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The Current Understanding of Continence and Defecation

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ABSTRACT

Problems of continence and defecation are encountered in all facets of medical practice. Yet, the anorectum is cloaked by misunderstanding. Recent research has shed new light on this subject and newer concepts based on systematic investigations have paved the way to a rational approach. Motor function of the anorectum can now be delineated by manometry, electromyography and nerve stimulation. More complex functions like the co-ordination for continence and defecation are measured using other studies including defecating proctography, scintigraphic balloon topography, scintigraphic evacuation and colonic transit.

The amalgamation of data from these studies have led to a logical sequence for the maintenance of normal continence and defecation that is developed in this manuscript based on our current understanding of anorectal motility and physiology. This allows patients who are resistant to straightforward diagnosis to be selected for specialised tests resulting in categorisation and a rational management strategy for their problems.

Keywords: anorectal motility, physiology, continence, defecation

INTRODUCTION

The anorectum functions as a co-ordinated unit to maintain fecal continence and facilitate defecation. This is a summation of numerous interrelated autonomic and physiological mechanisms which has been intensely investigated over the past decade and more. However, the mechanisms responsible for these functions remain the subject of debate and speculation.

There are few regions in the human anatomy that have remained as shrouded in misunderstanding as has the anorectum. With newer research using methods which are able to quantify parameters of anorectal motility and physiology, relatively dogmatic physiological concepts have been challenged. As a result, there is now a renewed appreciation of the clinical importance of anorectal physiology which subsequently leads us to the understanding of associated disorders like disordered defecation and incontinence.

The aim of this monograph is to piece together a logical sequence of events for the normal physiology of fecal continence and defecation and then detail the clinical and investigational tests that quantitate anorectal motility that may be useful in determining its associated disorders.

THF NORMAL PHYSIOLOGY OF FECAL CONTINENCE

Fecal continence is the result of a complex combination of conscious and unconscious control. These include among other factors a competent, closed anal sphincter acting in symphony with a co-ordinated pelvic floor, normal anorectal sensation and sampling reflex, adequate rectal capacity and compliance and normal rectal and anal canal motility (Table I). As long as the combination of these result in the anal canal pressures being higher than those in the rectum, continence is maintained[1].

The anal canal pressure is maintained by the tonic contraction of the internal anal sphincter. The striated external anal sphincter is under voluntary control and augments the anal canal pressures. Its significance is demonstrated by a 50% incidence of fecal soilage in patients with a simple external sphincter defect after obstetric tears and this is successfully alleviated by an overlapping sphincteroplasty[2].

The anal sphincter mechanism is helped by the acute anorectal angle which is maintained by the sling effect of the puborectalis muscle of the pelvic floor. The high incidence of resulting fecal incontinence in patients in whom the puborectalis was divided to relieve outlet obstruction as a cause of constipation reinforces the significance of this muscle[3]. In addition, children with congenital absence of both

Table I – Factors involved in normal fecal continence

1.	The anal high pressure zone a) tonic internal anal sphincter b) voluntary external anal sphincter
2.	acute anorectal angle and dynamic reflexes within the anal sphincters and puborectalis which respond to changing intra-abdominal pressures
3.	rectal compliance, tone and capacity
4.	anorectal sensation and reflex emptying
5.	rectal filling and emptying
6.	motility and evacuability of the rectum
7.	anal canal motility
8.	volume and consistency of stool

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the external and internal anal sphincters are often continent[4]. In the past, it is believed that the presence and subsequent correction of an obtuse anorectal angle by a post-anal repair would restore continence. However, analysis of results revealed that success of this particular procedure was correlated with the resultant rise in anal sphincter resting and squeeze pressures rather than a correction of the angle[5].

The flap valve theory of fecal incontinence suggests that the anterior wall of the rectum is pushed downwards onto the upper anal canal when the intra-abdominal pressures rise[6]. This prevents rectal contents from moving down to the upper anal canal. Parks proposed this theory from observations that there was an association of an obtuse anorectal angle and presumably an inability of the anterior rectal wall to form a valve, with fecal incontinence. Later studies using defecography failed to reveal such an event even when the anal sphincters were maximally stressed[7].

Another theory, the flutter valve theory proposes that increased intra-abdominal pressures results in a high pressure zone in the lower rectum which occludes it and prevents rectal contents from progressing distally[8]. Anorectal manometry shows that the high pressure zone lies in the mid anal canal and no high pressure zone is demonstrable in the lower rectum.

