Progress report

Anal continence

Anal continence depends on an adaptable barrier formed at the ano-rectal junction and in the anal canal by a combination of forces. These are due in part to the configuration of the region and in part to the action of muscles. The forces are activated in response to sensory information obtained from the rectum and the anal canal. In order to understand some of the concepts of the mechanism of anal continence, some of the features of the anatomy and physiology of the region will be discussed.

Anatomy (Fig. 1)

The lumen of the rectum terminates at the pelvic floor and is continued, downwards and posteriorly, as the anal canal, passing through the levator ani muscle sheet and surrounded by the internal and external anal sphincters. The anal canal is 2.5 to 5 cm in length and 3 cm in diameter when distended. The axis of the rectum forms almost a right angle (average 82°) with the axis of the anal canal. It has been established by radiological studies that the anal canal is an antero-posterior slit in the resting state.¹ The former concept of the anal canal being surrounded successively craniocaudally by the internal anal sphincter and then the external anal sphincter has been replaced by the knowledge that the two muscles overlap to a considerable extent with the external sphincter wrapped round the internal sphincter^{2,3}.

SMOOTH MUSCLE

The circular muscle coat of the rectum is continued into the internal anal sphincter which is 1.5 to 5 mm in thickness and surrounds the cranial 2 to 4 cm of the anal canal. The outer longitudinal muscle coat of the rectum passes as fibrous extensions to interdigitate with the levator ani and external anal sphincter muscles.

STRIATED MUSCLE

The levator ani muscles form the pelvic floor and their most important component in connexion with anal continence is the puborectalis which arises from the posterior aspect of the pubis and passes posteriorly round the ano-rectal junction to join with the puborectalis from the other side to form a sling. Fibres pass from this muscle to join the fibrous extension of the rectal sheath and to the external anal sphincter. Contraction of this muscle sling pulls the ano-rectal junction upwards and forwards and increases the angle between the anal canal and the rectum.

The external anal sphincter surrounds the caudal 2 to 3 cm of the internal anal sphincter and projects caudad to it for 0.5 to 1 cm. Three layers—deep, superficial, and subcutaneous—can be distinguished. The two caudal layers

A

B

Fig. 1A and B Diagrams of transverse (A) and sagittal (B) sections through the anal canal and lower rectum to demonstrate the factors involved in anal continence. The arrows in the outline diagrams on the right represent the forces involved.

are attached to the perineal body anteriorly and to the coccyx posteriorly. Although muscles have been enumerated individually they are intimately connected and act in concert.

SENSORY NERVE ENDINGS

Numerous free nerve endings are found in the submucosa of the rectum but no organized sensory nerve endings, which are restricted to the anal canal extending 0.5 to 1.5 cm cranial to the anal valves⁴.

Physiology

SENSORY

Colon

Sensation from the sigmoid colon is rarely appreciated in the normal subject. Hypogastric colic in response to sigmoid distension or hypermotility is usually an early warning that an abnormally fluid stool is passing along the colon. With experience the subject knows that this will put a great strain on the continence mechanism and will take steps to avoid it.

Rectum

Information from the rectum is the most important sensory component. It is well known that distension of a balloon in the rectal ampulla gives rise to a feeling of fullness in the perineum. In normal adults this is first appreciated at a pressure of about 50 mm Hg^{5,6}. The sensation lasts only a few seconds at this level of stimulation but becomes more demanding and persistent with increasing distension. It becomes intolerable at about 150 mm Hg pressure, ie, with a large balloon after inflation with 300 ml air. No organized sensory nerves are found in the rectum to subserve this sensation but there are numerous free nerve endings and the extensive myenteric nerve plexuses. Most workers believe that the perineal fullness is dependent on nerve endings within the rectum itself. However, after resection of the upper part of the rectum and anastomosis of descending colon to the rectal stump low in the pelvis, some patients still experience perineal fullness when a balloon is inflated in the colon above the anastomosis but still within the pelvis. This sensation requires a greater stimulus than normal. It may indicate that some extrarectal nerves play a part at the higher levels of stimulus⁷. One possible extrarectal source has been mentioned as a result of studies of rectal sensation in children operated upon for Hirschsprung's disease. It has been suggested that the urge to defaecate may arise in the puborectalis part of the levator ani muscle⁸. From the intact rectum the impulses pass to the lumbo-sacral area of the spinal cord via the sacral nerves and thence to consciousness. Cutting or crushing the rectal mucosa does not elicit pain but submucous injection of 4 to 5 ml of phenol in oil, as in the injection treatment of internal haemorrhoids, can give rise to a feeling of distension which can verge on pain even when care has been taken to ensure that the injection site is in the rectal ampulla well away from the nerve endings in the anal canal.

