Remarks ON THE MEANING AND MECHANISM OF VISCERAL PAIN

AS SHOWN BY THE STUDY OF VISCERAL AND OTHER
SYMPATHETIC (AUTONOMIC) REFLEXES.

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I.—SYMPATHETIC REFLEXES.

In the following study an attempt is made to demonstrate the principles on which pain and other symptoms of visceral disease are produced.

A great many phenomena of which we are cognisant have never been carefully analysed, but have been heedlessly attributed to some seemingly self-apparent cause. On critical examination it will be found that the phenomena are of a nature totally different from that usually accepted, and involve a complex mechanism hitherto unsuspected. Many of the observations quoted here may seem trivial and unimportant, but as straws show the direction in which the wind blows, so an appreciation of the true nature of these simple reflexes reveals the meaning of many important clinical symptoms at present overlooked or misunderstood.

Ever since 1891, when I found out that definite areas of the skin may become reflexly hyperaesthetic in visceral disease, I have not only used this symptom as an aid to diagnosis, but I have pursued the inquiry into other reflex phenomena. The conclusions arrived at in these papers are not hasty generalizations from a few observations, but are the results of many years' patient study, observation and practical application, and are therefore the natural deductions from a great mass of well authenticated facts. If I seem to pay scant attention to the results of other workers in this field of observation, it is not for lack of appreciation of such writers as Hilton, Ross, and Head, but simply because space prevents me dealing with any matter other than that essential to my argument. A certain parallelism may be found in some of these observations to some of those of Head, but a conclusion is reached different from that he has lately enunciated. From his remarkable researches he has been able to demonstrate that the skin is endowed with two forms of sensibility—an "epicritic" and a "protopathic." By means of the former, we perceive the finer forms of stimulation as touch, accurate localization, refined difference in temperature, and so forth. The "protopathic" sensibility represents a more primitive and blunted form, localization is not so accurate, touch is not perceived, but pain is felt on pricking with a pin, the points of the compass are only recognized as distinct when separated by at least 2 cm., the extremes of temperature only are appreciated. His demonstration of these forms of cutaneous sensibility is convincing; but when he goes on to attribute "protopathic" sensibility to the viscera, his conclusions are not borne out by the evidence he produces. When one contrasts the wealth of material he gives to demonstrate the protopathic sensibility in the skin with the paucity—nay, with the absence—of facts in favour of his assertion that the viscera are endowed with protopathic sensibility, one realizes that some other principle must govern the nerve supply of the viscera. One is driven to this conclusion with the greater force when it is considered that the viscera are totally insensitive to all the forms of stimulation which Head employs to produce the sensation he terms "protopathic." So far as his writings show, Head has not taken into account a great many phenomena that throw a flood of light upon this subject, and which, I think, lead logically to a proper appreciation of the sensations produced by the viscera.

Classification of the Symptoms of Visceral Disease.

The symptoms of visceral disease may be looked upon as threefold: (1) Symptoms due to modification of function; (2) local symptoms due to changes in the organ itself; (3) symptoms which arise through implication of the nervous system. It is with the consideration of the reflex nervous symptoms included in this last division that the following study is concerned.

The Purpose of Visceral Reflexes.

If it be kept in mind that these reflex symptoms are essentially protective in function, a clearer conception of the nature and meaning of the symptoms will be obtained and will guide to a better understanding of the subject. If a pain be felt in the neighbourhood of an organ with which the pain can be associated it is assumed by many that the pain is felt in the organ. A careful consideration of all the facts will lead to a very different conclusion. Thus a patient with a gastric ulcer may feel the pain in the epigastrium. Where the pain is felt, the rectus muscle is found slightly rigid even on gentle palpation. If pressure be exercised the hardness of the muscle at once increases, and at the same time the patient is conscious of great pain arising from the increased pressure on the muscle. In such a case, though the pain and muscular tenderness and contraction be in the epigastrium the ulcer may be situated at the cardiac end of the stomach. It is evident that these sensory muscular phenomena have a protective purpose. Were the stomach itself sensitive, violence would reach and injure the organ before pain was experienced, but by the interposition of sensitive structures which are coupled to a powerful muscular reflex external to the stomach, the diseased organ is effectually guarded against external violence.

