

# Quantification of Evacuation Proctography

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**PURPOSE:** This study was designed to determine if evacuation proctography provides a clinically acceptable estimate of the time and completeness of rectal evacuation. **METHODS:** Rectodynamics, using a weight transducer and chart recorder to quantify the weight and rate of contrast expelled, was combined with evacuation proctography to assess agreement between the evacuation times recorded and the weight of contrast expelled compared with the lateral area change on proctography. **RESULTS:** Mean difference of evacuation times measured by the techniques was 0.1 seconds and the standard deviation of the differences was 1.9 seconds with 95 percent agreement limits of  $\pm 3.9$  seconds. The mean difference between the percentage of contrast evacuated by weight and the change in rectal area on proctography was 4.3 percent. The standard deviation of the differences was 11.9 percent with 95 percent agreement limits of -19.5 percent and +28.1 percent. **CONCLUSION:** Evacuation proctography provides a valid estimation of the time and completeness of rectal evacuation. [Key words: Proctography; Defecography; Rectum, physiology; Defecation]

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Evacuation proctography is an established radiologic technique to image the dynamic rectal changes during voluntary expulsion of barium paste.<sup>1</sup> In addition to visualizing rectal anatomy on evacuation, proctography may also provide an estimate of the rate and degree of rectal emptying. Rectodynamics, by use of a weight transducer and chart recorder, allow graphic quantification of rectal evacuation.<sup>2</sup> This study was designed to validate the proctographic estimation of evacuation time and completeness by simultaneous rectodynamics.

## METHODS

Consecutive patients referred for evacuation proctography underwent simultaneous rectodynamics. Before proctography the patient was given two glycerine suppositories and instructed to empty their rectum. Evacuation proctography was performed using a

standard technique. With the subject in the left lateral position, 120 ml of barium sulfate paste (E-Z-Paste<sup>®</sup>, 2 g/ml, E-Z-EM Inc., Westbury, NY) was injected into the rectum using bladder syringes and a cutoff Foley<sup>®</sup> catheter (Bard Urological Co., Covington, GA). The subject was then seated on a special commode (containing 4-mm copper filtration), placed on the foot rest of the screening unit, in the upright position. The patient was instructed to evacuate as rapidly and completely as possible. Fluoroscopy of rectal emptying was recorded on video.

A weight transducer (Uniweigh, Maygood Instruments Ltd., London, U.K.), sited under the disposable plastic bag for barium collection, was connected to an amplifier and chart recorder (Lectromed MX2P and MX216, Letchworth, U.K.) to plot the weight of contrast expelled against time. The percentage of contrast expelled and the time taken to do so were calculated from the graph (Fig. 1). Equipment was calibrated at regular intervals.

The video of each examination was analyzed using a computer video capture and digitizing system in conjunction with an image analysis program (DataTranslation Ltd., Wokingham, U.K.). The system was calibrated to compensate for radiographic magnification. Automated edge detection and image enhancement enabled precise identification of contrast/soft tissue boundaries allowing measurement of the lateral rectal area before and after evacuation (Fig. 2A and B).

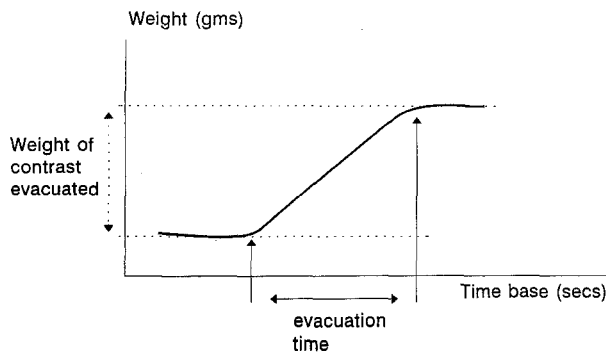
Evacuation, timed from the initial opening of the anal canal to completion of rectal emptying, was measured in seconds using the video counter. Percentage change in lateral rectal area pre-evacuation and post-evacuation was determined from computer image analysis, to give an estimate of the percentage of contrast evacuated.

