A PHYSIOLOGICAL EXPLANATION OF PAIN DUE TO FUNCTIONAL DISTURBANCE OF THE MUSCLES OF THE COLON.

BY

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It has long been known that the colon is liable to a functional disturbance of its muscular coat which consists in such a hardening of its walls as to render the outline of the bowel sufficiently distinct to suggest its forcible distension with gas. This theory, however, as to the cause of the hardening is not admissible because palpation of the colon shows that the character of the hardening and its distribution could not be explained by distension with gas, and the phenomenon must be due to some peculiar activity of the muscular coat of the bowel. This hardening is associated with pain and usually with tenderness of the hardened portions of the colon. This abnormal rigidity of the colon constitutes one of the common physical signs of the complaint known as "mucous colitis." It also occurs in the caecum in cases of appendicitis, and the tumour felt in this condition is sometimes mainly due to this cause. It may, however, occasionally occur apart from all other symptoms of disturbance of the colon, not even constipation being present.

The clinical aspects of this peculiar state of the colon wall was discussed in the International Medical Congress which was held in Paris in the year 1890. It first came under my notice in 1892, when I had a patient in whom the whole of the ascending colon from the iliac fossa to the hepatic flexure could be felt as a tube with rigid walls nearly the diameter of a woman's wrist. The case was supposed to be one of appendicitis, and the patient had had many similar attacks prior to my seeing him. The colon retained this remarkable rigidity for some days; it passed off gradually from above downwards, and when the muscular spasm had apparently ceased the hardening could, nevertheless, be sometimes felt to return for half a minute or so under the hand during palpation, the bowel rising up and forming a hard tumour the size of a small hen's egg and then softening again. It was quite clear to me that this extraordinary case demonstrated the existence of a form of muscular activity in the bowel wall which was not generally recognized, and the muscular hardening which was palpable in the colon appeared to me to be strong confirmation of the theory advanced by the late Professor Rutherford of Edinburgh that muscular fibres had not only the power of contraction but also of an extension which was a vital act on the part of the muscular tissue.

A study of this and many similar cases which have come under my notice since has been sufficient to convince me that the muscular fibres of the circular coat of the colon have the power of becoming rigid in an extended condition and of thus turning the colon into a tube with rigid walls and a definite lumen whose diameter varies in different cases and sometimes is as much as 1½ inches or more.

I have palpated the colon in the right and left iliac fossae in practically every patient I have examined during the last thirty years, and this careful examination of the muscular tone of this part of the intestine has abundantly confirmed the opinion I formed in 1892 that muscular fibres must have the power of becoming rigid in an extended condition. Until quite recently the accepted teachings of physiology have given no help whatever to the clinician so far as any explanation of this phenomenon is concerned. In the year 1915, however, Professor Sherrington contributed an important paper to *Brain* which gives an entirely satisfactory explanation of the muscular hardening which is clinically observable in the colon.

Postural Activity of Muscular Fibres.

In this paper Professor Sherrington shows that muscular fibres, in addition to the power of contraction, have another form of activity to which he applies the term "postural activity," because it plays so important a part in maintaining the posture of the body. This form of activity might be mistaken for a true tonus, but he shows that if voluntary contraction be eliminated (by removal of the cerebrum of an animal, such as a cat) the muscles are capable of exerting considerable force without any definite contractile activity. For instance, if a limb be supporting a weight, the removal of the weight will not cause any material movement of the limb, as would have been the case if the weight were being

supported by contractile activity. It seems as if a muscular fibre had the power of becoming rigid in any condition of extension or contraction and of retaining this attitude for a long period of time, or, on the other hand, of varying it as necessary under nervous control. In the case of the bladder he draws attention to the fact that an almost empty bladder can be gradually distended with almost no alteration of the intravesical pressure, the muscles, while retaining the same grip upon the contents, gradually lengthening, so as to enlarge the size of the bladder.

He kindly gave me the bearing of his observations upon the question here discussed. He says:

"In their postural or tonic activity the tension of muscles or muscle fibres is largely independent of their length. Therefore a ring-muscle, for example, in the gut, may quite well assume a 'cartilaginous' hardness and yet maintain a ring-shape of any desired lumen—or if requisite might presumably obliterate its lumen: The case of the gut is quite analogous to the bladder or stomach; the musculature of these latter will exert no more pressure upon 200 c.cm. of content than on 50 c.cm. They grasp their content with the same pressure independently of the length of the muscular fibres, just as the hand can grasp an orange with the same light pressure as a walnut."