The Autonomic Nervous System.

Under this term Langley has included the visceral nerve supply, the nerves supplying the blood vessels, the pilo-motor nerves, etc. The efferent fibres of this system leave the central nervous system at four regions, which are separated from one another by regions from which no autonomic fibres pass. The nerves of the first of these regions arise in the brain ("midbrain autonomic system") and supply the sphincter of the iris and ciliary muscle. The nerves from the second region ("bulbar autonomic system") pass out in the seventh, glosso-pharyngeal, and vagus nerves. The nerves from the third region include the sympathetic, and leave the spinal cord in the white rami from the first thoracic to the second or third lumbar nerves. The nerves from the fourth region ("sacral autonomic system") leave the spinal cord in the second, third, and fourth sacral nerves.

The Sensory Nerve Supply of the Chest and Arm.

Before entering into the facts bearing upon these reflexes I would direct attention to a field for investigation that offers unique facilities for determining many doubtful points. As I have said, the proximity of a diseased organ to the site of pain may mislead the observer as to the exact part in which the pain is felt, but if the pain is felt in a part remote from the organ but where a nervous connexion of the organ with the area in which the pain is felt can be demonstrated, a clearer conception of the mechanism by which the symptoms arise will be obtained. This end is admirably provided in the distribution of the sensory nerves supplying the chest and arm.

Certain portions of the eighth cervical and first, second, and third dorsal spinal nerves are distributed in a peculiar manner. Thus, the eighth cervical is distributed to the ulnar border of the hand, while the ulnar border of the forearm and internal surface of the upper arm is supplied by the first, second, and third dorsal nerves, portions of the second and third dorsal nerves also being distributed to the skin of the chest.

In Fig. 1 the shaded area represents the distribution of the eruption in a case of herpes zoster which affected the eighth cervical, first and second dorsal nerves. It was because of the resemblance of the area of distribution of the eruption in herpes zoster to the anaesthetic areas observed by Ross and Thorburn in affections of the spinal cord, and to the fields mapped out by Sherrington that led me many years ago to suggest that herpes zoster was an affection of the ganglia of the posterior spinal roots—a suggestion I found afterwards had already been put forward on other grounds by von Barendsprung. The subsequent researches of Head and Campbell have fully confirmed this view. The reason I employ this field for observation is because many patients suffering from visceral affections—as heart disease—refer their sensations to this area, and we have in such cases a test not only of their reliability—for one can scarcely suppose they would invent such a characteristic distribution of

their sensations—but also of the mechanism by which these sensations arise. I shall show that this peculiar area can be affected in a variety of ways—(1) by the appearance of the goose-skin eruption—that is, the pilo-motor reflex; (2) by the sensation produced by stimulation of the sympathetic nerves—the autonomic sensation; (3) by the pain and cutaneous hyperalgesia that are present in affections of the heart. Here I shall deal with (1) and (2), reserving the symptoms in heart affections for a somewhat detailed study.

The Pilo-motor Reflex.

If certain stimuli be applied to the skin, as by rubbing the skin with a piece of flannel, over the part stimulated the hair follicles may protrude (goose-skin), due to contraction of the pilar muscles which are attached to the hair follicles. Under favourable circumstances, from this localized eruption a widespread eruption may extend rapidly in very definite directions. Thus, if the skin under the nipple be stimulated, the eruption may spread up the chest as high as the second rib and then down the arm in the area shaded in Fig. 1. The eruption may involve the whole chest, or it may affect only the anterior surface of the chest, extending to the axilla and down the arm. These and other peculiarities I described in an article published in *Brain* in 1893.

Fig. 1.—The shaded area corresponds to the distribution of the eruption in a case of herpes zoster affecting the eighth cervical, first and second dorsal spinal ganglia. The shaded area also corresponds to the region in which a goose-skin eruption and the autonomic sensation can be produced, as well as the region where pain and cutaneous hyperalgesia are found in affections of the heart.

The Autonomic Sensation.