Anal canal

In contrast to the rectum, the anal canal is plentifully supplied with organized sensory nerve endings. Acute appreciation is present of pain and light touch.

Heat and cold can also be felt⁴. These impulses pass via the pudendal nerves to the spinal cord.

MOTOR

Numerous investigators have studied the physiology of the anus and rectum with a wide spectrum of techniques. Almost all of these methods can be said to be to some extent unphysiological as they require the presence of a probe within the anal canal. Nevertheless, certain broad areas of agreement exist as well as several reports of conflicting findings and of differing interpretations. The exact definition of the role played by components of the continence mechanism is difficult because they overlap so much both anatomically and physiologically. Most workers have used some device to measure the pressure within the anal canal and rectum: balloons of various sizes^{9,10,11}, open-tipped tubes^{8,10,11}; radiopill sensitive to pressure changes⁸; obturators with partitions to try to isolate the effect of the internal and external sphincters⁵. At a later stage the squeeze in the anal canal has been recorded by deformation of small strain gauges placed in the canal^{14,15}.

All these methods have a fairly predictable finding, namely, that there is a high pressure zone in the anal canal. Depending on the probe used the average peak pressure found at about 2 cm from the anal verge may be from 25 to 120 mm Hg in a normal adult at rest. Although some relationship has been found between the pressure recorded and the size of the balloon, this does not hold when non-compressible obturators of increasing size are used. The anal canal can quickly adapt to these and gives a resting pressure which is similar for all diameters from 5 to 21 mm¹⁶. Measurement of squeeze using strain gauges also gives a peak about 2 cm. This level is caudad to the puborectalis sling in the area where the internal and external anal sphincters overlap. A phasic variation in this pressure is noted by most workers. Electromyographic recordings show continual activity at rest in the levator ani and external anal sphincter muscles^{17,18,19,20,21} and continuous electrical potentials have also been recorded from the internal anal sphincter at rest^{22,23,24} so that all could contribute to the resting pressure.

Agreement exists on the presence of the high pressure zone in the anal canal but not on its importance in maintaining anal continence nor on the part played by the internal and external anal sphincters in its production. Some authors favour the internal sphincter^{24,25,26,27} and others the external sphincter²⁸. In part the differing views are due to interpretation of pressures at points along the anal canal being held to be due mainly to one or other of the muscles. As has been mentioned already, the overlapping of the sphincters makes this a difficult task. Even when the external sphincter is paralysed, the pressure zone is not materially altered except when a small bolus is pulled through the anal canal²⁵ so that the resting pressure would seem to be largely due to the internal anal sphincter. Although it has been demonstrated that activity is always present in the external anal sphincter and pelvic floor muscles, these muscles can only be contracted voluntarily for periods from 40 to 60 seconds. Thereafter, despite continued efforts by the subject, both the electrical activity in the muscle and pressure within the anal canal return to basal levels^{19,20,29}.

REFLEXES

Another common field of investigation has been to study the effect of dis-

tension of the rectum on the anal canal. With a small distending force of up to 50 ml of air in a balloon in the rectum (up to 25 mm Hg pressure) the pressure zone in the cranial 2 to 3 cm of the anal canal diminishes. At the same time there is a transient increase in the activity of the external anal sphincter as gauged by the electromyogram. The diminution in anal canal pressure would be sufficient to allow rectal content to reach far enough into the anal canal to contact the sensory zone and so aid in recognition of the nature of the content¹². Further rectal distension leads to inhibition of the electromyogram in the external anal sphincter²⁰. These reflexes are altered in some diseases, eg, Hirschsprung's disease.

