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Some aspects of anal continence and defaecation[1]

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EDITORIAL SYNOPSIS Evidence has previously been advanced in favour of the anti-reflux mechanism at the cardia being a mechanical process analogous to the 'flutter valve' and this study suggests that a similar mechanism is responsible for preserving anal continence.

The purpose of this paper is to present a hypothesis about how we achieve anal continence, yet, given appropriate circumstances, can defaecate at will. The hypothesis arises directly out of a study of the anti-reflux mechanism at the cardia (Edwards, 1961, 1963), since similar problems and control mechanisms seem to exist at both these exits from the abdomen.

The mechanism of defaecation has been thought mainly to involve the contraction of the lower colon and the rectum, aided by an increase in intra-abdominal pressure. Conversely, continence has been thought to be achieved by the contraction of the anal sphincter, which is presumed to be able to withstand both intra-abdominal pressure and the pressure developed by the contracting colon or rectum. Supposedly the rectum is normally empty and at intervals a powerful peristaltic contraction of the colon propels faeces into the rectum. This stimulates pressure-sensitive nerve endings in the wall of the rectum, producing the 'call to stool' together with a reflex inhibition of the internal sphincter of the anal canal (Goligher, 1951). If we do not take voluntary action by contracting the external anal sphincter, the stool is passed with or without the assistance of an increase in intra-abdominal pressure.

This hypothesis may be appropriate to the defaecatory habits of decerebrate animals, infants, and those with neurological lesions or severe diarrhoea. In general, the observations upon which this theory is based are not at this moment disputed. Two questions are not answered, however: (1) how is continence preserved without conscious effort during violent changes of intra-abdominal pressure such as are produced during coughing, vomiting, and weight lifting, when the rectum contains faeces, as is common without the subject being aware that it does so (Goligher, 1951); and (2) how can we defaecate at will by raising intra-abdominal pressure provided there are faeces in the rectum? This paper presents experimental results and arguments in support of a hypothesis which answers both these questions.

METHOD

Intraluminal pressure in the rectum and the anal canal was estimated by using single, end- or side-hole, water-filled 1·0 mm. bore by 1·5 mm. O.D. polythene tubes or four-channel side-hole polyvinyl chloride tubes of 1·0 mm. bore and smooth circular 4 mm. diameter cross section, attached to a Schwarzer Z9/37 transducer recording on a Schwarzer Physio-script, ST6 s 29. Water was injected continuously at 5 or 10 ml. an hour. Squeeze pressure and resistance to stretch (Edwards and Rowlands, 1960) of the anal canal and rectum were recorded with latex balloons 10 mm. long and 5 or 7 mm. diameter connected to air-filled 0·75 mm. twin bore polythene tubes and a Schwarzer Z9/37 transducer or metal-capsule optical manometer (Rowlands, Honour, Edwards, and Corbett, 1953). The rectum was distended by inflating with air a thin condom segment 10 cm. long, tied to give almost square ends; the pressure within the condom was recorded through an air-filled 0·75 mm. bore tube and a Schwarzer transducer. The tubes were inserted as far as possible into the recto-sigmoid area with a sigmoidoscope which was then withdrawn. Pressure profiles of the anal sphincter were obtained by recording pressure at successive levels as the recording tubes were withdrawn in steps of 1·0 cm.

Pressure recordings were made on 39 volunteers with no known disease of the rectum or anal canal, ranging in age from 20 to 70, with the exception of a group of three male and female volunteers who had had an anal sphincterotomy for anal fissure performed two weeks previously. Not all procedures were carried out on every subject.

A radio-opaque coating of the mucosa of the anal canal was obtained without causing a sensation of something

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in the rectum or anal canal by passing a sigmoidoscope to the recto-sigmoid junction and instilling barium sulphate powder as the sigmoidoscope was slowly withdrawn. The *x*-ray tube was screened with 3 mm. of lead sheet to give a beam 3 in. diameter at the input phosphor of a Marconi 5 in. image intensifier for cine-radiography and for single exposures. Defaecating rectograms were obtained after feeding 20 g. barium sulphate powder mixed with sodium-carboxy-methyl-cellulose with each meal for three days beforehand. Radiographs were taken of volunteers who were either post-menopausal women or men aged over 70 years. We do not think that such age changes as might be present in such a group are relevant to our findings.

FORCES TENDING TO PREVENT INCONTINENCE

RESTING PRESSURES IN THE ANAL SPHINCTER In spite of claims by other workers to the contrary (Gaston, 1948), we have been unable to demonstrate two separate zones of contraction of the sphincter and therefore we refer to the 'sphincter segment' rather than to the internal or external sphincter.

The pressure profile of the sphincter segment depends upon the method of measurement and we obtained different profiles with air-filled open-tube and miniature balloon systems and with water-filled open-tube systems. A series of profiles of the anal sphincter were obtained by one of us in 1955 with the original air-filled system (Rowlands *et al.*, 1953) using the open-tube and miniature 3 and 7 mm. diameter balloon systems described elsewhere (Atkinson, Edwards, Honour, and Rowlands, 1957; Edwards and Rowlands, 1960). The profile obtained with the air-filled end-hole open tube gave negligible closing pressures for the resting sphincter. This finding seemed so incongruous at the time that it was attributed to a technical artefact. We still do not know its significance. The profiles previously obtained with miniature balloons were similar to those obtained by similar air-filled balloons in the recent study. Hill, Kelley, Schlegel, and Code (1960) and Duthie and Bennett (1963) also found the profile to be dependent upon the method of measurement. For the purpose of our hypothesis we were interested in the closing pressure of the sphincter (Edwards and Rowlands, 1960) measured by a water-filled open-tube system and we record here the results of this method only.