In addition to mechanical factors, maintenance of fecal continence is augmented by dynamic reflexes that increase muscular activity in response to intra-abdominal pressure changes. Distension of the rectum is associated with marked electrical activity in both the anal sphincters and puborectalis.

The presence of a compliant rectum in addition to the increased sphincter activity allows continence to be preserved since the relationship of lower pressures in the rectum and higher pressures in the anal canal is maintained. The volume of first sensation in the rectum varies from 11 – 68 mLs, urgency normally develops after distention with about 200 mLs while the maximum tolerated volume varies from 220 – 510 mLs[9]. The mean rectal compliance thus varies widely from 4 – 14 mLs/cm H_20. The rectum adapts to filling and responds to rectal distention by a reflex decrease in compliance. Therefore, the rectum can accommodate up to 300 mLs without a marked change in intra-luminal pressure (receptive relaxation). Volumes higher than this result in a rise in pressure until tolerance is approached. This is associated with the feeling of urgency to defecate[10]. The presence of diseases like inflammatory bowel disease, radiation and ischaemic proctitis result, in a rigid rectum with reduced compliance. The rectum is then unable to fulfill its duty as a reservoir and acts more like a conduit. The result is increased bowel frequency, urgency and often fecal incontinence despite "normal" anal sphincter pressures because the rectal pressures often exceed them at lower volumes. In such cases, the replacement of a diseased rectum with a compliant neorectum (either an ileal pouch or healthy colon or colonic pouch) will restore continence. On the other hand, in Hirschsprung's disease, the compliance is increased, creating a functional megarectum.

Anorectal sensory receptors reside either in the rectum or in the pelvic muscles. The preservation of sensation after proctectomy and coloanal anastomosis supports their presence in the pelvic floor. Flatus generates less pressure than solids[11]. The ability to perceive different intra-rectal pressures may help differentiate rectal contents. Sensory perception has also been found in the proximal anal canal mucosa[6]. These may explain the presence of the rectoanal contractile reflex. The former is the simultaneous distention of the upper anal canal associated with slight rectal wall contraction. This reflex prompts a transient rise in resting pressure in the distal anal canal. This is followed almost immediately by a transient relaxation of the internal sphincter in the proximal anal canal resulting in a decreased resting pressure. This is the rectoanal sphincter inhibitory response (Fig 1). Transient relaxation of the internal anal sphincter is thought to allow recognition of rectal contents by the proximal anal mucosa, the sampling reflex. Sampling has been shown to occur between 4 to 10 times per hour in ambulatory manometric studies of healthy individuals[12].

This reflex is not solely responsible for the maintenance of continence as it is absent after ileo-anal anastomosis where continence can still be achieved. Continence is also unaffected when local anaesthetics are applied to the anal mucosa.

Motility of the rectum

Static physiological studies described three types of rectal contractions: i) simple contractions which occur at 5 to 10 cycles/min; ii) slower contractions occurring at about 3 cycles/min with amplitudes of up to 100 cm H_20, and iii) slow propagated contractions which occur infrequently with high amplitude[13]. More recent ambulatory manometric studies have demonstrated three types of motor activity: i) isolated prolonged contractions of 10 to 20 seconds duration occurring mainly during waking hours; ii) clusters of contractions of relatively low amplitude occurring at a frequency of 5 to 6/min, lasting 1 to 2 minutes, with a periodicity of 20 to

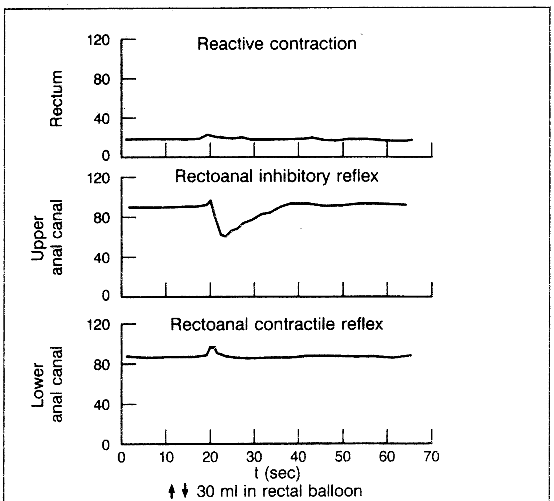

Fig 1 – Manometric readings in the rectum, upper and lower anal canal demonstrating the rectoanal contractile and inhibitory reflex with rapid inflation and deflation of an intrarectal balloon.

