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THE FUNCTIONS OF THE ANAL SPHINCTERS, SO-CALLED, AND THE ACT OF DEFECACTION.

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I. HYRTL, in his treatise on Topographical Anatomy, devotes three pages to the consideration of what he designates as the *Sphincter Ani Tertius*. He first points out that the presence of such an obstacle to the escape of feces is, *à priori*, probable chiefly from the fact that numerous cases have been reported in which patients have had control over the evacuations, even after the other sphincters have been extirpated or rendered inert by laceration or disease. This assumption he shows to have been corroborated by the discovery, made by Nélaton and Velpeau, of a thick bundle of the circular muscular fibres of the rectum three or four inches above the anus. While admitting that this sphincter is often but faintly indicated, or even entirely deficient, Hyrtl claims to have usually found it well-marked.

From his description, the only inference is that Hyrtl has generally found a bundle of muscular fibres so encircling the rectum as to exercise the function of a sphincter, at least when the other sphincters are for some reason inoperative. On inflating recta, however, in accordance with the direction given by him (Plate I.), it is rather surprising to discover that no such annular constrictions appear. At the point in the rectum designated by him is, nevertheless, observable a semicircular constriction of the rectum confined to the anterior wall; corresponding to this, but an inch or more higher up, is always seen a second semicircular constriction affecting the posterior wall only. The effect of these two semicircular constrictions is to give the rectum

the shape of the letter S. If, now, the rectum be cut open, and its mucous membrane dissected off, as directed by Hyrtl, each of these two constrictions may be demonstrated to consist, as he says the "third sphincter" does, of an agglomeration of the circular muscular fibres of the rectum. By the kindness of Professor J. B. S. Jackson, I am able to show you seven recta — taken from dissecting-room subjects, and therefore not in the best condition for demonstration — from which he has dissected off the mucous membrane after cutting them open longitudinally. In all of these you cannot fail to find corroboration of my statements in the presence of two distinct masses of circular fibres (Plate II.), each encircling about half the circumference of the canal.

If, now, a mass of feces be supposed to advance through the rectum following the sinuosities, it is evident that these bundles of fibres, when not in active contraction, would present scarcely any obstacle to its progress. It is further noticeable that these partial constrictions of the canal differ only in degree from the constrictions visible in the higher segments, which give to the rectum its characteristic sinuous appearance.

After this brief anatomical prelude I will at once recount the clinical observations upon which this study is based.

As a result of the rectal examinations, which they are frequently obliged to make, gynecologists early become familiar with the fact that the finger passes through the perineum in a direction almost perpendicular to the vagina; that, having emerged from the internal sphincter, it enters a large flaccid pouch designated the *ampoule rectale* by the French, which passes backwards, resting upon the perineum, the coccyx, and the sacrum. At about two and a half inches from the anus the finger encounters a confused mass of folds through which the continuance of the canal can only be discovered by considerable burrowing. Here an annular constriction, diminishing the lumen by about one half, seems to be felt.

If, now, the rectum be distended with water, the finger will almost invariably detect, in place of the lax folds, what still seems to be an annular constriction, but which a more careful exploration will show to be composed of two distinct semicircular bands slightly overlapping each other, the posterior being somewhat higher than the anterior. I recognized these peculiarities clinically several months ago, and only obtained anatomical corroboration of the fact last week, when I obtained these specimens.

Being familiar with the views of Nélaton, Hyrtl, and others, I at first sought to assign to this apparent constriction of the rectum sphincteric functions, but soon had to relinquish that idea, for the exploration of very many recta in the living failed to reveal a single one in which the lumen of the supposed sphincter, when quiescent, had a smaller diameter than three quarters of an inch ; while in the majority it was over an inch. Surely so inconsiderable a constriction could hardly present any efficient opposition to the passage even of solid excreta. This conclusion is more than confirmed by this inflated rectum, as has been indicated above. The semblance of an annular constriction is probably produced by an approximation of the superior (and posterior) semicircular band to the inferior (and anterior) by the pressure of the superimposed pelvic contents.