The length of this segment was 3 to 5 cm. and the pressure recorded was not the same along the whole segment. The mean maximum pressure of 40 profiles in 11 subjects without disease of the lower bowel, using a 4 mm. diameter, smooth-walled, 4-channel open-tube system was 50 cm. water (range 7 to 85 cm.) above intrarectal pressure and the mean minimum was 16 cm. water (range 2 to 60 cm.). (Fig. 1). Although the pressure profile varied widely between subjects the profiles obtained on several occasions from the same subjects by the same method were similar.

VOLUNTARY CONTRACTION OF THE SPHINCTER When the subjects were asked to contract the anal region deliberately, as though trying to counter an urgent call to stool, an increase in pressure was recorded all along the sphincter segment with a mean of 48 cm. water (range 5 to 140) above its resting value. The effective increase in pressure was less because there was a coincident increase in intrarectal pressure of 18 cm. water (range 3 to 40 cm.). The increase in pressure in the sphincter segment could not be sustained for more than 50 to 60 sec. and usually fell off steadily after about 40 sec., although the subject was unaware that his efforts at contraction were

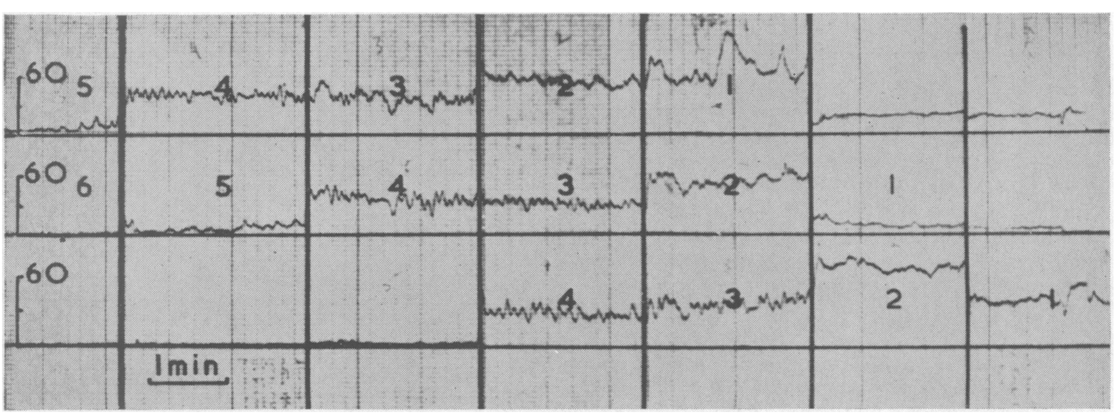

FIG. 1. *The pressure profile of the rectum and anal canal of a normal adult recorded from water-filled open-tubes, the tips 1 cm. apart. At the thick vertical lines the tubes were withdrawn 1 cm. and digits indicate the distance in centimetres from the anal margin. Pressure in centimetres of water.*

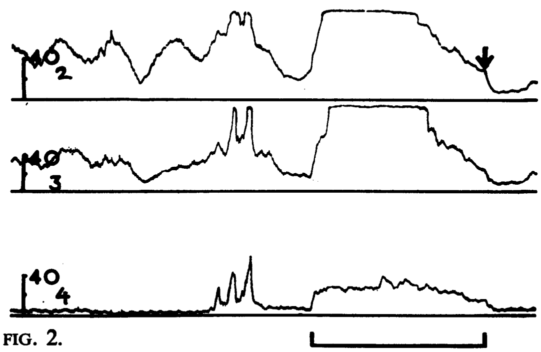

FIG. 2.

FIG. 2. *Simultaneous tracings from fluid-filled open tubes, the upper and middle from the sphincter segment, 2 and 3 cm. from the anal margin, the lower from the rectum at 4 cm. Pressure in centimetres of water. During the signal, for 75 sec. the subject voluntarily contracted the 'sphincter' maximally until told to relax at the time indicated by the arrow. Intra-abdominal (intrarectal) pressure is well sustained but intrasphincertic pressure falls off rapidly.*

FIG. 3a.