30 minutes. This is mainly a postparandial event, and iii) runs of powerful phasic contractions of >50 mmHg amplitude occurring at 2 to 3 cycles/min lasting 3 to 10 seconds. These have a periodicity of about 92 minutes in the day and 56 minutes at night[14].

The latter complexes are termed rectal motor complexes (RMC). These occur more regularly and frequently during sleep. They are also disrupted after meals for periods ranging from 150 to 180 minutes. Their function although unknown, is postulated to keep the rectum empty[15].

Motility of the anal canal

The anal canal has a unique motility pattern consisting of slow waves and ultra slow waves. Slow waves are small oscillations at 10 to 20 cycles/min and an amplitude of 5 to 25 cm H_20 superimposed on the resting tone. This slow wave manifests a gradient within the anal canal with the frequency highest distally[16]. This results in a tendency to propel the contents proximally into the rectum. The anal canal is kept empty thus maintaining continence. Ultra slow waves are found in only about 40% of normal subjects. These have an amplitude of 30 to 100 cm H_20 and a duration of about 33 seconds and a frequency of 3 cycles/min[17]. An association of ultra slow waves with high resting pressures have been found. Both the slow and ultra slow waves are regular fluctuation of internal anal sphincter activity, as shown on electromyographic studies[18].

Co-ordination of anorectal motility

Prolonged ambulatory manometry has demonstrated that RMC's are always accompanied by a rise in the mean anal canal pressure and contractile activity. The former keeps the rectum empty while the latter helps to keep the anal canal closed thus maintaining a greater anal canal pressure relative to rectal pressure[19] and preserving continence (Fig 2).

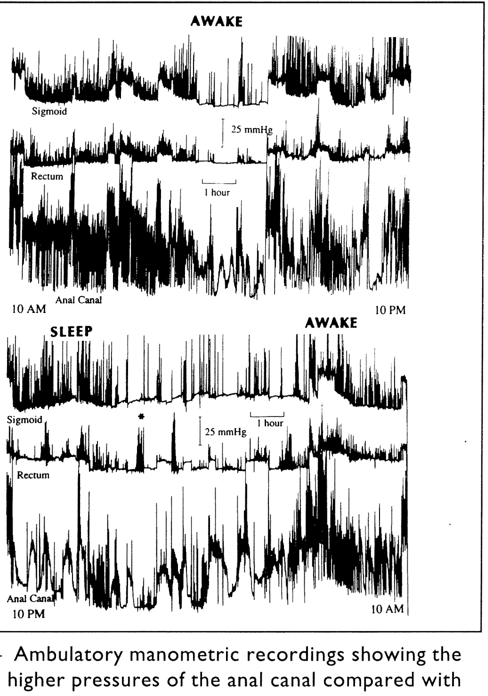

Fig 2 – Ambulatory manometric recordings showing the relative higher pressures of the anal canal compared with the intrarectal pressures.

Stool volume and consistency

Stools are normally passed anywhere between 3 stools/day to 3 stools/week. In addition to the frequency, there is also a wide variation in consistency. Changes in consistency toward either extreme can stress the mechanisms of continence. For example, if small hard pellets of stools introduced into the rectum slowly, the perception of rectal contents may be delayed till relatively severe distention of the rectum occurs. Liquid stools on the other hand, introduced rapidly into the rectum can overcome the continence mechanisms even in healthy individuals. It is therefore not surprising that volunteers find passing large deformable stools easier and with less straining required compared with small hard pellets[20]. Semi-solid stools are also more completely evacuated than solid or liquid stools[21]. Therefore, it is logical that manipulation of stool consistency and volume be the first line in the management of patients with fecal incontinence.

