures.

In patients with a stiff perineum, the angle may appear adequate, but there is minimal contraction or relaxation of any of the muscles of continence. The baseline tone of the muscles is low and changes little with attempted contraction. There is little or no change in balloon shape during either contraction or relaxation. This has been seen following the surgical repair of congenital defects such as imperforate anus and in patients without prior surgery or medical conditions. These patients may present with either constipation or incontinence, depending upon their colon transit time.

Some patients with a stiff perineum have associated colonic inertia and suffer from constipation. These patients are likely to become fecally incontinent if flow to the rectum is suddenly increased or if the stool becomes more liquid. It is critical to identify the stiff perineum prior to surgical intervention because any surgical or medical treatment that reduces colon transit time may result in total fecal incontinence in these patients.

Though rectal prolapse or procidentia cannot be diag-

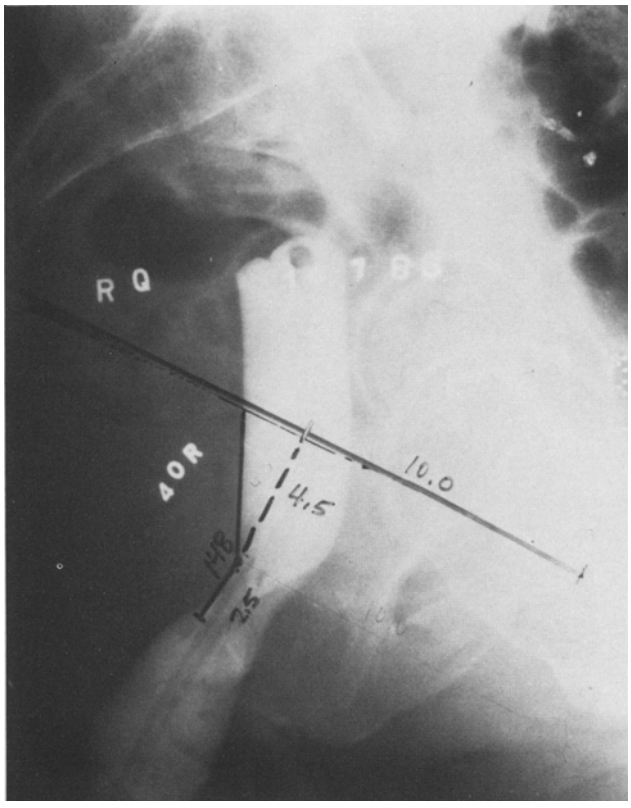

FIG. 5. Sphincterogram of incontinent subject at rest with hips slightly flexed. This demonstrates how the weakening of the sphincter and puborectalis muscles produces a flatter angle and a shorter anal canal.

nosed with the Lahr balloon, prolapse is often associated with sphincter and puborectalis weakness, which may result in fecal incontinence. In these patients the angle is very flat and the pressures are very low. There is little motion of the anal canal and angle during squeeze.

Following sigmoid resection and posterior rectopexy, where the rectum is pulled posteriorly and sewn to the sacrum, many incontinent prolapse patients become continent of stool. Postoperative sphincterograms demonstrate how the anorectal angle has been sharpened by pulling the distal rectum posteriorly.

Patients with prolapse who are continent do not usually have abnormal puborectalis or anal sphincter function. Patients with rectal prolapse who are also incontinent demonstrate muscle function indistinguishable from patients with incontinence but no prolapse.

During normal evacuation the puborectalis relaxes, allowing the distal rectum to move posteriorly, straightening the anorectal angle and facilitating the movement of stool from the rectum. In contrast, some patients with constipation have paradoxic puborectalis contraction. When they bear down to evacuate, the puborectalis contracts instead of relaxing. This sharpens the anorectal angle and makes it more difficult to empty the rectum. This paradoxic puborectalis contraction has been shown by Bleijenberg and Kuijpers[2] to respond to biofeedback or learned puborectalis relaxation.