FIG. 3a. *Simultaneous tracings from fluid-filled open tubes. At the vertical lines the tubes were withdrawn 1 cm. Digits indicate the number of centimetres from the anal margin. Pressure is in centimetres of water. The sphincter segment is at 0-3 cm. A sharp and sustained rise in intra-rectal pressure occurs with straight leg raising but the increment in pressure in the sphincter develops slowly.*

FIG. 3b. *Tracings from air-filled 7 mm. diameter balloons 6 cm. apart. At the vertical lines the balloons were withdrawn 1 cm. and a recording made of a 'bearing' or 'pushing down' effort. The lower tracing is from the rectum, the upper from successive segments of the anal sphincter to the exterior. The high intrarectal pressure produced by 'bearing down' is not well transmitted to the balloon in the sphincter.*

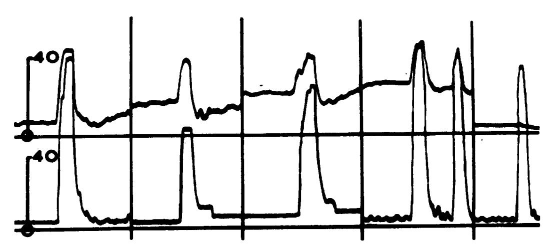

FIG. 3b.

failing so lamentably (Fig. 2). Similar results have been reported by Gaston (1948, 1951), by Parks, Porter, and Melzak (1962), and by Duthie and Bennett (1963).

PRESSURE IN THE SPHINCTER SEGMENT WHEN INTRA-ABDOMINAL PRESSURE IS RAISED When intra-abdominal pressure was raised by bearing down as in a defaecating action, but without relaxing the pelvic floor, or by raising the straightened legs from the bed, a rise of pressure was recorded from the sphincter segment. A mean increase of intra-abdominal (measured as intrarectal) pressure of 69 cm. water from 12 studies was accompanied by a mean increase of pressure along the sphincter segment of 28 cm. water. The pressure in the innermost part of the segment usually rose synchronously to the level of the intra-abdominal pressure as though by simple transmission and not by superimposition of intra-abdominal pressure upon the inherent squeeze pressure of the muscle segments. The increase in pressure was usually progressively less well transmitted the further towards the exterior the pressure recording points were drawn (Fig. 3a and 3b) suggesting the presence of a barrier to the transmission of intraluminal pressure. Sometimes the pressure at a point within the segment would rise slowly after an abrupt rise in intra-abdominal pressure. This observation is similar to that made in a hiatus hernia with a slightly incompetent hiatus (Edwards, 1961, 1963).

Records obtained with a chain of adjacent 7 × 10 mm. air-filled balloons during a 'bearing down' manoeuvre repeatedly showed what appeared to be relaxation in two situations. 1 A balloon near the anal margin recorded a decrease in pressure during the 'bearing down' effort itself (Fig. 4a). This decrease in pressure was interpreted as the 'peeling off' of the sphincter segment from the balloon chain with descent of the pelvic floor. 2 When the recording balloon was at the rectal end of the sphincter segment, the increase of intra-abdominal pressure produced by a 'bearing down' effort was transmitted to it. After this effort had stopped, the pressure recorded in the sphincter segment fell to the level recorded from the rectum for a few seconds (Fig. 4b) before returning to the resting level for the sphincter. This 'relaxation' was interpreted as the delay in return of the pelvic floor and in the closing off of the innermost part of the sphincter segment.

CONDITIONS TENDING TO PRODUCE INCONTINENCE

INTRA-ABDOMINAL PRESSURES Intrarectal pressure, reflecting intra-abdominal pressure, was recorded

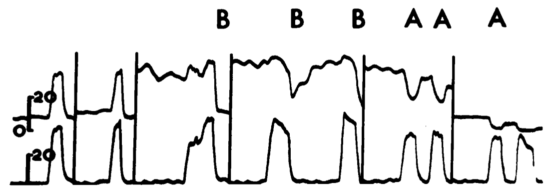

FIG. 4. *Tracing from 7 mm. diameter air-filled balloons 5 cm. apart in the rectum and anal canal. At the vertical lines the balloons were withdrawn 1 cm. and a record made of a 'bearing down' effort. The upper tracing moves through the anal canal, the lower is in the rectum throughout. At A the pressure in the outer part of the sphincter falls synchronously with the increase in rectal pressure; at B there is a temporary fall in pressure in the inner part of the sphincter when the rectal pressure returns to normal.*

while the subject carried out various manoeuvres. Coughing produced transients of more than 30 cm. water; straight leg raising produced pressures of 30 to 50 cm. water; and 'bearing down' as though attempting to empty the bowel, pressures of 10 to 180 cm. water. Intra-abdominal pressures of up to 280 cm. water have been recorded by Agostoni and Rahn (1960) during maximal expulsive efforts of expiration apparently without loss of continence.

PRESSURES DEVELOPED BY CONTRACTION OF THE COLON AND RECTUM During periods of up to 30 min. duration, with the subject resting and the rectum empty, the pressure recorded from the rectum produced by any contraction of the rectum, or conducted to the rectum from the colon, ranged between 0 and 20 cm. water. There appeared to be no 'basal tone'; the basal pressures seemed to be determined by hydrostatic forces and could be changed by changing the position of the patient. We did not attempt to record the pressure in the sigmoid colon.