These clinical observations led to oft-repeated investigations on my own person, when I soon detected the action of these bundles of fibres under the following circumstances : A finger in the anus would invariably give rise, within a few seconds, to those peculiar sensations which we all correctly recognize as indicative of an impending evacuation of the intestines, even though the excreta may not have descended so far as to press upon the perineum. In every instance these sensations would be speedily followed by the emergence from the still lax folds at the point of constriction, of a mass of more or less solid feces, which would descend rapidly to the anus. If at this moment the fingers were kept applied to the distended semicircular

bands, their muscular fibres could be plainly felt to contract *behind* the fecal mass, until the lumen of the rectum was *completely occluded*. After numerous repetitions of these observations the conviction was forced upon me that this, so-called, third sphincter not only fails to oppose the advance of the fecal mass, but in fact contributes most forcibly to further its progress. In other words, these bundles of muscular fibres are found to possess identically the same expulsive functions as the other bundles of ordinary circular fibres of the intestine, and to differ from them only in volume and hence presumably in power.

This was not all. Further careful observation with the finger led to my detecting a distinct relaxation of the *tonic contraction* of these bundles of circular fibres just before the fecal mass had reached that point of the rectum in its descent and dilated them, as it might have done, by its mere bulk. In other words, a distinct inhibitory action came into play, — such as has been shown to affect the internal sphincter of the anus, — and relaxed the constricting bands in front of the feces; the result being, of course, the very reverse of what should be found in a sphincter. This observation fully corroborates the conclusions of Pflüger, Wolf, Ludwig, and others, that in peristalsis the action of the intestine is under central control, being inhibited by the splanchnics intensified by the vagus, in advance of the fecal mass. I have failed to detect the slight contraction of the fibres, preceding the complete relaxation by inhibition, which Gower's researches have shown to take place in the rectum, two inches from its lower extremity. Such inhibitory relaxation of the circular fibres in front of the fecal mass throughout the intestine would seem almost essential to its easy passage under the impulse of the circular fibres contracting in the rear.

The above anatomical and clinical observations all tend to indicate that the term "Third Sphincter Ani," applied by Hyrtl to these constricting bands, is a misnomer; and to show that they are simply a part of the general circular

layer of muscles, whose function is to dilate before and contract behind the scybala, thereby propelling them on their way, and not retarding them.

II. Having seemingly elucidated the true function of the "Third Sphincter Ani," and proved by the above observations that it should more properly be termed a *Detrusor Fæcium*—if deserving of any special appellation—my attention was next directed to the action of the Internal Sphincter.

In this thick bundle of the circular fibres of the rectum my finger speedily detected the relaxation in front of the descending feces which has been demonstrated by the admirable investigations of Goltz¹ and Gowers² to be dependent upon inhibitory action. Some little discrimination was at first required, for the reason that the irritation of the anal mucous membrane by the insertion of the finger always evoked a reflex contraction of the external sphincter, and other perineal muscles. The action of these muscles was, however, found to subside when the finger was held immovably in the rectum, and could even be restrained by the exercise of the will. During such a period of muscular quiescence, the tonic contraction of the internal sphincter was very perceptible. After the interval of a few seconds during which I was generally conscious of sensations indicative of peristaltic action in the rectum, inhibitory relaxation of this sphincter would supervene, and almost immediately feces be felt presenting at the anus.

This tonic contraction of the internal sphincter with intermittent relaxations was found by Gowers to exist in a "man who, by a violent fall on the sacrum, had apparently injured the posterior roots of all the sacral nerves, and both roots of the lowest sacral nerves," and in whom "there was no muscular paralysis or loss of nutrition except in the levator ani, the sphincter ani, and the sphincter

¹ *Pflüger's Archiv.*, vol. viii., 1874, p. 479.

² *Proceedings of the Royal Society*, No. 179, 1877. Reprint, p. 7.

vesicæ, all of which were paralyzed to the will; there was no evidence of injury to the spinal cord;" further, in two men "with paraplegia, due probably to disease of the dorsal region of the spinal cord, in whom there was reason to believe that the lumbar enlargement of the cord was free from material damage." In each of these patients, "although the incontinence of feces was complete, the sphincter was habitually in a state of continuous slightly varying contraction." This was, however, "inhibited by any irritation applied to the mucous membrane of the rectum. Such an irritation was readily effected by the injection of a small quantity of air into the rectum. . . . After a brief period of complete relaxation, contraction occurred, at first slight, and then slowly increasing. . . . in most cases, to a higher point than the original pressure, and a subsequent slight fall occurred until the initial pressure was reached. When the irritation was produced by a solid body, a slight brief increase in the contraction preceded the relaxation of the sphincter.

