Rectal Gas Volume Measured by Computerized Tomography Identifies Evacuation Disorders in Patients With Constipation

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BACKGROUND & AIMS: **Approximately one third of patients who present to gastroenterology care with constipation have rectal evacuation disorders. We aimed to compare rectal gas volume, measured by computerized tomography (CT), in constipated patients with and without rectal evacuation disorders.**

METHODS: **In a retrospective study, we collected data from 1553 patients with constipation, evaluated over 20 years. We analyzed data from 141 patients evaluated by anorectal manometry, balloon expulsion tests, and colon transit tests, collecting records of abdominal and pelvic CT examinations. Patients were classified into 3 subgroups: those with rectal evacuation disorders, slow-transit constipation, or normal-transit constipation. Two observers used standard CT software to identify variable regions of interest on each cross-sectional CT image that contained rectum and measured areas of gas in each slice; they then summated entire volumes of rectal gas. For the 3 groups, we compared rectal gas volume, maximal rectal gas transaxial area (measured by CT), and area of rectal gas (vertical) on the 2-dimensional abdominal film (scout) using the Kruskal–Wallis test.**

RESULTS: **The intraclass correlation coefficient between 2 observers' measurements of rectal gas volume was 0.99 ($P < .001$). There were overall group differences in rectal gas volume and the maximal rectal gas transaxial area (both $P < .001$). The median rectal gas volume was higher in patients with rectal evacuation disorders (13.84 cm^3) than in patients with slow-transit (2.51 cm^3) or normal-transit constipation (1.33 cm^3, both $P < .05$). Similarly, the area of rectal gas, which correlated with the maximal rectal gas transaxial area (Spearman correlation coefficient, 0.7; $P < .001$), showed overall 3-group differences ($P = .033$), with greater areas of rectal gas on the abdominal scout film in patients with rectal evacuation disorders than in those with normal-transit constipation.**

CONCLUSIONS: **In an analysis of patients with constipation, we found rectal gas volume, determined by abdominal CT imaging, to be greater in patients with than without rectal evacuation disorders.**

Keywords: Balloon Expulsion; Abdominal Radiograph; Colonic Transit.

Chronic constipation is a common disorder with a prevalence of 2% to 27% in Western countries.[1–4] After exclusion of structural diseases, there are 3 large categories or subgroups of patients with chronic constipation: normal-transit constipation, dyssynergic defecation or rectal evacuation disorders, and slow-transit constipation (STC).[5]

Commonly applied symptom criteria recommend identification of straining or incomplete evacuation among patients with functional constipation.[6] However, these symptoms do not specifically distinguish constipation resulting from abnormal colonic function from that arising from failure of rectal evacuation, as may occur in patients with pelvic floor dyssynergia, descending perineum syndrome, or anismus.[7] Among patients in the community with symptoms consistent with constipation, approximately one-third report straining or a sense of incomplete rectal evacuation that are suggestive of a rectal evacuation disorder. In fact, in a cohort of 1411 patients presenting with constipation to a single physician in a gastroenterology practice in secondary or tertiary care, almost 30% had evidence of a rectal evacuation disorder.[8] A therapeutic trial of

Abbreviations used in this paper: **AUC, area under the receiver operating characteristics curve; CI, confidence interval; CT, computerized tomography; ICC, intraclass correlation coefficient; MRI, magnetic resonance imaging; NPV, negative predictive value; PPV, positive predictive value; RED, rectal evacuation disorders; RGV, rectal gas volume; ROC, receiver operating characteristics; ROI, region of interest; STC, slow-transit constipation.**

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increased dietary fiber differentiated simple constipation from that caused by slow-transit, drug-induced constipation, or evacuation disorder, but could not differentiate among the latter 3 groups.[9]

Rectal evacuation disorders are the most common cause of refractory chronic constipation.[3,10] Identification of rectal evacuation disorders has required formal testing with anorectal manometry, balloon expulsion,[7] or defecography (eg, with magnetic resonance imaging [MRI]) to confirm the typical clinical features identified on history and rectal examination[5] that suggest a rectal evacuation disorder. MR defecography or dynamic pelvic MRI can evaluate pelvic floor anatomy, dynamic motion, and rectal evacuation simultaneously with excellent resolution of anal sphincters, levator ani muscles, and soft tissue surrounding the rectum without radiation exposure. However, the major limitations include high cost and lack of availability, suggesting that alternative radiologic approaches are desirable to screen for the presence of rectal evacuation disorders among the large numbers of patients presenting with constipation.