When the rectum was distended by inflating the condom with air so that the mean diameter of the 10 cm. long cylinder was up to 6 cm., the intrarectal pressure usually did not increase by more than a few centimetres of water when measured by a water-filled tube system with the tip open adjacent to the mid point of the wall of the condom. The pressure developed within miniature balloons alongside the condom was much greater than that recorded from the open tube, indicating that the condom was pressing against the rectal wall which was resisting this pressure either by its inability to stretch, or by the presence of immovable material adjacent to it, for example, the floor or walls of the pelvis. Pressures developed in these small balloons varied with the position of the balloon and with the extent of inflation of the condom. For this reason intrarectal pressure is difficult to determine with certainty while the rectum is being distended by a balloon, but with an open-tube system the intraluminal pressure of the whole rectum did not appear to be raised even when the 'call to stool' sensation was unpleasantly strong. (This difference between the pressure recorded by the open tube and the small balloon alongside the distended condom is presumably because the open tip tube communicates with a potential cavity which is continuous with the unstretched upper rectum, where the pushing force of distended condom onto rectal wall is absent, and is comparable with the concept of closing pressure and resistance to stretch elaborated elsewhere (Edwards and Rowlands, 1960). It raises the problem of how the meaning of a recorded pressure is related to the method of measuring that pressure.) There was no suggestion of any effective rectal contraction that might be involved in a defaecatory mechanism, although pressures were not measured during defaecation. It seems likely that propulsive pressures are produced by the colon and that the rectum acts as a partially distensible passive reservoir for faeces, much as the stomach does for food.

RESPONSE OF SPHINCTER SEGMENT TO DISTENSION OF RECTUM In all of 11 subjects in whom the condom was inflated in the rectum there was always a decrease in pressure in the sphincter within a few seconds of inflation. The decrease ranged from 15% to 75% of the resting pressure in the sphincter. This decrease occurred at small distending volumes or mean diameters of the balloon, for example 75 ml. or 3 cm., and occurred whether or not any sensation was felt in the rectum. Similar reductions in sphincter activity have been recorded by Gaston (1948), Goligher (1951), Parks *et al.* (1962), Bennett and Duthie (1964), and Schuster, Hendrix, and Mendeloff (1963).

SPHINCTER AFTER INTERNAL SPHINCTEROTOMY Through the kindness of three of Mr. Ian Todd's patients, who allowed us to examine their sphincter segment two weeks after internal sphincterotomy for anal fissure, we found that after this operation the sphincter segment was much less easy to define and there was much less rhythmic variation in pressure within it than in the normal sphincter segment. We were not able to record the pressure profile before operation, but the profiles obtained after operation were less than the average profiles obtained from a group of normal subjects. Bennett and Duthie (1964) found a distinct reduction in the pressures recorded after a total internal sphincterotomy, that is, a deeper and longer incision than that which Todd used. In Duthie's patients control of continence was slightly impaired with an occasional slight leak of a little gas or liquid for some weeks after the operation; Todd's patients admitted slight soiling for a few days after the operation. We found no evidence of incontinence when we examined them. Bennett and Goligher (1962) recorded that continence for flatus and liquid was slightly impaired in 30 to 40% of patients after sphincterotomy and that the incidence was the same whatever the extent of sphincterotomy. The important observation is that full continence is common in the absence of internal sphincter activity and a low squeeze pressure of the sphincter segment.

THE CONTRIBUTION OF THE PELVIC FLOOR After 'internal' sphincterotomy some slight 'tone' may remain in the sphincter segment and we presume it to be the result of tonic contraction of the pelvic floor (Porter, 1961). Porter (1962) found by electromyography that when the rectum was distended by a balloon the initial response was contraction of the external sphincter muscle, followed after about one minute by a prolonged relaxation. By open tube manometry we were unable to demonstrate an increase in squeeze upon the lumen corresponding to this increased muscle activity; instead we found a decrease in squeeze over a period of two to three seconds followed by an increase towards, but not up to, the resting value over about 30 to 60 seconds.

These observations suggest that measurements of pressure within the anal canal record, almost entirely, the action of the smooth muscle segment, and that the external sphincter or pelvic diaphragm exerts very little squeezing action upon the anal canal except during voluntary contraction. The situation appears to be closely similar to that at the oesophageal hiatus of the diaphragm with its contained cardiac sphincter (Edwards, 1961, 1963).

RADIOLOGICAL RESULTS

Lateral and antero-posterior radiographs of the rectum and anal canal after coating the mucosa with barium sulphate powder showed the canal to be flattened from side to side rather than to have a circular or stellate cross-section when empty (Fig. 5).

A segment about 0·5 cm. long, at the junction of the anal canal and the rectum, became emptied of the barium powder as the subject moved about, suggesting that this segment might be subjected to greater squeezing forces than the adjacent parts of the gut tube (Figs. 6 and 7). This appeared to correspond approximately with the inner surface of the pelvic diaphragm and was reminiscent of the segment of oesophagus emptied of barium by the difference in pressure between the abdomen and the thorax (Creamer, Harrison, and Pierce, 1959). It is

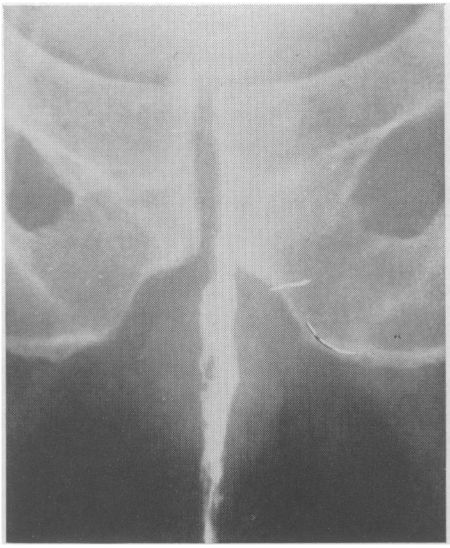

FIG. 5a.