"In the slow rise after this inhibition there was often an indication of a tendency to rhythmical action. . . . Goltz observed that in dogs, after division of the dorsal cord, a rhythmical action was caused by the presence within the sphincter of any foreign body. In man it does not appear that the presence of any unirritating foreign body within the anus, provided it is kept still, constitutes stimulation or excites any reflex action. No rhythmical variations were, as a rule, observed in the tonic contraction. In one case of disease of the dorsal spinal cord, however, the mere presence of the instrument caused sometimes a lengthened inhibition, at the end of which some rhythmical contraction occurred. But it was found that in every case the continuous injection of a jet of air into the rectum developed very uniformly a rhythmical action."

I have quoted the observations of Dr. Gowers for two purposes: First, to show that with the exception of the initial contraction and the rhythmical action, they accord

perfectly with my own less precise, but no less accurate investigations ; and, secondly, to show the data on which he bases his conclusions ; these, as far as they go, agree perfectly with the conclusions at which I arrived independently, and recounted to my friend Professor H. P. Bowditch, before he called my attention to the paper of Dr. Gowers. I quote again at length :—

“ I would, however, draw especial attention to the points of resemblance between this reflex action of the internal sphincter and that of the middle coat of the intestine in peristaltic action, which suggests the probability that the action of the sphincter, apart from the will, is under the control of a similar mechanism, and is indeed only, so to speak, a concentrated and more specialized instance of the action of the transverse fibres of the rectum. The action of the intestine, as well as that of the sphincter, is under central control, being inhibited by the splanchnics, intensified by the vagus. The deliberate character of the reflex action of the sphincter resembles closely the deliberate character of the intestinal reflex.

“ Increased intestinal contraction, like that of the sphincter, is excited most readily by irritation of the mucous membrane. Moreover, Goltz believed that in dogs the muscular coat of the rectum participated in the rhythmical contraction which he observed in the sphincter ; and my own observations have shown that the reflex action I have described is not confined to the thickened extremity of the bowel, but can be obtained in a modified form as high as two inches from the lower extremity.

“ The power of reflex action which is possessed by the whole internal sphincter must be possessed by each bundle of muscular fibres of which it is composed. As the sphincter may be regarded as an aggregation of bundles of fibres, such as are contained in the transverse muscular coat of the intestine, so the latter may be regarded as a serial arrangement of the bundles of which the internal sphincter is composed. An action of each bundle of fibres so ar-

ranged, such as we have seen to occur in the sphincter as a whole, must result in peristalsis, in the movement of a contained and stimulating body along the intestine. If each bundle of fibres passes through the same series of successive contractions and relaxations as the sphincter ani, then the curve traced by the action of the latter will represent not merely the condition of one bundle of fibres in successive intervals of time, but also the condition of successive bundles at the same time, and two such curves in opposition will represent a diagrammatic longitudinal section of the intestinal wall. The effect, therefore, of the presence in the intestine of a mass of feces, or other contents would be to cause, first, in the moderately contracted intestinal wall in front of it, an increased contraction, the effect of which would be to prevent the diffusion of the contents along the intestine (which would materially interfere with their movement); secondly, complete relaxation of the next portion of the intestinal wall into which the contents of the intestine could pass; and thirdly, a strong contraction behind, sustained and moving as the stimulating body, as the initial contraction gave place to relaxation. The process would, no doubt, be materially modified by the contraction of the longitudinal fibres of the bowel, which would prevent the undue distention of the relaxed portion, and thus assist the transmission onwards both of the contents of the bowel and of the resulting stimulation. . . . The intermitting contractions of the sphincter under a continuous stimulation may represent the successive waves of peristaltic action when the intestinal contents are abundant. It is further noted that the presence of the instrument in the anus, after the effect of its introduction had passed off, was the source of no stimulation, just as contents may be at rest within the bowel, and if they are not moved, and do not irritate the mucous membrane, may excite no peristaltic action."

