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Reproducibility of the proctometrogram

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SUMMARY The reproducibility of a method of measuring rectal distensibility by continuous controlled fluid inflation with a balloon has been evaluated in 15 patients. The volume at sensation threshold, constant sensation and maximal tolerance, the pressures at these volumes and rectal compliance were measured. The mean coefficients of variation of the seven variables measured ranged from 4·7%–7·9%. The expected correlation between rectal compliance and maximal tolerable volume was confirmed ($r=0·85$, $p<0·001$). The high reproducibility makes this investigation reliable for use in clinical practice and research.

In 1927 Rose described a method of recording pressure responses within the urinary bladder in response to filling.[1] Since then the cystometrogram has become accepted as a useful aid in studying the bladder in health and disease. Joltrain and his colleagues proposed a method of measuring the filling pressure of the large intestine in 1919.[2] They described a few observations but drew no important conclusions. White, Verlot, and Ehrentheil independently rediscovered the method in 1940.[3] They noted abnormalities in patients with neurological disease by filling the entire colon with water. Their technique for undertaking the colonmetrogram was difficult, messy, and hazardous and was therefore not accepted in clinical practice. Scott and Cantrell used a similar technique to study the effects of section of the parasympathetic nerve supply of the colon in the anaesthetised dog.[4] Lipkin *et al*[5] were probably the first to use balloon distension of the sigmoid colon to measure its pressure-volume relationships and to describe alterations with pharmacological agents. Godec *et al*[6] and Bubrick *et al*[7] used balloon distension of the rectal ampulla with air as an adjunct to the evaluation of bladder dysfunction and postulated its use for the study of neurogenic bowel dysfunction. Preston and coworkers described a method of evaluating rectal pressure and volume in constipation using fluid distension.[8] None of these techniques, however, have been subjected to reproducibility studies.

We have used a method of continuous controlled balloon rectal distension modified from Bubrick *et al*[7] to measure rectal sensation, volume and compliance. This study reports on its technique and reproducibility.

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Methods

PATIENTS

Approval for this investigation was given by the Ethical Committee of the North Lothian District, Lothian Health Board, Edinburgh, Scotland, on 16 June, 1983. Informed consent was obtained from all the subjects participating in the study.

Fifteen patients (five men, 10 women, age range 16–85 years, mean 48·4 years) were evaluated in the reproducibility study. Their details are shown in Table 1. Seven patients underwent repeat proctometrograms on the same day at an interval of two to four hours, whilst the remaining eight patients were recalled for a repeat test approximately 10 days later. All the patients were requested to fast from the night before and to empty their bowel on the morning of the study but no laxatives were used. Immediately before the proctometrogram a digital rectal examination and limited sigmoidoscopy with a

Table 1 *Details of patients evaluated in reproducibility study*

Disease	*Patients (no)*
No anorectal pathology	2
Acquired megacolon	3
Chronic constipation	3
Radiation proctitis	3
Irritable bowel syndrome	2
Solitary rectal ulcer	1
Coloanal sleeve anastomosis (radiation injury)	1

paediatric instrument and without air insufflation were done to ensure that the rectum was empty.

The apparatus used is shown in Figure 1. The patient lies in the left lateral position. A high compliance balloon (condom type, deflated dimensions 19 cm × 5 cm) bound onto non-distensible polyvinylchloride tubing (internal diameter 5 mm, reference number 800/002/067 Portex Limited, Kent, UK) is introduced into the empty rectum. A microtransducer (type 16 CT silicone, Gaeltic Limited, Dunvegan, Isle of Skye, UK) within the rectal balloon monitors pressure continuously and is connected to a chart recorder (Devices Limited, UK). The microtransducer is precalibrated to record pressures from 0 to 100 cm H_2O, the chart speed being 10 mm per minute. It is possible to use a water filled microballoon (internal diameter 4 mm, HSC4, Precision Dippings Ltd, Bristol, UK) connected *via* fine non-distensible tubing to an external transducer to record pressure instead of the microtransducer. It is important to exclude air from the system before inflation and to place the balloon in the rectal ampulla where the lowest rectal pressure is usually recorded (approximately 15 cm H_2O). Continuous balloon inflation is done at a rate of 67 ml/min (4 litres per hour) by means of a peristaltic pump (Nouvag SP40, Plastic Pumps Limited, Middlesex, UK).