Theories of Anal Continence

PRESSURE ZONE

The most commonly accepted explanation of anal continence is that the high pressure zone (average 25 to 120 mm Hg) in the anal canal provides an effective barrier against pressure in the rectum (average 5 to 20 mm Hg). Although a higher pressure is found in the anal canal than in the rectum when the subject is at rest, circumstances can arise, for example, on straining or on performing a Valsalva manoeuvre, when some investigators have made records which show a higher pressure in the rectum without any incontinence occurring. This has led to the invoking of physical factors outside the anal canal as providing additional protection¹.

ANGULATION BETWEEN RECTUM AND ANAL CANAL

The angle of 80° between the axis of the rectum and the anal canal is maintained except when the hips are flexed more than 90°³⁰ or during defaecation¹. It has long been held that this angulation, maintained by the pull of the puborectalis sling, is an important factor in anal continence.

FLUTTER VALVE

As a result of manometric and radiological studies, Phillips and Edwards¹ suggested that additional protection could be afforded by intraabdominal pressure being transmitted, at the level of the levator ani, laterally to the side of the anal canal in the region of the anorectal junction. The anal canal is an antero-posterior slit and this pressure could compress it in a similar way to the working of the simple non-return flutter valve used on some respiratory apparatus. This was proposed because when the anal canal was coated with radioopaque material an occlusion could be seen in the region of the anorectal junction. This ingenious hypothesis is attractive but cannot exclude that the above findings are due to puborectalis activity nor do they explain the lack of identification of a localized zone of higher pressure at the cranial part of the anal canal. While this mechanism may protect against a rise in intraabdominal pressure it cannot provide protection against an increase in intrarectal pressure.

RESISTANCE TO OPENING

Differential pressure recording by withdrawing a probe from the rectum and re-inserting it via the anus led Harris and Pope³¹ to propose that the pressure recorded in the anal canal depended not so much on the ability of the muscles to squeeze around the anal canal but rather on their ability to resist the

opening up of the canal. Various methods have been used to assess this function. The reaction of the anal canal was measured in response to injecting microlitre amounts of water through a small tube until no further increase in pressure was observed¹³. A similar technique was applied using a small balloon²⁶. Another procedure was to insert a special obturator which could be expanded within the anal canal and measure the resistance encountered^{32,33,34}. Apart from any force exerted by the muscles, the adhesion of the moist surfaces of the mucosal lining of the anal canal would have to be broken to allow the potential space to be opened. Another possible factor is a lengthening of the anal canal by the contraction of the posterior parts of the levator ani muscles, in a similar manner to the changes in the urethra when the pelvic floor is elevated.

FORCES AROUND THE ANAL CANAL

Some impression of the forces involved can be gained from the diagrams (Fig. 1). Using a probe with numerous strain gauges set to appreciate forces in four quadrants around the anal canal¹⁴ it was shown that the cranial portion has forces maximal posteriorly, less laterally, and minimal anteriorly. This finding was compatible with the combined action of the puborectalis sling and the internal anal sphincter, the latter providing the anterior component on its own. More caudad the internal and external sphincters together provide the force which is greater laterally than anteroposteriorly. The external anal sphincter provides the final voluntary guard.

Practical Aspects

DIAGNOSIS OF DISEASE

Physiological studies in the anorectal region have revealed abnormalities which can help in diagnosis. Forty-seven children with Hirschsprung's disease have been shown to lack the reflex decrease in pressure within the anal canal in response to rectal distension³⁵ although another group of five children with Hirschsprung's disease had normal reflexes¹¹. In addition to studies of squeeze in the anal canal, pharmacological testing of strips of aganglionic internal sphincter muscle showed failure of the normal relaxation to ganglion-blocking drugs¹⁵. Other pharmacological studies to differentiate sphincter muscle from the remainder of the colonic muscle are at an early stage³⁶. Recovery of continence after operations for imperforate anus has also been examined³⁷. Myotonic contraction in internal and external anal sphincters was noted in seven patients tested who suffered from myotonic dystrophy³⁸.

Clear distinction between patients with incontinence and normally continent subjects has been achieved by several workers using different combinations of pressure-sensitive probes and electromyography of the striated muscle^{11,26}. Defects in sensory and/or motor function can be readily appreciated by most of these techniques. It would be attractive to be able to state that this diagnostic information about the degree of incontinence led to the appropriate treatment but unfortunately this is not yet possible. Apart from surgical techniques to repair a traumatic defect in a sphincter and some operations designed to provide a new external anal sphincter or puborectalis sling³⁹ by a muscle transfer, the only technique which has been successful in some patients is electrical stimulation of the muscles in the anal region^{40,41,42,43}.