I think it will seem strange, to all who reflect upon the above lucid reasoning, that the author should not have

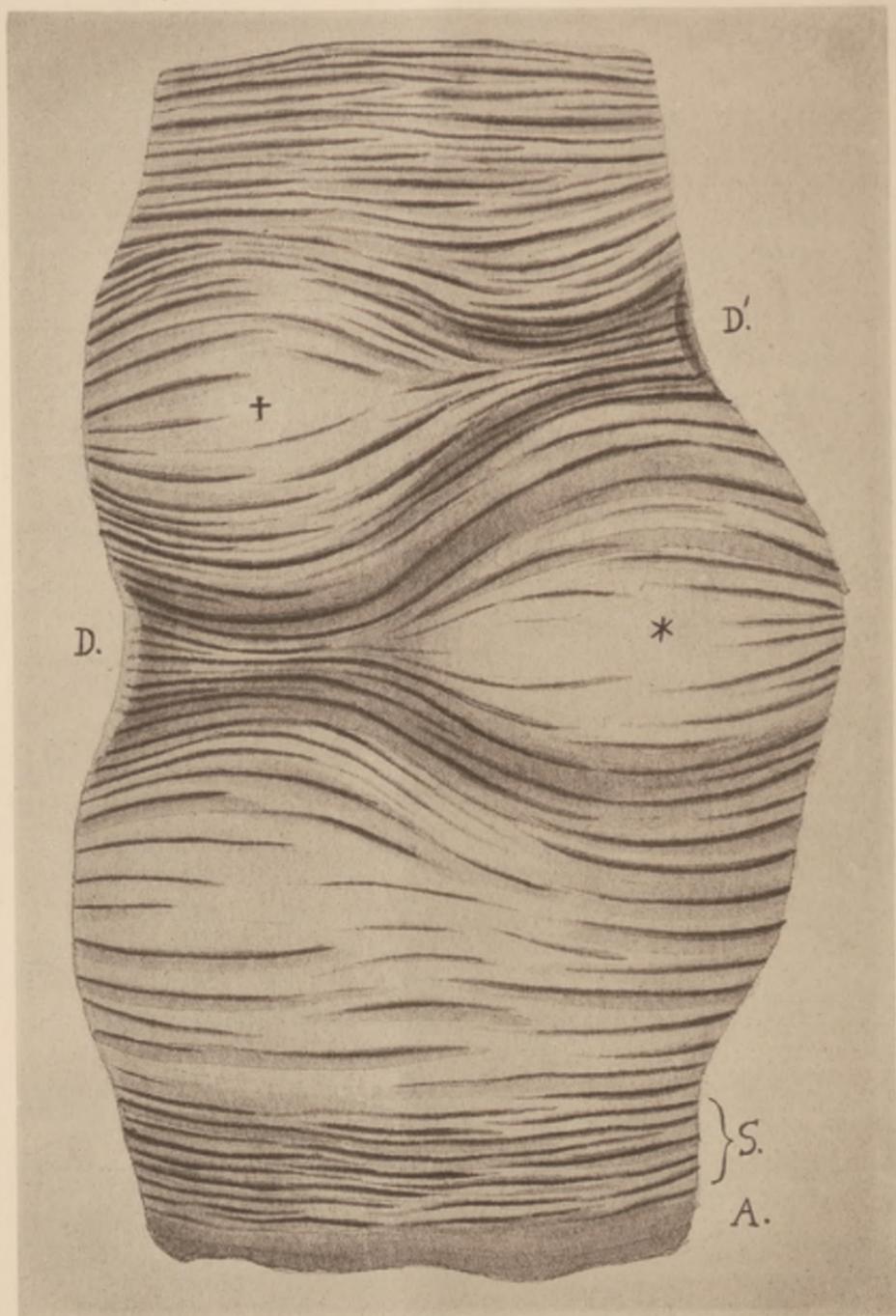


Fig. II.

FIGURE II.

Rectum from a male subject, cut open longitudinally, and the mucous membrane dissected off so as to show the circular muscular fibres.

D and D' correspond to the same letters in Plate I. and indicate the aggregation of fibres constituting the anterior and posterior segments of the Superior Detrusor Fæcium (Third Sphincter) respectively.

S is the Inferior Detrusor Fæcium (Internal Sphincter.)

A, the Anus.

† and * correspond to the same marks in Figure I.

This drawing shows the muscular fibres passing from the anterior to the posterior segment of the Superior Detrusor, by the action of which they may be approximated to each other.

FIGURE I.

Rectum from a male subject, tied below at the anus, and inflated.