Statistical analysis was performed with Minitab<sup>®</sup> Version 8.2. (Minitab Inc., State College, PA). Agreement was assessed by calculating the standard deviation (SD) of the differences between the two methods as described by Bland and Altman.<sup>3</sup>

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**Figure 1.** Rectodynamics graph of weight of contrast evacuated against time.

## RESULTS

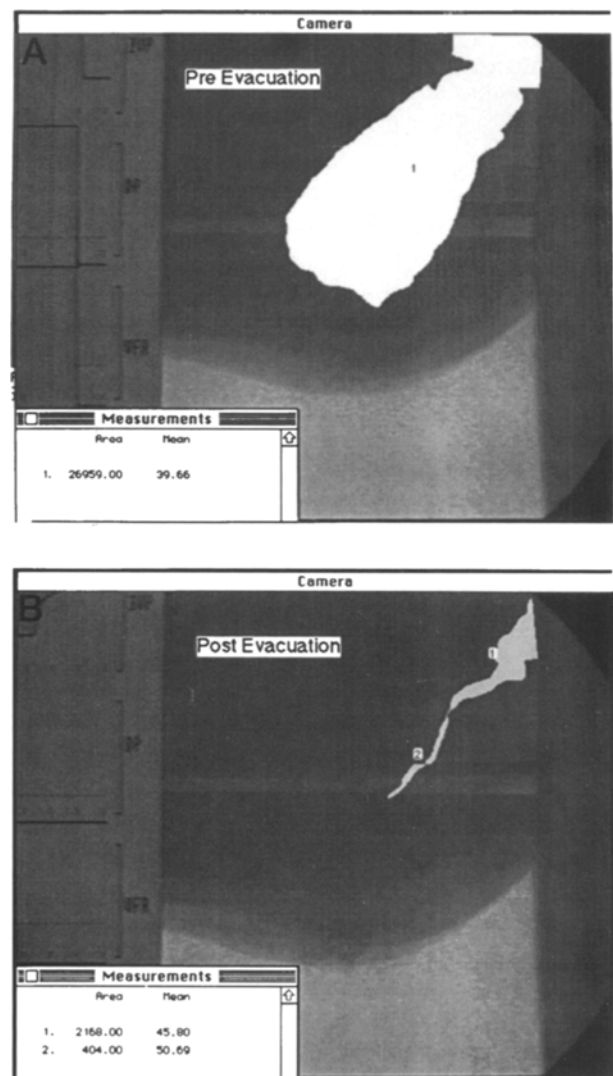
Sixty-nine patients (14 male and 55 female) were entered into the study. Three others were excluded because of retained residue.

Mean evacuation time on both rectodynamics and proctography was 15.3 seconds with a SD of 14 seconds (range, 2–80 seconds by graph and 2–77 seconds by proctography). Line of equality of evacuation time on proctography against rectodynamics is shown in Figure 3. Differences between corresponding time values plotted against the means, as described by Bland and Altman (1986),<sup>3</sup> is shown in Figure 4. Overall mean difference was 0.1 seconds. SD of the differences was 1.9 seconds, giving 95 percent limits of agreement of  $\pm 3.9$  seconds. Forty-five patients had an evacuation time of less than 15 seconds on rectodynamics. Overall mean difference in this group was 0.03 seconds with a SD of 1.5 seconds, giving 95 percent limits of agreement of  $-2.9 \pm 3.0$  seconds.