He also uses the following simile:

"Perhaps I can put the notion briefly by comparing the muscle fibre to a plaster-of-Paris brick, which would set and unset at the desire of a nerve. If a 6 inch brick were desired it flowed into a 6 inch length and there set; if a 3 inch, then it unset from the 6 inch length, became 3 inches shorter and proportionately wider, and set again. If a 9 inch brick, conversely."

In these observations of Professor Sherrington we have a perfectly satisfactory explanation of the hardening of the colon with which we are clinically familiar. We may not yet be quite certain as to the relationship between the postural activities of the colon muscles and their contractile functions, but this point is, I think, immaterial to the present argument. In the normal bowel there must be perfect co-ordination of these two types of muscular activity, otherwise a conflict between them would result. In the cases of which we are now speaking we recognize the occurrence of lack of co-ordination in consequence of an abnormal amount of postural activity interfering with the normal peristaltic contractions.

Possibility of Pain Arising in the Colon.

In such a case as this the stronger of the two types of muscular activity will overpower the weaker—an occurrence which, in the case of voluntary muscles, would be certain to give rise to pain, and the degree of pain would be proportional to the force of the opposing types of muscular activity.

In the case of the colon there is good clinical reason to believe that abnormal muscular activity of this nature is capable of giving rise to a true sensation of pain. When speaking, however, of the sensation of pain being caused by muscular conflict in the colon, we have to remember that it is devoid of nerves of common sensation, and therefore theoretically might be expected to be incapable of originating a sensation of pain. Before going farther into this question some physiological points must be considered in connexion with the relationship of the normal activities of the colon to the central nervous system.

The colon muscles are in touch with the brain through the sympathetic nervous system, and its muscular and secretory functions and blood supply are regulated by afferent and efferent impulses passing along sympathetic nerve fibres. Now muscular activities in the colon as elsewhere call for increased blood supply to the muscles concerned, and we know that increased blood supply to the splanchnic area (such as that which takes place during digestion) is associated with a certain amount of vaso-constriction of the cerebral vessels and of the arterioles of the systemic circulation. We have all experienced the mental and physical inertia which is apt to follow a full meal. We may therefore say that muscular activity in the colon (as in other parts of the alimentary tract) will give rise to certain afferent impulses which have the effect of causing relative vaso-constriction of the cerebral vessels, and which also are inhibitory to the systemic circulation.

When there is excess of postural activity the increased rigidity of the muscular wall of the colon which results from it must call for abnormally powerful contractile efforts for the accomplishment of peristalsis, quite apart from the possibility of a kind of muscular conflict taking place between the two opposed types of activity. This abnormal activity must originate abnormally powerful afferent impulses in the sympathetic nerves of the colon, and in so far as reflex

circulatory phenomena are concerned we must expect as a consequence an abnormal amount of inhibition of the cerebral circulation and also of that in the systemic muscles.

Therefore, if we take a series of patients who all show by increased hardness and by tenderness of the colon (in situations where it is palpable) that there is an abnormal amount of postural activity of its muscles we may reasonably expect them to show symptoms referable to inhibition of the normal vaso-dilatation which accompanies cerebral activity, and also of the normal vaso-dilatation in the muscles which accompanies physical exertion. In such a series of patients we do find many who show such symptoms as these. They will use some such expression as the following: "I do not know what has come over me, I seem to be losing my energy. When I sit down to write a letter or do a bit of brain work, instead of doing it as easily as usual I frequently find that I have to force myself to do it." They will speak of "brain weariness" and "mental inertia," and other symptoms suggestive of inhibition of the normal vaso-dilatation. That this is the true explanation, and that they are not suffering from ordinary neurasthenia, is shown by the fact that when by abnormal effort they have started to work (in other words, have accomplished normal cerebral vaso-dilatation) they work as easily as normal, and do not suffer from the exhaustion after the work is done which is so characteristic of a true neurasthenic state.