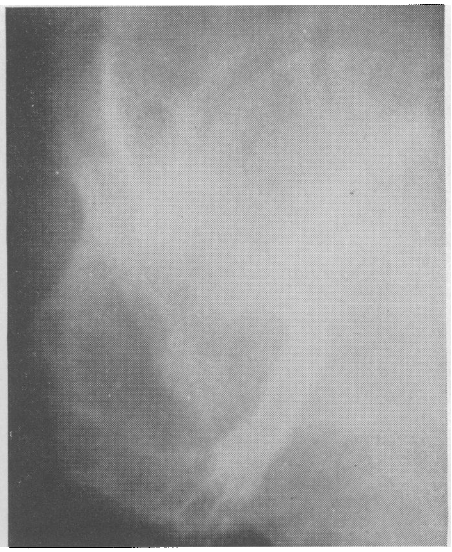

FIG. 5b.

FIG. 5. *Antero-posterior and lateral radiographs of the anal canal mucosa after coating with barium powder. Note the appearance of lateral compression.*

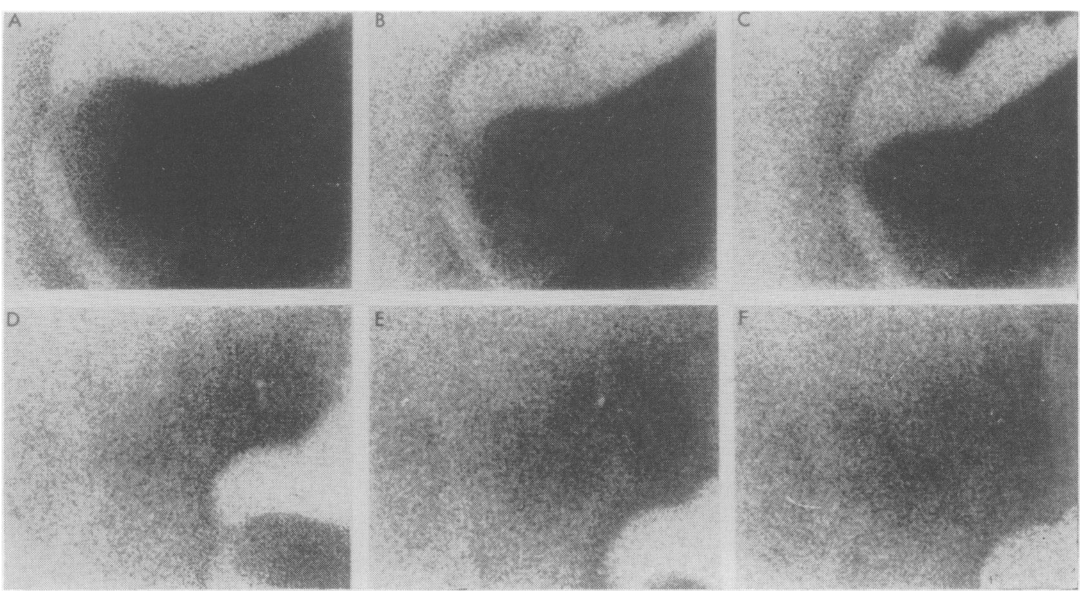

FIG. 6. *Frames from a lateral cine-radiograph of the movement of the anal canal and rectum. C is the resting position with the ano-rectal junction seen as a radiolucent segment. At A the subject has voluntarily contracted the 'sphincter' and in so doing has raised the pelvic floor, bringing more anal canal into view and raising the rectum. B is a stage during the relaxation back to C. D, E, and F are successive stages in 'bearing down' showing the descent of the pelvic floor and a forward and downward movement of the rectum away from the sacral shadow which lies above and to the left of the barium shadow.*