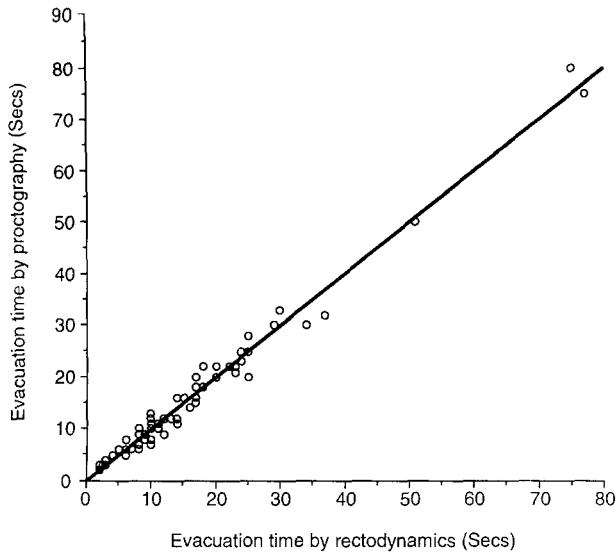
Mean percentage of contrast evacuated was 84 percent with a SD of 22 percent on both proctography (range, 4–100 percent) and rectodynamics (range, 18–100 percent). Line of equality for percentage area evacuated on proctography against percentage weight evacuated on rectodynamics is shown in Figure 5. Differences between corresponding values are plotted against means in Figure 6. Mean difference between the two methods was 4.3 percent, with a SD of 11.9 percent. The 95 percent limits of agreement were  $-19.5$  percent to  $+28.1$  percent. Fifty-three patients evacuated more than 66 percent of the contrast. In this group the overall mean difference was 6.2 percent, with 95 percent limits of agreement of  $-9.3$  percent to  $+21.9$  percent.

## DISCUSSION

Constipation is described as difficult or infrequent evacuation. Several studies in young women with idiopathic constipation have revealed pelvic floor incoordination and consequent failure of rectal evacuation in addition to delayed colonic transit.<sup>4–6</sup> The anorectal component to idiopathic constipation has been described as “anismus” and is characterized by delayed and incomplete rectal emptying.<sup>7</sup> This may be revealed clinically by the inability to pass a water-filled balloon.<sup>8</sup> Radiologic studies in constipated patients have demonstrated difficulty evacuating either liquid or semisolid contrast agents. In 58 patients with idiopathic constipation studied by evacuation proctography, the only significant finding was that 78



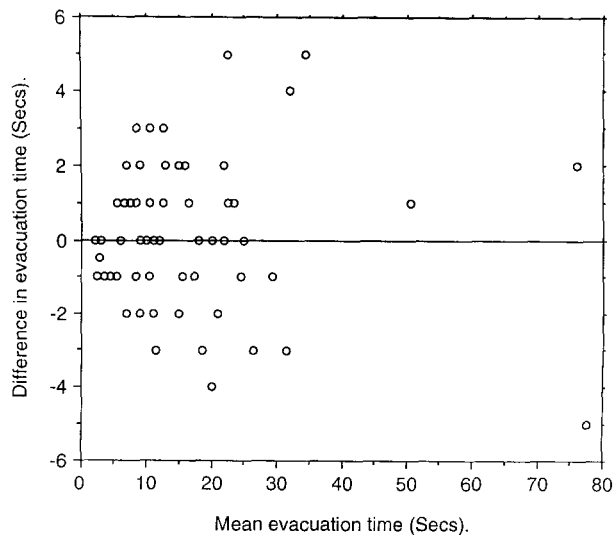
**Figure 2.** Computerized image analysis calculates lateral rectal area pre-evacuation (A) and postevacuation (B) and thus the percentage of contrast evacuated.



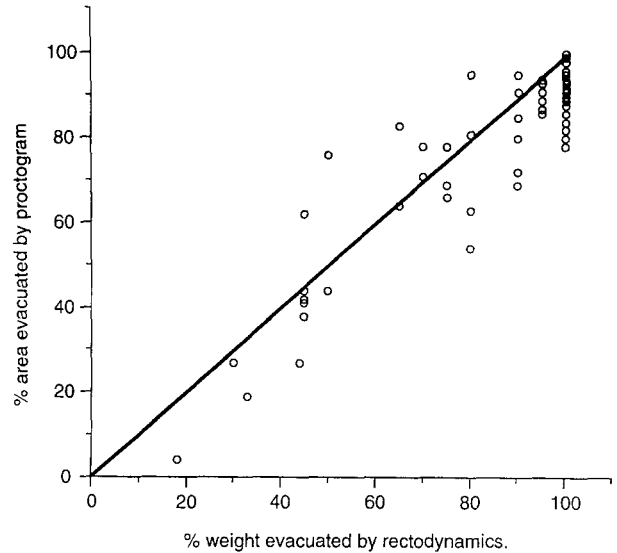
**Figure 3.** Evacuation time on proctography plotted against evacuation time by rectodynamics, with a line of perfect agreement.

percent had a prolonged evacuation time and 57 percent emptied incompletely when compared with a control group.<sup>9</sup> A varying degree of defecatory impairment has, therefore, been defined by evacuation proctography, raising the possibility of using proctographic estimation of the rate and completeness of rectal evacuation to diagnose anismus.