We also sometimes find in these patients who show excess of postural activity of the colon muscles that there are symptoms suggestive of inhibition of the vaso-dilatation which normally accompanies muscular exertion, and they will speak of lassitude and a sense of weariness, which, however, is not true exhaustion, because it will speedily pass off after a little brisk exercise. These symptoms are not usually continuous, but are more apt to come on intermittently, and are most liable to occur at times when the colon is functionally active. The early hours of the morning is apparently a time when the colon might be expected to be active in those patients in whom a morning evacuation of the bowels takes place. It is very common to find that such patients, when suffering from this functional colon disturbance, are apt to wake up of a morning (whether earlier or later) with very considerable mental depression, and when the time comes for getting up they are apt to feel distinct lassitude on muscular exertion instead of the normal absence of weariness after a night's rest. This lassitude, however, will pass off as soon as a little active exertion is undertaken, showing that it was merely of a vascular inhibitory nature, and not a true weariness.

The following is a very characteristic case where a sudden attack of mental depression would come on under circumstances which suggested that it had some reflex nervous origin, and was not a spontaneous mental phenomenon.

The subject was a dentist who came under my care for colon disturbance and whose mental troubles lessened as his colon condition improved and who has now for many years been quite free from them. I will quote his own description of the sort of attacks to which he was liable. He said: "I am sometimes enjoying a game of draughts with my wife of an evening after supper when suddenly a black cloud seems to come over me. My wife is unkind to me, my children are wicked, my practice is going to the dogs, and I am in the depths of misery till I can go to bed and sleep it off, as I can do." This same patient was liable to sudden attacks of mental depression with a suicidal tendency, so much so that when at the seaside he would not take a steamer trip unless he had some friend with him who promised never to leave him for an instant. Although happy as a rule, he felt that a sudden and uncontrollable attack of mental misery might overtake him at any minute just as a sudden attack of abdominal pain might do.

Returning to the question of pain in connexion with this functional muscular disturbance of the colon, it will readily be granted that if a muscular conflict does occur in the colon, such as has been described, the afferent impulses which would arise in the muscles concerned would be capable of causing a sensation of pain if the messages reached the sensory tracts of the cord. Now in the cases of which we are speaking pain is of frequent occurrence and of varying severity, and its clinical features are such as to confirm the theory that its causation must be the same as that of the reflex nervous symptoms of which we have spoken. For instance, as a rule the severity of the pain varies according to the amount of abnormal postural hardening (as judged by palpation) which is present in the colon. Also the pain is liable to occur at times of functional activity of the colon, just as the reflex symptoms do. Moreover, not infrequently it can be noticed

that the two sets of symptoms alternate in the same patient. The following is such a case.

A patient came complaining of indigestion and abdominal pain. He said, "I sometimes have pain in my abdomen, and I sometimes have attacks of mental depression, and it is a strange thing that when I am free from pain I have much mental depression, but when I have pain in my abdomen I am free from mental depression, and am happy. I cannot understand it—it ought to be the other way round; I ought to be happy when I am free from pain and depressed when I have got it, but I am not." In this case, when the nervous impulses were transferred from the sympathetic to the sensory tracts of the cord he felt pain; when they travelled to the brain along sympathetic paths he felt mental discomfort in place of pain.

In this connexion it is of interest to note that it is occasionally possible to substitute a sensation of pain for one of mental depression by intentionally inducing pain in a tender portion of the colon. By this means the afferent impulses which formerly were finding their way to some other part of the brain, and were causing mental misery, appear to be deflected to the sensory tracts and a sensation of pain takes the place of mental discomfort. I have on one occasion myself been able to experience this transference, and I sometimes find patients who can succeed in doing so after the possibility of the success of such an attempt has been pointed out to them.

The clinical study of these cases seems therefore clearly to demonstrate that pain can be caused by the transference to the sensory tracts of the cord of afferent impulses which arose in the sympathetic system and which if retained in that system would have caused disturbance of the brain of a reflex character and would not have caused physical pain. It seems probable that when the muscular activity which originates the nervous impulse is decidedly more powerful than those due to normal digestive activity there is considerable probability of this transference taking place, and where, as in cases approaching the severity of ordinary colic, the afferent impulse is an extremely powerful one the transference of the nervous impulse from the sympathetic system to the sensory tracts of the cord almost invariably takes place and a sensation of pain is the result. With regard to the localization of the pain it is not as a rule felt over the spot where it probably arose, but is usually "referred" or "segmental" in character.

Mental Misery of Colon Origin.