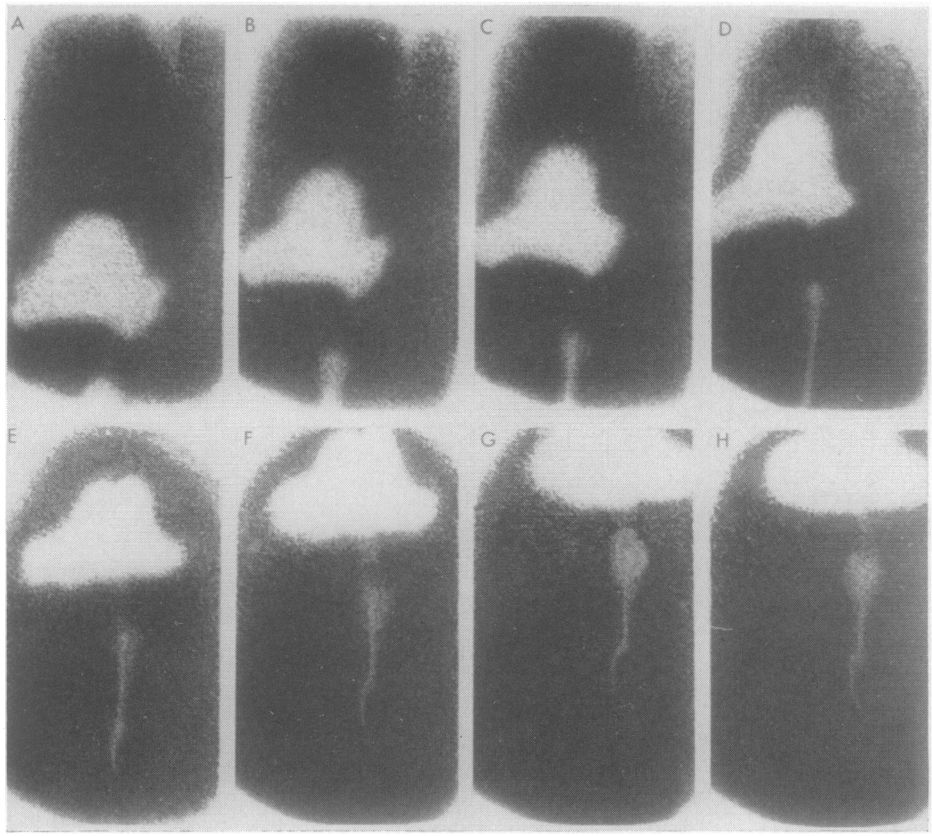

FIG. 7. *Frames from an antero-posterior cine-radiograph of the anal canal and rectum. D is the resting position showing the thin antero-posterior shadow of the anal canal, separated from the lower rectum above by a radiolucent segment, with the shadow of the pubic arch behind it. At A the subject has made a 'bearing down' effort; B and C are stages in the relaxation to D. E, F, G, and H are stages in the voluntary contraction of the 'sphincter' with consequent elevation of the pelvic floor. The shadow of the pubic arch is in the same position on each frame.*

too short to be explained by the squeeze of a muscle layer, and no corresponding zone of higher pressure has been found in manometric records.

Cineradiography of the anal canal and rectum after dusting the mucosa with barium powder showed a sharp rise of the pelvic floor, with increase in angulation of the rectum on the anal canal, when a voluntary effort was made to contract the sphincter segment. Conversely, during a 'bearing down' effort there was a sharp descent of the pelvic floor with lengthening and straightening out of the curves of the rectum (Figs. 6 and 7).

During defaecation of radiopaque faeces, filmed in the antero-posterior view, the pelvic floor was seen to descend, forming a funnel with its apex at the inner end of the anal canal. At the end of defaecation the funnel was closed and then obliterated as the pelvic floor rose to its normal position (Fig. 8).

DISCUSSION

The elaboration of the hypothesis which is based upon the preceding observations is divided into two parts, corresponding to the two questions posed in the introduction.

THE MECHANISM OF CONTINENCE Before continence can be endangered faeces must enter the rectum. The following arguments apply only to a situation where, in the normal person, the rectum contains faeces.

The pressures that have been recorded suggest that some mechanical valve is necessary for the following reasons: 1 After partial or complete internal sphincterotomy, which considerably reduces the squeeze of the sphincter segment, continence against increase of intra-abdominal pressure is preserved. The internal sphincter cannot therefore be concerned with gross continence, although it may contribute