Bench testing of the system measured the pressure-volume characteristics of the distending balloon itself (Fig. 2a). Several balloons of the same make tested showed identical characteristics. On inflation the balloon adopts a cylindrical configuration. There is an initial rise in intraballoon pressure of approximately 10 cm H_2O with infusion of the first approximately 50 ml water into the balloon. With further infusion there is no further rise in pressure up to a capacity of more than three litres. This system is therefore ideal for the measurement of rectal distensibility as the slope of the rectal pressure (P, cm H_2O) – volume (V, ml H_2O) graph after the first 50 ml infusion accurately reflects true rectal compliance (Δ V/Δ P, ml/cm H_2O). True intrarectal pressures can also be easily calculated from the graph by subtracting the 10 cm H_2O contribution from the balloon at volumes in excess of 50 ml. In the megacolon type of curve (Fig. 2d) the compliance is more easily calculated by dividing the maximal tolerable volume by the rectal pressure

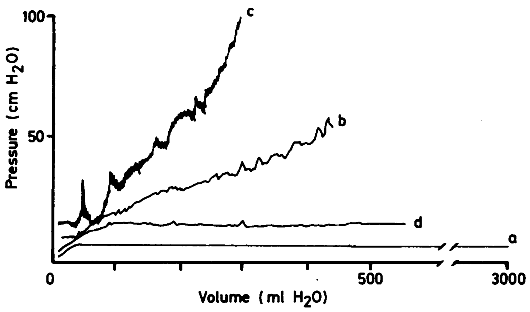

Fig. 2 *Diagrammatic representation of the pressure volume characteristics of the proctometrogram balloon (a) and proctometrograms from a normal subject (b), a patient with radiation proctictis (c), and a patient with acquired megacolon (d).*

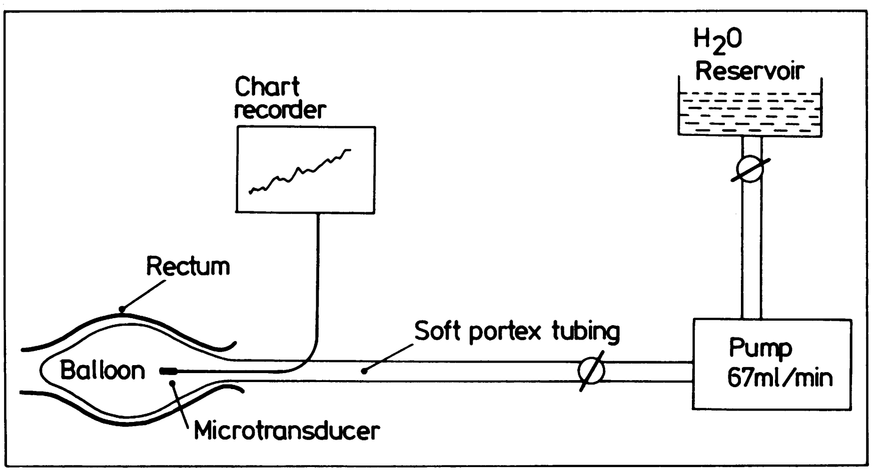

Fig. 1 *Apparatus for the proctometrogram.*

increment achieved on instillation of this volume although the slope of the graph can also be measured. The patient is asked to report the first perception of rectal filling and this is recorded as the sensation threshold. This is followed by a sensation of constant rectal distension and the volume at this sensation is also recorded. In some patients these initial sensations may be indistinguishable. Inflation is continued until the patient has a strong desire to evacuate the balloon and will not tolerate further distension – this is the maximal tolerable volume. This sensation is usually not painful. The balloon is then emptied *via* the tubing. The parameters recorded in the reproducibility study were the volumes and pressures at the threshold, constant and maximal tolerable sensations and the rectal compliance measured on the linear portion of the graph.