TABLE 1. *Shincterogram Measurements in Defecation Disorders*

	Incontinent with Prolapse N = 24	Incontinent N = 87	Prolapse N = 26	Constipation N = 64
Anorectal angle*	118 + 31	114 + 28	103 + 18	95 + 19
Anal canal length†	33 + 13	33 + 11	38 + 10	39 + 10
Squeeze pressure‡	67 + 17	68 + 23	80 + 16	91 + 22
Opening pressure‡	47 + 24	52 + 25	67 + 22	81 + 24

*Degrees + standard deviation.
†Millimeters + standard deviation.
‡Centimeters of water + standard deviation.

Since puborectalis contraction is a normal maneuver that occurs when coughing and passing flatus, it is important that the patient understands the maneuvers he is being asked to perform. If not, a patient with normal pelvic floor function may appear to have paradoxic puborectalis contraction.

The Lahr balloon sphincterography technique does not identify occult rectal prolapse or rectoceles.

Quantitative measurements of anorectal angle, anal canal length, anal squeeze pressure, and anal opening pressure demonstrate differences between groups of patients in different clinical categories (Table 1). Standard deviations are moderate and there is overlap between categories.

Discussion

After studying over 280 patients with a battery of tests, it was found that the balloon sphincterogram effectively evaluates the two muscular gatekeepers of the rectum. These two gatekeepers are the anal sphincter muscle, which closes the anal canal lumen, and the puborectalis muscle, which kinks the distal rectum at the anorectal angle. The two muscles are separated by a fascial plane[3] and have separate innervations.[4] The sphincterogram balloon objectively and visually depicts both muscular mechanisms.

Although balloon sphincterography seems to be a good method for evaluating the pelvic musculature, there are several things it does not do. The balloon does not define mucosal or anatomic abnormalities such as polyps, masses, prolapse, or rectoceles. Therefore, it does not take the place of endoscopy or defecography. It provides

no information on stool viscosity, colonic transit time, or rectal sensation. It does, however, give some subjective information on rectal compliance.

One defect of the work so far is the absence of a normal control group. Work performed at the Mayo Clinic using the sphincterogram balloon indicates that the mean values for normal controls lay somewhere between those of constipated patients and those of prolapse patients without incontinence.[5]

Balloon sphincterography can objectively document muscle function before and after sphincter surgery. The authors hope to use sphincterogram findings to predict which therapy is likely to give the best results in a particular patient.

In patients with constipation, balloon sphincterography can identify chronic sphincter spasm, paradoxic puborectalis contraction, and the stiff perineum. In patients with incontinence, it quantifies sphincter muscle weakness and failure of the puborectalis to adequately sharpen the anorectal angle. These findings, when combined with results of defecography and transit time studies, can assist in making clinical treatment decisions.

Better categorization of patients with these evacuation disorders can prevent the application of therapies unlikely to succeed. For example, constipation associated with paradoxic puborectalis contraction during evacuation with normal colon transit times would be unlikely to benefit from subtotal colectomy.

Constipated patients may have slow transit times but normal sphincter and puborectalis function. Surgically incising the sphincter or puborectalis in these patients might result in incontinence while failing to relieve symptoms of bloating, distention, and infrequent bowel movements. Subtotal colectomy in the face of a stiff perineum can result in severe incontinence.

Incontinent patients with normal pelvic musculature, rapid transit, and poor rectal compliance may benefit from treatment of the inflammatory process responsible for the rapid transit and stiff rectum. An attempted surgical sphincter repair might have disastrous results in such a case.

Conclusion

Two muscular mechanisms maintain continence and allow controlled, voluntary, rectal evacuation. Balloon sphincterography evaluates these muscles. It visually, objectively, and dynamically demonstrates muscle function against a known, controlled resistance. Balloon sphincterography has been used to safely study over 280 patients. Sphincterography effectively demonstrates anal sphincter weakness and flat anorectal angles in patients with fecal incontinence and identifies paradoxic puborectalis contractions in patients suffering from constipation. It identifies the stiff perineum, which should be ruled out in all patients prior to undergoing subtotal colectomy for constipation. It can document muscle function before and after surgery. Used in association with other diagnostic studies it helps the clinician make therapeutic decisions and avoid unnecessary or harmful interventions.

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