THE NORMAL PHYSIOLOGY OF DEFECATION

When the volume of sigmoid contents are sufficiently large, they trigger contractions which empty their contents into the rectum. Distention of the rectum stimulates stretch receptors in the rectal wall, pelvic floor and upper anal canal[22]. Intermittent progressive rectal distention initiates the rectoanal inhibitory response, resulting in internal anal sphincter relaxation and concurrent external sphincter contraction. The nature of the rectal contents are thus perceived by the sensory rich proximal anal canal (sampling) while continence is maintained by the strong external sphincter mechanism. When the decision is made to evacuate, the intra-abdominal and intra-rectal pressures are made to exceed that of the anal canal through straining. The increased pressures result in a co-ordinated reflex relaxation of the internal and external sphincter as well as the puborectalis. Puborectalis relaxation and the sitting or squatting position increases the anorectal angle[5]. The inhibition of the pelvic floor muscles also result in a perineal floor descent of about 2 cm which further increases the anorectal angle[23] and forms a funnel with the outlet at the top on the anal canal. The intra-abdominal pressure is thus directed on the fecal bolus, expelling it.

Once initiated, defecation is either a continuous process or passed in bits preceded by periodic straining. The pattern is influenced by stool consistency and size as well as by individual habit.

Upon completion, a closing reflex occurs. The internal sphincter and puborectalis muscles transiently contract and restore the anorectal angle[24]. This allows the internal anal sphincter to recover its tone, thus closing the anal canal.

In a socially inconvenient situation, defecation can be voluntarily deferred by contraction of the puborectalis and external anal sphincter. The contents in upper anal canal are returned to the rectum. Passive accommodation in the rectum keeps the pressure low and cortical pathways suppress the urge to defecate.

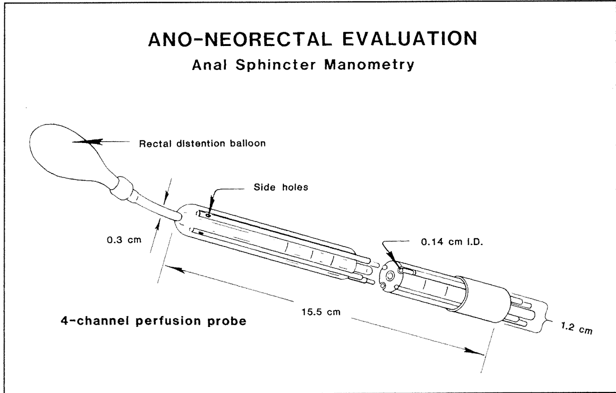

Fig 3 – A perfused 4-channel manometric probe used for anorectal manometry.

TESTS OF ANORECTAL MOTILITY

Motor complex functions are delineated by manometry, electromyography and nerve stimulation. More complex functions like the co-ordinated activity for continence and defecation are measured using one or more studies including defecating proctography, scintigraphic balloon topography, scintigraphic evacuation and colonic transit studies.

Anorectal manometry

The parameters measured include resting and squeeze pressures of the anal canal, the maximum capacity and distensibility of the rectal ampulla and the rectoanal inhibitory response. It is important to have controls for a particular technique as different techniques give varying results. However, no one method has shown superiority over any other.

A perfused 4-channel methylmethacrylate probe is shown in Fig 3. This has four 0.14 cm channels perfused with normal saline at 0.3 mL/min via a low compliance pneumohydraulic perfusion system orientated 90° apart. A sequential pull through resting pressure profile is obtained from the four quadrants at the proximal, middle and distal anal canal. Similarly, squeeze pressures are obtained using the same technique with the subject consciously squeezing the anal canal. The probe is then positioned at the proximal anal canal. A balloon which traverses the middle of the probe allows the measurement of the rectal capacity and inhibitory response. It is inflated and immediately deflated at 5 mLs increment in an attempt to elicit proximal anal relaxation – the rectoanal sphincter inhibitory response. The maximum tolerated volume represents the rectal capacity.

Balloon expulsion

This test is designed to determine the overall function of the pelvic floor. A small balloon attached to a tube is inserted into the rectum and filled with 50 mLs of water[25]. The subjects are then asked to expel the balloon. If the subject cannot spontaneously pass the balloon, weights are added to the external end. Healthy volunteers are usually able to expel a balloon filled with 50 mLs of water without help or with up to 150 gm of weight. On the other hand, patients with obstructed defecation have no spontaneous passage of the balloon until heavy weights are used (occasionally more than 500 gm)[26].

Electromyography

Single fiber techniques using a standard concentric needle are used for calculation of fiber densities. The puborectalis and external anal sphincter are studied at rest, during sphincter squeezing and Valsalva maneuver (when defecation is actively prevented) and during straining (simulating attempted defecation).