The clinical study of a series of cases where mental depression and neurasthenic symptoms result from functional disturbance of the colon muscles shows that there are some cases which cannot be explained by the theory of inhibited cerebral vaso-dilatation which has already been discussed. Where the circulation alone is concerned we have pointed out that the defect can be removed by a more vigorous mental effort, just as is the case with physical lassitude which can be overcome by a more vigorous muscular effort. It is not at all unusual, however, to find cases of functional colon disturbance where the mental depression is so severe as to be wholly beyond the patient's voluntary control, and constitutes an acute mental misery which is comparable in the mental sphere to a severe physical pain in the sphere of sensation. The occurrence of such cases compels recognition of the fact that nervous impulses arising in the colon and passing to the brain along sympathetic nerve paths have the power of directly disturbing that portion (or those functions) of the brain upon which the sense of wellbeing is dependent, and of giving rise to an acute mental misery which truly represents the physical pain which they would have felt if the afferent impulse causing it had been transferred from the sympathetic to the sensory tracts of the cord. It is my custom to tell such patients that they are feeling stomach-ache in their minds instead of in their bodies.

The fact that these cases are really due to the functional disturbance in the colon is demonstrable clinically by the fact that they yield to treatment which lessens the amount of postural activity in the colon. Patients have told me that the mental cloud of which they complained began to lift within a couple of days of commencing treatment for the colon trouble.

I have said nothing as to some less usual but very striking cases of reflex disturbance due to functional colon disturbance. I have seen two cases where the reflex contraction of the systemic arterioles was sufficient to cause attacks of vasomotor angina pectoris. I have seen cases with symptoms suggestive of Raynaud's disease yield speedily to

colon treatment. I have dealt successfully with cases of reflex weeping, of reflex screaming, and of reflex asthma and other interesting cases, which were clearly due to nervous disturbances arising in the colon. These varied cases have certain features in common. They are associated with colon hardness and tenderness. Symptoms are most likely to come on during periods of functional activity of the colon or when muscular activity in the colon is liable to be started by mechanical vibration. Moreover they are cured, and often speedily, by treatment which lessens the abnormal muscular activity of the colon.

In confirmation of what has been said as to the three chief ways in which the abnormal muscular activity of the colon affects the nervous system, it would be easy for me (as soon as time is available for analysing the material at my disposal) to select, from the hundreds of cases which I have treated during the last thirty years, three parallel series of cases where the condition of the colon, the mode of occurrence of the symptoms, and the results of treatment exactly corresponded, but where in the one series the symptom complained of would be pain, in the second evidences of reflex circulatory disturbance, and in the third series mental depression or mental misery (unaccompanied by any pain) would be the only symptoms complained of, except possibly constipation.

I hope that the further study of this subject will show that these theories regarding pain which I have brought forward have a solid foundation in fact, and that a more general recognition of the part which is played by functional muscular disturbance of the colon in cases which are apparently pure neurasthenia or causeless mental depression may greatly lessen the amount of suffering now being borne by these unfortunate individuals.

TWO HUNDRED AND TWENTY-FIVE CASES OF PNEUMONIA: AN ANALYSIS.

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SINCE October, 1917, I have attended 225 cases of pneumonia. I have excluded four patients, aged respectively 72, 70, 66, and 66, in whom pulmonary congestion was a contributory but not the main cause of death. I have tabulated the others etiologically as follows:

	No. of Cases.	Male.	Female.	Deaths.	Male.	Female.	Mortality per cent.
Lobar pneumonia	34	26	8	3	3	0	8.8
Bronchopneumonia:							
Primary and secondary to bronchitis	68	43	25	10	9	1	14.7
Secondary to measles and German measles	30	19	11	6	3	3	20.0
Secondary to pertussis	15	7	8	5	3	2	33.3
Secondary to pertussis <i>plus</i> measles	4	2	2	1	0	1	25.0
Secondary to acute gastro-enteritis..	1	0	1	1	0	1	100.0
Secondary to malaria	1	1	—	—	—	—	—
Influenzal (1,401 cases of influenza)...	72	38	34	6	2	4	8.3
Totals	225	136	89	32	20	12	14.2

The mortality for the series is 14.2 per cent. The youngest case was aged 3 weeks, the oldest 83 years; both recovered. Diphtheria and scarlatina do not figure in the list, and out of several hundred cases of the two diseases (endemic here) I have not seen one in which pneumonia occurred. Doubtless the mild nature of the cases as compared with former days accounts for this. I have included in the list only undoubted cases of pneumonia. Cases marked in my visiting books "pneumonia, capillary bronchitis, etc." have been omitted, as have also many cases of prolonged influenzal pyrexia quite possibly pneumonic in nature, so that I have under- rather than over-estimated the total number of cases.