D, D', are the anterior and posterior segments of the Superior Detrusor Fæcium (Third Sphincter).

R is the *ampoule rectale*.

† and * correspond to the same marks in Figure II.

This drawing shows the sinuosities of the rectum maintained by the action of the longitudinal fibres at the points where the circular fibres are collected in bundles, notably the two lower ones.

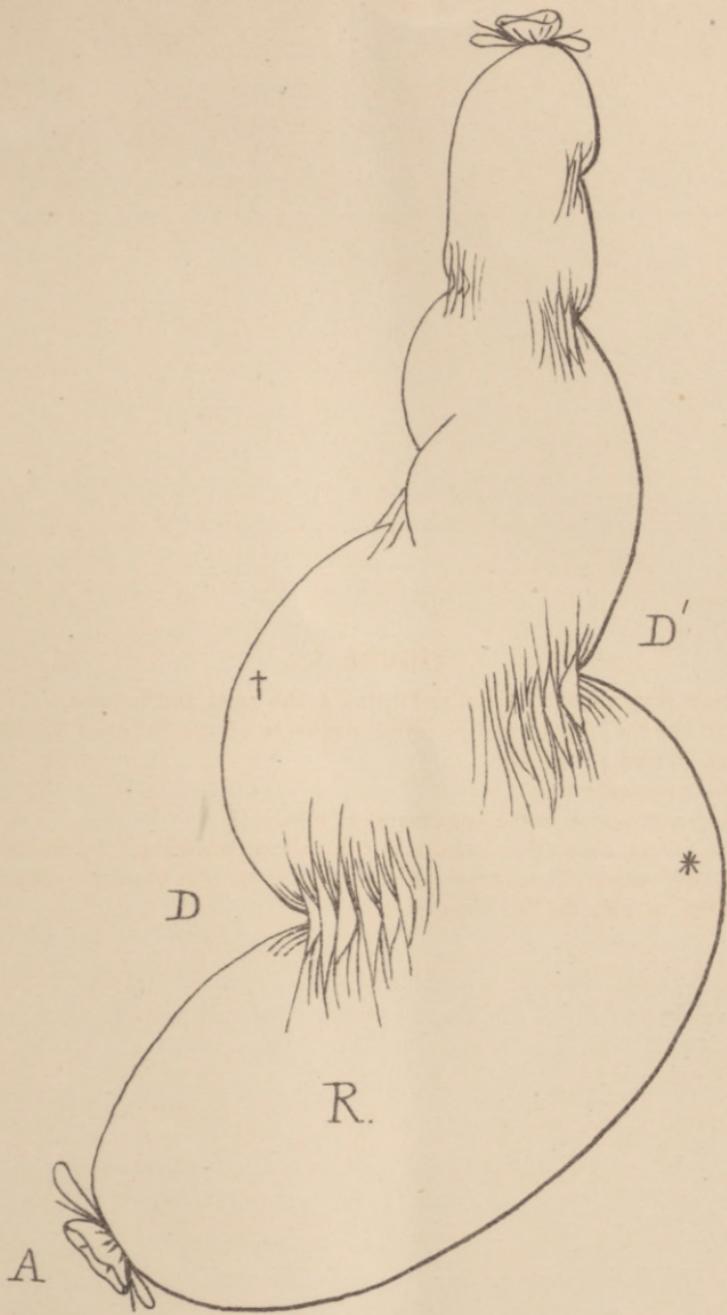


Fig 1.

gone a step further in his deductions, and asserted as the logical sequence of his argument, that the internal sphincter has but *one function, that of completing the expulsion of the feces from the alimentary canal.* That he does not throw off the traditional belief in the obstructive function of the so-called internal sphincter is evident from the passages quoted; for instance, he suggests the "probability that the action of the sphincter, *apart from the will,* is under the control of a *similar mechanism*" to that of "the middle coat of the intestine in peristaltic action." He fails to recognize the fact, which seems to me almost beyond question, that the sphincter is under the control of the *same mechanism* as the rest of the intestinal canal, and is, like that, at no time subject to volition. I have never been able to detect the least increase in the tonic contraction of the internal sphincter, even by the greatest exertions of my will; nor have I ever been able to resist the inhibitory relaxation of its fibres, except in so far as contraction of the external sphincter and of the perineal muscles has closed the extremity of the intestine and thus squeezed the lax internal sphincter together.