Pudendal nerve terminal motor latency

In this test, the pudendal nerve is stimulated as it leaves the pudendal canal and the arrival of the stimulus at the puborectalis or external anal sphincter is recorded. The delay required for the conduction of impulses is known as the pudendal nerve terminal motor latency. In addition, spinal motor latencies can be determined by stimulating over L1 and L4 (which supplies the external anal sphincter and puborectalis) and measuring the arrival of the stimulus at these muscles.

External measurement of perineal descent

A simple device has been developed that measures the amount of descent of the perineum on straining[26]. This device rests on the ischial tuberosities and a central measuring rod is placed at the anal verge. Upon straining, the anal verge descended at least 1 to 1.5 cm in healthy people. In patients with pelvic floor dysfunction, however, descent of the perineum was diminished[26], or alternatively, exaggerated[27,28].

Mucosal sensation

Attempts have been made to measure the electro-sensitivity and temperature sensation in the anal canal in order to quantify the subjective parameter of anal canal sensation. Patients with incontinence and haemorrhoids have been found to have elevated sensory thresholds. The opposite has been found in anal fissures[29]. Similar impairment of temperature sensation is found in patients with incontinence using more complex techniques[12].

Defecating proctogram

X-rays can be used to document the act of defecation (Figs 4a and b). Recently, video defecating protography has become increasingly popular as it enables real time assessment of the process. With these images, the resting and straining anorectal angles can be calculated. The finding of rectal intussusception is best documented by this investigation. A sigmoidocele although uncommon is another finding. The main problem with the proctogram is the significance of positive findings. For example, the finding of rectal intussusception had since been found to occur in 50% of healthy volunteers[30]. Based on current knowledge, it is best that results be interpreted by close correlation with a detailed history and physical examination.

Scintigraphic balloon topography

Scintigraphic techniques enable X-ray images to be obtained with low radiation exposure. It is utilised here to image the movements of the anorectal angle and pelvic floor. The anorectal angle narrows and the anorectal junction is pushed downwards with

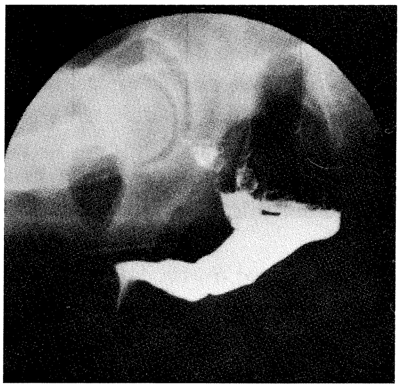

Fig 4a – Defecating proctogram showing a rectum filled with radiodense "stool".

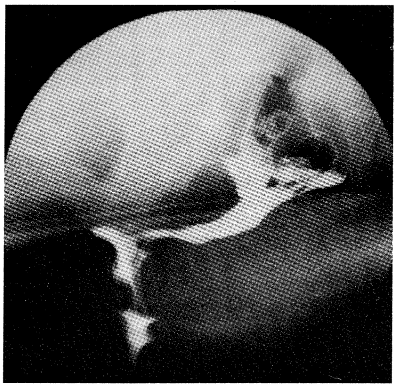

Fig 4b – Defecating proctogram showing the rectum emptying on straining.

sphincter squeeze and Valsalva maneuvers in healthy subjects[31]. Deviation of these values are found to occur in disorders of continence and constipation[26].

Scintigraphic evacuation

The use of scintigraphy is extended here, utilising radio-labelled artificial stools to quantify the pattern and efficiency of evacuation[32]. After the maximum rectal capacity has been determined, the artificial stool is introduced into the rectum. A gamma camera is used to record the process of defecation. The efficiency (% evacuation) can then be calculated. Abnormal emptying efficiency and patterns have been shown in patients with disorders of continence[26].

Colonic transit

This by definition does not come under anorectal motility. However, its determination allows one to pinpoint if there is a disorder in movement of fecal material around the colon (delayed colonic transit time), a disorder in the process of evacuation or both[33].

CONCLUSION

The understanding of normal physiology of continence and defecation has redefined the physiologic challenge posed by its disorders by allowing a systematic approach to diagnosis. The evolution of these specialised tests allow a patient who proves resistant to straightforward diagnostic means to be classified into diagnostic categories by quantifying the anorectal or colonic function. The clinical value of anorectal motility is thus profound in that once the patients are categorised, the various treatment modalities available can be rationally applied.

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