I make no claim to absolute scientific accuracy in the table, but as I have made a practice of taking notes of all cases of pneumonia I have a vivid recollection of all the cases

and think I am fairly correct. Probably the cases of primary bronchopneumonias are over-estimated and those of influenza under-estimated. A large number of the cases occur in infants and young children, and unless occurring in the influenza seasons, or in houses where adult members are ill with influenza, the differential diagnosis at the lower ages must needs be very difficult.

All the patients were of the industrial class, living for the most part (five were in hospital) in overcrowded, not always overclean, houses, and had as nurse, as a rule, a harassed female already preoccupied with the needs of a large number of children. The mortality, in spite of this, seems to compare favourably with that of hospital statistics. Is it because only the worst cases are sent to hospital, or is it the journey thither?

Recurrences were noted in twelve patients, each having two attacks. I have excluded in this connexion three patients now in a state of chronic bronchopneumonia; I have credited each with one attack, their condition never having resolved. They are liable to attacks of febricula—all, in fact, have withstood influenza, and were I not cognizant of their condition I should have labelled them all influenzal pneumonia, on account of the physical signs.

A study of the cases shows that pneumonia, especially in the fatal cases, is often a disease of ill health. With the exception of the cases under one year, after the infectious diseases (and even in them a certain amount of contributory ill health can often be demonstrated) the possession of a clean bill of health is of paramount importance in the prognosis. I have little fear of pneumonia in a young, undoubtedly healthy adult. This is, of course, well recognized by all physicians, as witness the old German army statistics, mentioned by Osler, in which the death rate among 40,000 picked men was only 3.6 per cent.

Previous Morbidity of Cases.

Of my non-fatal cases phthisis definitely existed in 4. It was diagnosed (before the pneumonia) by a tuberculosis physician in 2 (I was doubtful—both now in good health); 2 were marked "? T.B. element"—both had attended previously at a tuberculosis centre; one was marked "strumous child—liable phlyctenular conjunctivitis"; one "scars neck after T.B. glands"; one "one brother phthisis, other T.B. elbow"; and one occurred in a young boy admitted to hospital for operation for "? chronic appendix or T.B. peritonitis." He developed pneumonia whilst waiting operation, which was postponed until he got stronger, and has not yet been performed. These make 12 tuberculous, or strongly suspected tuberculous, patients; 3 were recent syphilitics, well beyond the secondary stage—that is, the pneumonia was not due to the syphilis. Chronic bronchitis existed in 5, and gouty bronchitis in one. An attack of subacute rheumatism (old undoubted case of rheumatism) was followed by pneumonia in one; he was removed to hospital for treatment of the rheumatism on a cold day, and the pneumonia was due, I thought, to the removal and not to the rheumatism. One man had aortic incompetence—also old rheumatic. One infant was a congenital syphilitic baby and one rickety. Two adults were chronic alcoholics; and one boy, aged 16, a congenital idiot. These make 28 morbid cases, and to these must be added 3 (recurrence took place in 3 of the 28), which make 31 morbid cases out of 193—a percentage of 16.

Fatal Cases.

Two of these were of very tender age—one 6 weeks, the other (a twin) 11 weeks; both followed pertussis. Of the morbid conditions, one, aged 4 months, was a premature (eight months) baby; two, aged 10 and 11 months (former a twin), had "severe anaemia"; one, aged 11 months, was a congenital syphilitic, marasmic baby; one, aged 2½ years, was a paraplegic child who had been so for three months after an attack of myelitis (not poliomyelitis), which I attributed to influenza; one, aged 26, was a dwarf with chronic bronchitis and emphysema; and one, aged 53, was a chronic asthmatic. Phthisis also played a prominent part here; 3 were definitely phthisical: the ages were 32, 25, and 4½ years. The two latter were mother and daughter, and all three were victims of the November, 1918, influenza epidemic. I might mention here that 5 out of the 6 influenza deaths were in "morbid" patients. In 3 cases phthisis was strongly suspected before the pneumonia: No. 1, aged 34 (since his death his wife and a daughter, the latter one of this series, are dead of phthisis); No. 2, aged 3½ years, lasted for three months after pneumonia following measles *plus* pertussis, and