Rectodynamics was developed to quantify rectal evacuation without the need for ionizing radiation.<sup>2</sup> As such it would be a suitable technique for monitoring response to treatment, such as biofeedback behavioral therapy.<sup>10</sup> Rectodynamics has demonstrated that normal patients evacuate rapidly and completely,



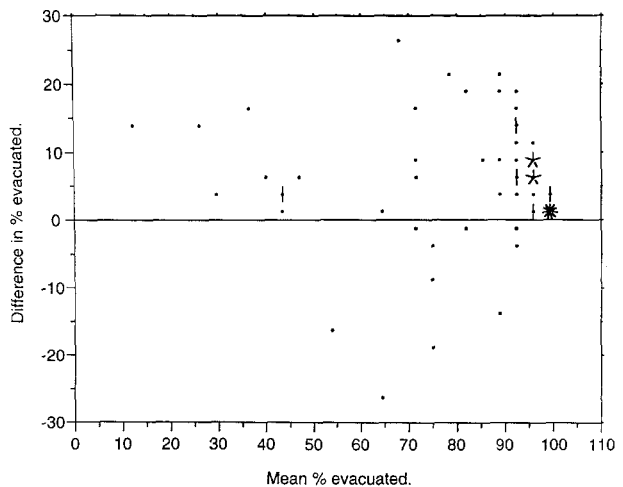
**Figure 4.** Plot of the difference between corresponding time values against means.



**Figure 5.** Percentage of contrast evacuated calculated from proctography plotted against the percentage weight evacuated calculated from rectodynamics, with a line of perfect agreement.

whereas patients with idiopathic constipation demonstrate delayed and incomplete rectal emptying. It is claimed that such tests of rectal evacuation may be more informative than a radiologic investigation.<sup>11</sup> It has also been suggested that estimation of these parameters from evacuation proctography is likely to be inaccurate.<sup>12</sup>

Rectal emptying is judged from the lateral area of contrast in the rectum.<sup>13</sup> Retained volume of contrast after proctography has been estimated planimetrically,<sup>14</sup> but the depth of the radiographically dense barium cannot be assessed. It is assumed that rectal collapse is circumferentially uniform. However, posteroanterior views indicate that the rectum folds over



**Figure 6.** Plot of difference between corresponding estimates of percentage evacuated against means.

as it empties<sup>15</sup>; therefore, this assumption may not be true throughout evacuation. Rectodynamics quantifies the weight of contrast expelled; therefore, the percentage evacuated may be determined precisely. By comparing this to measurement of the lateral area of the rectum, it was possible to determine the relationship of area to volume of contrast expelled. Computer image analysis used to determine the cross-sectional area of rectal contrast is more accurate and reproducible than tracing. Also, the time to evacuate, clearly defined from rectodynamics, has been used to validate the proctographic assessment in patients in whom both techniques have been performed simultaneously.

Our study demonstrated that evacuation proctography is able to predict completeness of rectal emptying within limits that are clinically acceptable, despite the assumption that rectal collapse on voluntary evacuation is cylindrical. No such assumptions are necessary when validating evacuation time, and consequently agreement with rectodynamics is greater. Measurement of evacuation time is more difficult with both methods when evacuation is prolonged. Start of evacuation is clearly demonstrated by both methods; the anal canal is seen to open on proctography, and the rectodynamic graph starts to rise. However, the end point is difficult to define when there is prolonged evacuation of small amounts of contrast. The graph rises by very small increments, a phenomenon described by Shafik.<sup>11</sup> This is not a problem in the clinical setting, as a larger margin of error is acceptable when the evacuation time is significantly prolonged.

Evacuation proctography may be used to quantify rectal evacuation in a similar fashion to rectodynamics, in addition to providing structural information. As such it may be used to diagnose functional disorders of evacuation, such as anismus.

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