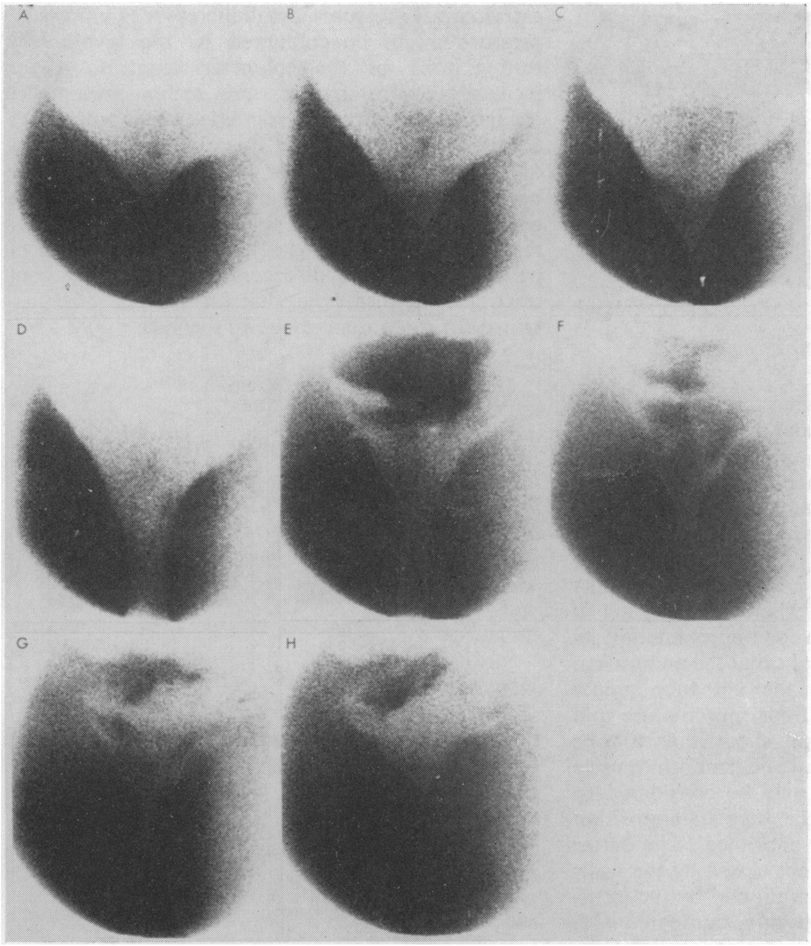

FIG. 8. *Frames from an antero-posterior cine-radiograph of defaecation of radio-opaque faeces. At A the pelvic floor (in black) supports the rectum and the anal canal is empty. As defaecation proceeds (B and C) the pelvic floor descends and forms a funnel until the anal canal is opened and filled (D). As the rectum empties (E and F) the pelvic floor rises and the funnel is closed (G and H).*

to the completeness of the gas- and water-tight seal. 2 Distension of the rectum is accompanied by a relaxation of the squeeze of the whole sphincter segment, and by a diminution of electromyographic activity of the pelvic floor, yet faeces in the rectum do not necessarily impair continence. 3 Intra-abdominal pressure of the order of 200 cm. of water may be reached without loss of continence or voluntary contraction of the sphincter. The squeezing force of the sphincter segment, without deliberate contraction, is of the order of 16 to 50 cm. water, and we have obtained records in which the intra-abdominal pressure was greater than that in the sphincter segment. With a maximal voluntary squeeze the pressure in the sphincter segment may be increased to 40 to 240 cm. water, but the effective closing force of such a voluntary contraction is reduced because of a coincident increase in intra-abdominal pressure. Moreover, voluntary contraction can only be sustained for about 50 sec., yet physical efforts involving increased intra-abdominal pressure frequently continue for longer without incontinence. The 'external sphincter' cannot therefore be responsible for sustained continence by virtue of its centripetal contraction, a conclusion supported by radiographs of the anal canal which show it to have an elliptical rather than a stellate cross-section at rest.

A possible mechanical system Evidence has recently been advanced in favour of the anti-reflux mechanism at the cardia being a mechanical process analogous to the flutter valve commonly used in basal metabolism equipment and spirometers. This valve consists of a rubber tube moulded so that its walls lie side by side, flattened together in gentle contact. (Fig. 9). If the pressure at A is greater than

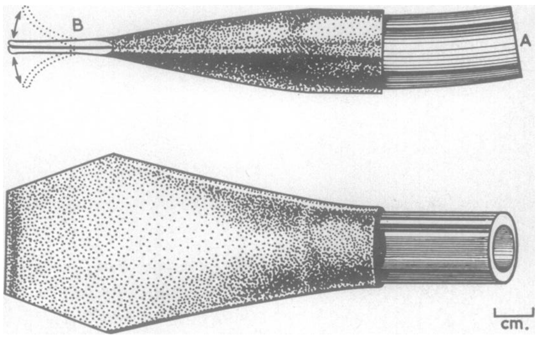

FIG. 9. *Flutter valve. See text.*

at B, for example, when blowing through the valve, the walls are pushed apart and will flutter. If the pressure at B is greater than at A, the difference in pressure tends to approximate the walls and once this has happened the greater the difference in pressure the more firmly are the walls pressed together.

This general principle can be applied to all exits from the abdominal cavity where the channel is associated with a mechanism for approximating its walls in a slit form. At the anal canal the anatomical conditions are appropriate; the gut tube passes through a slit in the pelvic floor musculature and radiographs of the anal canal show it as a tube flattened from side to side. The smooth muscle sphincter of the anal canal may be considered to help to keep the walls of the tube in apposition (Fig. 10) and so keep the valve 'primed'. The flutter valve would in this way be kept closed by the walls of the slit in the pelvic diaphragm and by the intra-abdominal pressure which is positive compared with atmospheric pressure. Any increase of intra-abdominal pressure that does not push down and stretch out the pelvic floor will close the valve more tightly (Fig. 11). This hypothesis is supported by ciné-radiology which shows that during body movements which increase intra-abdominal pressure a short segment of gut tube is squeezed empty of its coating of barium, suggesting a plane at which the difference in pressure between the abdominal cavity and the canal acts to compress the flutter valve tube.

We suggest that continence against changes of intra-abdominal pressure is achieved in this way, but we wish to emphasize that continence against an increase in intrarectal pressure, which is produced by contraction of the colon or rectal wall, can only be achieved by contraction of the anal sphincter segment aided feebly by the support of the walls of the slit in the pelvic diaphragm, because the postulated valve mechanism would not be effective against intraluminal pressures much in excess of extraluminal pressures. Small increases of intrarectal pressure might be countered by the involuntary resting tone of the sphincter segment. Major increases of intrarectal pressure, such as presumably occur in diarrhoea, dysenteries, and ulcerative colitis, must be countered by voluntary contraction of the sphincter segment or pelvic floor, in particular because distension of the rectum tends towards reflex relaxation of the pelvic floor and sphincter segment (Parks *et al.*, 1962). It is the experience of patients with these disorders that voluntary contraction is neither very powerful nor can it be sustained for more than about 50 seconds.