It seems curious that the fact that the internal sphincter differs from the external sphincter, and resembles the circular layer of the intestine in consisting of unstripped muscular fibres, should never have suggested to anatomists and physiologists that it is a part of the peristaltic system of the intestine.

Analogy certainly affords emphatic support to this view. In the bladder the circular unstripped fibres of the middle coat become more pronounced near the orifice of the urethra, and the "layer they there form has commonly but erroneously been regarded as the true sphincter vesicæ. The fibres just described may be collectively termed the detrusor urinæ, and their contraction effects the expulsion of the urine from the bladder."¹

¹ *Physiology of Micturition and Retention of Urine*, by Henry Power, M. B., Practitioner, January, 1875, p. 39.

On the justifiable assumption then, that the internal sphincter is really a detrusor fæcium, we are fain to accept the *external sphincter* as the only muscle which has the sole function of an anal sphincter. The internal sphincter, by its tonic contraction, supported by the tonic state of the external sphincter, and more especially of the perineal muscles in which it lies, certainly closes the aperture of the intestines, before the wave of inhibitory relaxation, that precedes the wave of peristaltic contraction, has reached the internal sphincter in its advance through the intestines.

Let, however, solids, liquids, or even gases, in sufficient volume, be propelled through the rectum by peristaltic action, and we find that before they have reached the internal sphincter it has relaxed its fibres and opened the passage for their escape. But to prevent the untimely discharge of these matters, the mucous membrane of the rectum and anus is acutely sensitive to the pressure of the intestinal contents, and excites by reflex action a *contraction in the external sphincter and perineal muscles* which closes the opening. The closure, although at first automatic, is subsequently maintained or remitted by the exercise of the will.

It seems highly improbable that the inhibition of the contraction of involuntary fibres is subject to volition as is stated by Powers in his paper on micturition above cited. The will does, however, relax the reflex contraction of the voluntary muscles.

The role of the perineal muscles, especially of the levator ani, is, I believe, very important in opposing the escape of feces from the rectum. These muscles do not encircle the anus, but their contraction closes the opening in precisely the manner that the muscular fibres of the uterus constrict the utero-placental sinuses.

III. The *external sphincter* has always been recognized as a purely voluntary muscle, and, like all such, contracts by reflex action in response to a local excitation as well as by direct volition. It is the only one of the anal muscles which can properly assume the title of sphincter.

THE ACT OF DEFECACTION.

Having thus presented the functions of the several so-called sphincters in a somewhat new light, I propose to consider the mechanism by which the rectum is evacuated.

The first and most potent factor in eu-catharsis is unquestionably *peristaltic action*. This is generally supposed to be excited when the accumulation of excreta in the large intestine has reached a certain volume and consistency. The fecal mass is propelled toward the anus by the contraction of the successive circular fibres of the intestine behind, while those in front are successively relaxed by inhibitory action. The longitudinal fibres probably act at the same time as the circular to prevent saccular dilatation of the tube, as suggested by Gowers, and perhaps to straighten it. It further seems not unlikely that these longitudinal fibres tend to retract the relaxed circular fibres over the advancing mass, as occurs in the esophagus during deglutition, thereby pushing forward the contents of the tube.

My investigations have shown that peristalsis is the only force at work up to the moment when the head of the fecal column has come to press upon the perineum. A forcible contraction of all the abdominal muscles is then — and under ordinary circumstances not until then — automatically evoked. The effect of this effort is to diminish the capacity of the abdomino-pelvic cavity, thereby compressing its contents and driving them in the direction of the least resistance. As the perineum, closing the outlet of the pelvis is, at such a moment, the only portion of the abdomino-pelvic walls that is not in a state of active contraction, and is hence capable of being distended, it yields before the uniform downward pressure. Before this force the perineum yields, its centre descending to an extent varying from one to two inches by measurement, according to the tonicity of its muscles and fasciæ, and to the power of the abdominal muscles; the anal groove is thus completely obliterated; the curve of the rectal canal, where it

enters the perineum, is straightened, while the *ampoule rectale*, which rests almost horizontally upon the perineum and coccyx, is brought into a nearly perpendicular position; finally, the internal sphincter, so-called, already relaxed by inhibition, together with the external (true) sphincter, is dilated to the greatest possible extent.