Figure 2 shows some typical proctometrograms from patients in this study (Table 1). In a normal subject (Fig. 2b) there is a slow and steady rise in intrarectal pressure with distension in an approximately linear fashion. In sharp contrast to this is the proctometrogram from a patient with symptoms of urgency and frequency of defaecation following mild chronic radiation rectal injury from radiotherapy for prostatic carcinoma (Fig. 2c). The graph is shifted to the left with a relatively steep rise in pressure and there was marked reduction in sensation threshold, maximal tolerable volume and rectal compliance in this patient. In chronic idiopathic constipation and acquired megacolon the pressure volume relationship is shifted to the right (Fig. 2d) and there is a relative increase in sensation threshold, maximal tolerable volume and rectal compliance.

Results

Figure 3 shows a reproducibility plot for the maximal tolerable volume in the 15 patients studied (Table 1). The straight line represents a 100% reproducibility graph. The mean coefficient of variation for this parameter was 4·7%. Figure 4 shows a similar plot for rectal compliance. There is more variation at the higher compliance values such as those found in acquired megacolon but the mean coefficient of variation is only 6·5%. Table 2 lists the reproducibility values of the other parameters of the protometrogram. The mean coefficients of variation ranged from 4·7% to 7·9%. No significant differences in reproducibility could be shown between the group of patients who had the investigation performed on the same day compared with the group in which it was performed on different days.

Figure 5 shows the significant correlation of the maximal tolerable volume with rectal compliance in the 15 patients comprising this study.

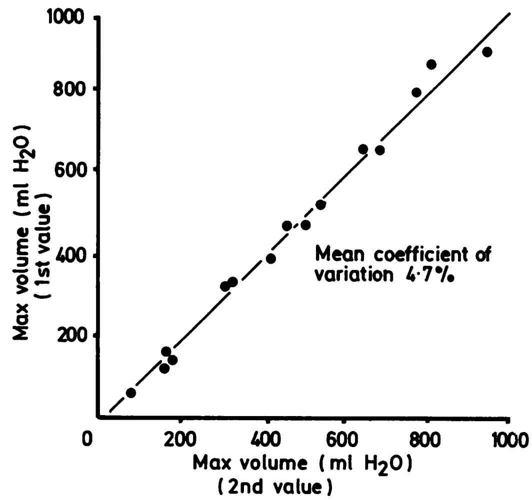

Fig. 3 *Reproducibility of maximal tolerable volume (n=15). The straight line represents 100% reproducibility.*

Discussion

An important function of the rectum is its ability to act as a dynamic reservoir for faeces. Like the urinary bladder this function is dependent on its functional capacity, perception of filling and contractile properties. The measurement of rectal volume, sensory perception and distensibility is therefore of undoubted value in the physiological investigation of anorectal function.[9 10] The information obtained helps to explain the basis of many

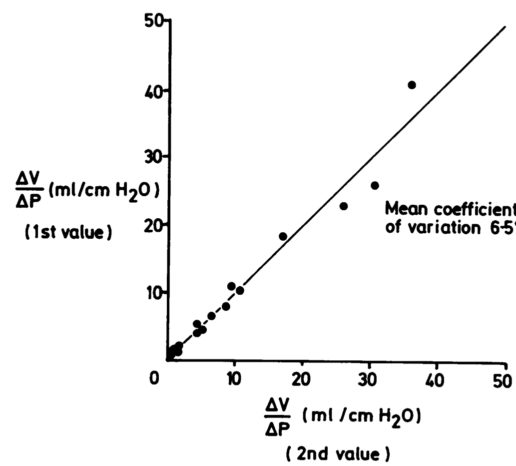

Fig. 4 *Reproducibility of rectal compliance (n=15). The straight line represents 100% reproducibility.*