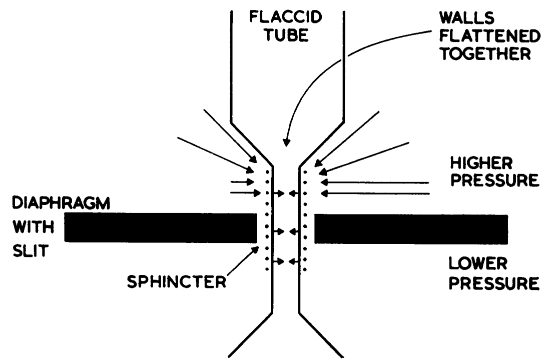

FIG. 10. *Diagram illustrating the principle of the flutter valve at a slit opening.*

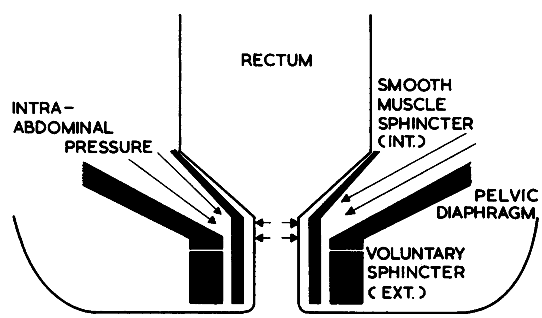

FIG. 11. *Diagram illustrating the application of the flutter valve principle to the anal canal.*

This hypothesis may be linked with the findings of Goligher (1951) that loss of the anal mucosa impaired continence, and with the finding of Duthie and Gairns (1960) and Duthie and Bennett (1963) that the mucosa of the anal canal contained many nerve endings up to 3 cm. in from the anal verge, but the mucosa of the rectum and the innermost-part of the anal canal contained no sensory endings, although there might be stretch receptors in the muscle wall of the rectum. Impulses from these stretch receptors appear to travel along a different pathway from that which carries impulses from the receptors in the anal mucosa (Nathan and Smith, 1953). We suggest that the flutter valve mechanism keeps the anal canal closed during muscular activity so that the anal mucosa is not stimulated. If intrarectal pressure increases above intra-abdominal pressure, the valve is opened and rectal contents reach the sensitive anal mucosa. The receptors warn of an impending breach of the defences and elicit an immediate voluntary contraction of the pelvic diaphragm which restores confidence by squeezing the stimulating material back into the rectum.

MECHANISM OF SOCIALLY ACCEPTABLE DEFAECATION

If our hypothesis of continence against intra-abdominal pressure is correct, it is necessary to postulate a mechanism for breaking the seal of the flutter valve in order that defaecation can be initiated voluntarily. The valve might be opened in two ways. First, an increase in intrarectal pressure above the surrounding intra-abdominal pressure would tend to push the walls apart from within. This force could be countered by the contraction of the anal sphincter. Second, the walls might be pulled apart from without. We suggest that this is achieved by contraction of the abdominal wall muscles with controlled descent of the pelvic floor, which forms a funnel with the inner part of the anal canal and straightens out the curves of the rectum (Fig. 8). The observations by Parks *et al.* (1962) on the resting tone of the pelvic floor muscles and their relaxation during attempts at defaecation lend support to this suggestion. On the basis of our hypothesis, defaecation could be initiated at will provided there were faeces in the rectum, but the quantity discharged would depend on how much faecal material descended into the funnel. An additional mechanism would be necessary to sustain a flow of faeces from the colon and there may well be a reflex contraction of the colon initiated by the beginning of defaecation. We have not so far been able to measure this. Since propulsive contraction of the distal colon and rectum is unusual during sigmoidoscopy or proctoscopy, distension of the anal canal alone is unlikely to be the stimulus. We have found no evidence that the levator ani aids defaecation by pulling the anal canal craniad over the extruding faecal mass (Garry, 1934); rather does the reverse happen.

The function of the rectum, if we may be teleological, might be that of a compliant reservoir to receive the contents of the colon and dissipate an intraluminal pressure that would otherwise open the valve and create a state of emergency by exposing the anal mucosa. Such a situation probably exists in dysentery where the rectal reservoir is inadequate in size, or in proctitis where the compliance of the rectal wall may be impaired. This might explain why the Maunsell-Wier operation sometimes results in poor control (Goligher, 1951) because of loss of reservoir capacity as well as loss of sensory area. Lastly we suggest that there is some mechanical similarity between rectal prolapse and hiatus hernia.

CONCLUSION

We suggest that socially acceptable defaecation depends on the following sequence: colonic movements transport faeces into the rectum and elicit a call to stool by stimulating stretch receptors in the wall of the rectum which passively stretches. If the rate of inflow of faeces is so fast as to open the closed segment of the flutter valve at the inner surface of the pelvic floor, anal receptors are stimulated, and give warning of an impending breach of the defences. This warning is answered by a voluntary contraction of the pelvic floor and anal sphincter which closes the valve again. When circumstances are appropriate, the valve may be opened voluntarily by allowing the pelvic floor to descend and pull apart the innermost part of the relaxed sphincter segment. At other times the 'postural tone' of the pelvic floor maintains the slit form of the anal canal and the major factor in the control of continence against intra-abdominal pressure is the mechanical 'valve' mechanism of a compressible flattened tube passing through a slit orifice.

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