As the contraction of the abdominal walls does not ordinarily take place until the fecal mass has filled the lower segment of the rectum, and is pressing upon the perineum, the feces are in position to be driven forward through the opening in the anus by the increased tension of the abdomino-pelvic cavity; this mechanism acts as a powerful adjuvant of the propelling peristaltic action. When the advancing contraction of the circular fibres of the rectum behind the fecal column finally reaches the "third sphincter," and the latter closes upon the fugitive mass, the more or less rigid walls of the segment of the rectum below it have acquired somewhat the shape of a cone, of which the "third sphincter" represents the apex, and the dilated anus the base. Into this conical tube the "third sphincter," lying on a level with the bladder, prostate, and bottom of Douglas' pouch, is invaginated by the descent of the abdomino-pelvic contents under the impulse of the contracting abdominal muscles, so as to propel the excrement another step on its journey. My finger has repeatedly been able to push up the folds of the rectum around this contracted detrusor when thus invaginated; the detrusor may then be compared to the piston of a syringe.

The contraction of the circular fibres below the third sphincter never seems to be powerful enough to obliterate the lumen of the intestine, yet each bundle of fibres can be felt as a tense ring. The peristaltic contraction of the internal sphincter I have never been able to dissociate from the final act in the process of defecation, which consists in the restoration of the perineum to its normal plane by a contraction of its muscles. This usually calls for but little effort as, at the same time that it takes place, the abdom-

inal muscles relax so that the exaggerated downward pressure is removed. If, however, the lower segment of the rectum still holds the remnants of a fecal mass, the perineal muscles may be called into action, while the abdominal are still tense, the effect being to bring the floor of the pelvis (perineum) into forcible apposition with the lower surface of the pelvic contents, which are still firmly held in their depressed position. The anus is thus approximated to the "third sphincter," which has closed behind the feces, by which means the intestine is at length emptied.

I wish to direct special attention to the depression of the perineum by the contraction of the abdominal muscles, and its subsequent elevation to the normal plane by the activity of its own muscles, because physiologists generally overlook both of these changes in the perineum. They generally allude to the action of the abdominal muscles during defecation as though the force thus evoked was all expended upon the fecal mass to be expelled. This is manifestly incorrect. Having failed to recognize the depression of the perineum, they have naturally overlooked perineal contraction. That this action is necessary to restore the perineum to its normal plane will be immediately manifest to any one who will pay a moment's attention to the subject.

In accordance with these views, defecation consists of three separate successive acts: peristalsis, abdominal contraction, and perineal contraction.

Besides calling attention to this fact, my aim in these pages has been to present briefly the chief reasons for my belief that the functions of the Third Sphincter and of the Internal Sphincter of the anus have been hitherto misunderstood. I would suggest that they be called in future the Superior and the Inferior Detrusor Fæcium, respectively.

PRACTICAL DEDUCTIONS.

In view of the length of this communication, and the many possible bearings of these views upon rectal surgery, I shall confine myself to indicating briefly three directions

in which an application of these principles may cast some light.

1. In the first place the name (rectum) given by anatomists to this portion of the alimentary canal has led surgeons to suppose that a straight bougie ought not to meet any natural obstruction to its introduction. Plate I., however, shows that the end of any straight body would almost inevitably be caught by the posterior half of the superior detrusor. This obstacle I have repeatedly met during the past two years, and erroneously supposed to be the projecting promontory of the sacrum. For over two years I have been in the habit of dilating the portions of the rectum above this point by the inflation of a bag tied over the end of a silver male catheter, of which the curve has been considerably but not fully straightened. If, by rotation of the instrument, the curve be directed forwards, when it is passed through the perineum, backwards through the *ampoule rectale*, forwards again through the superior detrusor, and again backwards into the next segment of the rectum, the obstructions met by a straight tube have been invariably avoided.

2. As the anterior half of the superior detrusor is just below the level of the bottom of Douglas' pouch, it seems probable that the point at which intra-peritoneal abscesses are most likely to perforate the rectum is just above this constricting fold.

3. As the superior detrusor is shown to be forced down into the canal below during defecation by the action of the abdominal muscles, the suggestion presents itself that this part of the rectum is the one which first emerges in cases of prolapse of the rectum. I have, however, had no opportunity of verifying this fact.