Table 2 *Reproducibility of the proctometrogram*

Parameter	Mean coefficient of variation (%)
Volume at sensation threshold	7·9
Volume at constant sensation	6·7
Maximal tolerable volume	4·7
Pressure at sensation threshold	7·6
Pressure at constant sensation	6·2
Pressure at maximum tolerable volume	5·1
Rectal compliance	6·5

symptoms such as those described after radiation rectal injury, and may help to decide the logical course of treatment.[11] The technique of the proctometrogram described offers a relatively simple, cheap and practical method of evaluating the physiology of rectal function in health and disease. The use of water as the distending agent eliminates the necessity of correction for pressure and temperature in calculating the distending volume when gas is used.[14] The continuous infusion pump makes the tedious calculation involved in stepwise inflation methods[9 12] unnecessary. The bench properties of the high compliance rectal balloon (Fig. 1a) were found to be consistently identical for the type used in this study. The characteristics of individual types of balloon should be ascertained, however, before use *in vivo*. The use of the microtransducer to measure rectal pressure avoids the drawbacks associated with fluid filled transducer systems.[13] The calculation of intrarectal pressure and compliance is made much simpler compared with other methods[12] because of the lack of any significant pressure contribution by the balloon. The relatively low rate of infusion (67 ml/min) was used because it corresponds to an intermediate rate (10–100 ml/min) used in medium fill cystometry[14] and hence probably represents a more physiological rate of filling. It has also been observed that the sharp increase in pressure when the maximal tolerable volume is reached is seen less often compared to other workers,[14 15] partly because of the lower infusion rate – for example, Preston *et al* who used a similar balloon with higher rates of infusion – and partly to the larger size and capacity of the balloon used in this study – for example compared with Bubrick *et al* who used a balloon of only 405 ml capacity. These factors may also explain the relatively higher maximal tolerable volumes observed in normal subjects in this study (Fig. 2b). Lipkin and Sleisenger[16] found, not unexpectedly, that the onset of pain on distension of either the rectum or sigmoid colon was inversely proportional to the level of water pressure exerted by the balloon. Although they did not report differences in the rate of inflow, these certainly existed. There is more variation in measuring threshold sensation and pressure compared with the other parameters. This is not surprising in view of the transient and intermittent nature of this sensation which is also more difficult to explain to the patient. The reproducibility at higher volumes (Fig. 3) and compliance (Fig. 4) is also reduced although overall reproducibility remains high and the measurements therefore reliable. Such a reproducibility has not been previously shown with other methods. The functional reservoir capacity of the rectum might be expected to be dependent on its compliance. We have been able to confirm this in practice (Fig. 5) and shown a high correlation between these parameters. The compliance and accommodation properties of the rectum may also play a role in determining the characteristics of the rectosphincteric reflex as suggested by the studies of Arhan *et al.*[17]

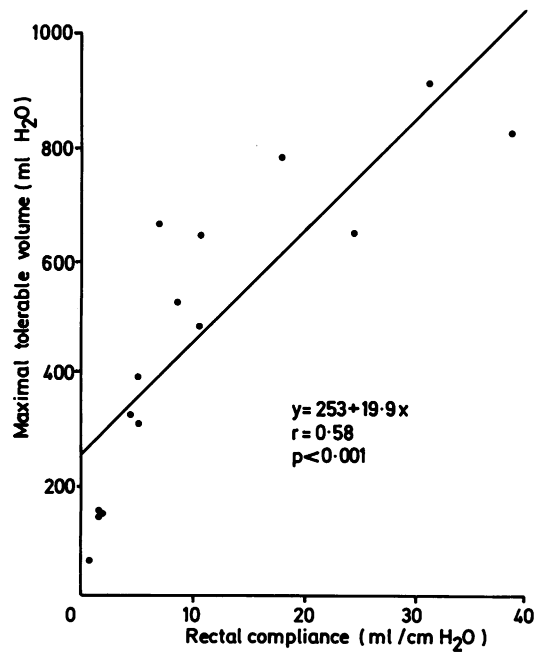

Fig. 5 *Correlation between rectal compliance and maximal tolerable volume (n=15).*

In order to obtain consistent and reliable results care must be taken to ensure that the rectum is empty, that there is no air within the system and in the placement of the balloon. Drugs can alter the pressure volume characteristics of the colon[5] and their effects should therefore be considered.

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