DEFINITION OF ANAL CONTINENCE

Despite the extent of the work on the mechanism of anal continence, it is not easy to arrive at a generally acceptable definition of when a patient is normally continent. There is no problem in segregating the subject who controls faeces and flatus at all times or the patient who has no control at all. Between these extremes it is not so clear. Lack of control of faeces would occasion complaint if it were gross but minor leaks causing soiling of underclothes might not even be mentioned by the less fastidious. Similarly, some individuals do not often have occasion to need to control the passage of flatus when others would complain of unwitting escape of gas. It may be said that if a patient reports inadequate anal control he is incontinent to a greater or lesser degree. Any attempt to assess this function in a group of patients requires a standard form of interrogation to uncover all the instances in which continence is less than perfect⁴⁴.

It also must be noted that a patient may have a grossly deficient apparatus for anal continence and yet not be incontinent. This circumstance can arise when colonic function is such that firm faeces are delivered to the rectum on one or two occasions in the day when circumstances are suitable for defaecation. For example, a patient with a rectal stump of 3 cm after sphincter-saving resection of the rectum can be continent in this fashion when a patient with a stump of 6 to 7 cm may be incontinent because he has more liquid faeces. Even in the 'normal' subject anal continence is only relative. Few can claim to be at ease with a large fluid stool in the rectum.

AVOIDING DEFECTS IN ANAL CONTINENCE

It is mainly in surgical practice that the need arises to take care to preserve continence. Of the many factors involved the two most important in this respect are the preservation of rectal function and of an intact ano-rectal ring. In any procedure in which the rectum may be removed, from Hirschsprung's disease in childhood to rectal neoplasia in the adult, the aim is to leave as much of the rectal sensory mechanism as possible. Not only does this preserve the reflexes arising from here but also the reservoir function is important with the capacity to retain faeces until defaecation is possible. When the rectal stump is 7 cm or more in length both these functions are adequately maintained in most cases. However, when it is not possible to have such a long remnant, it is still worth considering a sphincter-saving procedure because acceptable continence may result if colonic function is propitious (see above).

The integrity of the ano-rectal ring is at risk in surgery for fistulae in the anal region. With a fistula of which the internal opening in the anal canal is caudad to the level of the anal valves, there is no danger to continence by its excision. Above the anal valves the percentage incidence of defects in continence increases as the cranial end of the canal is approached. At least 1 cm length of the internal anal sphincter along the anal canal must be preserved and with this the puborectalis sling will also remain. In addition to the weakening of the muscles around the anal canal, extensive surgery for large high level anal fistulae results in scarring which deforms the anal canal and may make its closure more difficult. Even more minor procedures, such as division of the fibres of the internal anal sphincter in one sector in the base of a chronic anal fissure, may produce lack of complete anal control as a consequence when a scar is formed along the anal canal producing an insensitive groove⁴⁵.

Summary

Anal continence is relative. It is a balance between the consistency of the rectal contents and the rate of their delivery into the rectum and the competence of the anal canal mechanism with the suppression of the urge to defaecate. It is possible to influence the former side of the balance both by diet and by drugs. The other factors are less easy to change. No statement of the mechanism of anal continence would meet with agreement by all those working on the subject. The following outline embodies the opinions which I think are most widely held. The place of some of the other interesting concepts has still to be confirmed.

The entry of faeces into the rectum from the sigmoid causes sensory stimulation in the rectum and pelvic floor. This may reach consciousness and be felt as an urge to defaecate but often is not noticed, depending on cortical conditioning with social habits. Reflex relaxation of the cranial part of the anal canal may allow the rectal contents to come in contact there with the sensory epithelium. The main physical factors preserving anal continence are the maintenance of the angle between the rectum and the anal canal, the antero-posterior slit of the anal canal, and the tonic activity of the internal anal sphincter muscle. Additional support comes from the external anal sphincter which has its main function as an emergency to give additional voluntary protection for up to one to two minutes.

In my opinion progress in our understanding will come from the further study of the pharmacological and electrophysiological aspects of the anorectal region.

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