In healthy subjects who underwent infusion of a gas mixture into the jejunum, impaired propulsion and self-restrained anal evacuation increased gas retention.[11] Moreover, in healthy subjects, infusion of gas into the rectum produced marked relaxation of the rectum,[12] and, potentially, collection of gas there.

Our study hypothesis was that the constipation associated with rectal evacuation disorders is associated with a greater volume of gas in the rectum than in constipated patients without rectal evacuation disorders.

The aim of this study was to compare the rectal gas volume measured on computerized tomography (CT) imaging between constipated patients with and without rectal evacuation disorders.

Methods

This medical record review study was approved by the Mayo Clinic Institutional Review Board (16-003630) for patients who had provided unrestricted consent to the use of their medical records for research purposes. The study population,[13–22] criteria for rectal evacuation disorders, slow- or normal-transit constipation,[23–26] and conduct of procedures, anorectal manometry and balloon expulsion studies,[8] and colonic transit measurements,[15] are detailed in the Supplementary Material. Q10

Identification of Rectum on Computerized Tomography Scans

After a preliminary study of several images from these patients without knowledge of the subgroup, we standardized the vertical extent of rectal gas from the transaxial slice at the lower margin on the pubic symphysis to the slice at the entry to the lower pelvis, that is, the lower margin of the sacro-iliac joints. These anatomic landmarks served to standardize the comparison of rectal gas volumes in the 3 groups of patients and to minimize the potential of including part of the sigmoid colon, with its variable extent, shape, and orientation, in the pelvis. Adopting this approach based on these bony landmarks was necessary because standard anatomic texts do not provide a clear definition of the upper extent of the rectum or any anatomic demarcation between the rectum and the sigmoid colon. Our definition of the rectum reflected the straight part (rectum = straight) of the distal colon in the lesser pelvis delineated by the lower margin of the sacro-iliac joints, in contrast to the more variable anatomic structure of the sigmoid (sigmoid = S-shaped) colon located in the greater pelvis and lower abdomen. This approach was used for the transaxial CT images as well as the evaluation of the surface area of the rectal gas on the abdominal scout film of the CT.

Measurement of rectal gas volume. Previous studies have used CT assessment of intestinal gas volume by using specialized software programs.[27,28] We used the abdomen–pelvic CT obtained as close as possible to the time of the definitive diagnosis of subtype of chronic constipation (based on clinical criteria and anorectal manometry), as long as the medical record documented the presence of constipation at the time of the CT scan. We adopted the method used in the measurement of volume of a solid organ using software available as a standard program on CT imaging.[29,30] This method assessed the area using a manually operated variable region of interest (ROI) tool on each cross-sectional CT slice that contained rectum to carefully outline the area of gas in the rectum in each slice, multiplied by the slice thickness. The area of ROI was computed automatically using Quick query Radiographs and photographs Electronic Analysis and Display Station (version 5.7.2). We then summated the volume of each slice for the entire gas identified in the rectum. Thus, the summated rectal gas volume was expressed as cm^3 using the following formula: $\text{rectal gas volume}\,(cm^3) = \sum(\text{area of ROI on each slice} \times \text{thickness of each slice})$. Q11

The measurement of rectal gas volume (RGV) was performed independently by 2 observers (S.-Y.P. and D.K.) who were instructed on how to identify and measure RGVs. Before starting the study, the 2 observers performed measurements on 10 standard cases, and interobserver and intra-observer coefficients of correlation and interclass correlation coefficients were calculated to evaluate the interobserver reliability.

Measurement of rectal gas area on abdomen scout film. By using abdomen scout film on abdomen CT, the surface area of rectal gas was outlined by using the same manually operated ROI approach, and the software program calculated the area.