When the pilo-motor reflex appears over a considerable area it is often accompanied by a peculiar shivering sensation, which is generally supposed to be due to the contraction of the pilar muscles, and is invariably referred to as the "goose-skin" sensation. In the paper just referred to I remarked, "This sensation is peculiar to itself, and to what it is entirely due I am not certain. The mere traction and shrinking of the skin does not appear to be its sole cause, because I find it present where there is no evident goose skin produced, and it even extends to areas where the hair follicles do not exist. Again, the goose skin may be present when no such sensation exists." Since I wrote this, thirteen years ago, I have made many other observations, and can verify the fact that the sensation is altogether distinct from the pilo-motor reflex, and hence I suggest a distinctive name (*autonomic*) for it, derived from the term applied by Langley to the portion of the nervous system of which the sympathetic is a part. Its probable cause I will discuss in dealing with the sense of cold. Here I may remark that in stimulating the chest, as already described, the sensation may be produced, and it follows the same path as the pilo-motor reflex, though there may be no sign of protruding hair follicles. The sensation may often be felt to extend beyond the area of distribution of the hair follicles to the ulnar border of the hand and little finger, over an area corresponding to that mapped out in Fig. 1. This sensation is also felt spreading like a wave over the body, sometimes so intense as to give rise to the sensation of cold, as when patients describe the sensation as that of iced water trickling down the back.

Implication of the Spinal Cord in the Production of these Reflexes.

The mechanism by which these reflexes are produced offers an interesting field for speculation and observation.

That it cannot be by local stimulus affecting only the structures in the skin is evident from the fact that the symptoms do not spread in an indefinite manner over contiguous areas of skin (for instance, they never go up the chest above the first rib), but spread in a manner as well defined as the eruption in Fig. 1. That it is due to stimulation of certain portions of the spinal cord is probable from the following reasons: (1) the cells of the neurone producing the pilar contraction are situated in the spinal cord; (2) the stimulus producing these symptoms produces also other phenomena (as dilatation of the pupil) which originate in the spinal cord; (3) it is only in the spinal cord that such a definite group of phenomena can be affected by one and the same stimulus; (4) the area affected by the pilar contraction and autonomic sensation correspond exactly with the areas in which pain is felt, and sensory abnormalities are present in visceral disease and lesions of the cord.

By what system of nerves the stimulus is conveyed to the cord is not clear. It is not by the ordinary paths, as neither pain nor touch, nor moderate degrees of cold or heat are capable of producing the reaction.

The Autonomic Pupil Reflex.

When I had reasoned that this pilo-motor reflex and autonomic sensation must be due to stimulation of the centres in the spinal cord, I reflected that if this were so the stimulus passing up the cord affecting the cells from which the sympathetic fibres arise would be bound to affect the cells that supply the nerves of the dilator pupillae, which Langley describes as leaving the spinal cord by some of the upper dorsal nerves. The first individual I tested for this purpose showed a well-marked transient dilatation of the pupil, and since then I have been able to demonstrate this reaction in a considerable number of people. The method I employ to produce this reaction is to rub gently but firmly with a piece of flannel under the nipple. If a goose-skin appears spreading up the chest, or if the autonomic sensation is felt spreading into the arm, then a transient dilatation of the pupil occurs. In my own person I can readily demonstrate this pupil reaction. If I am cold, then neither the pilar nor pupil reflex occurs, nor is the autonomic sensation felt. If the reaction does occur, a few minutes must elapse before it can be reproduced. When the dilatation of the pupil takes place on myself the autonomic sensation is always felt. So marked is this relationship, that though the dilatation of the pupil gives rise to no sensation, I can tell if the pupil has reacted or not by the presence or absence of the autonomic sensation. Another peculiar and confirmatory observation I found in one patient. He suffered from angina pectoris, and I was testing him for the pupil reflex, which I could never get, though occasionally the autonomic sensation was felt in the characteristic area. Nearly every time I tested him he said he felt a chilly sensation passing up his cheek. I repeated the experiment several times on the right side with the same result. These observations were confirmed on several separate occasions, and, as I did not understand this result, I merely made a note of it. Afterwards, I found that Sherrington had described that in stimulating the sympathetic fibres issuing with the third dorsal nerve in the monkey he had produced elevation of the hairs of the cheek.

The Mechanism by which the Sensation of Cold is produced by the Ingestion of Cold Fluids into the Stomach.

In the experiments I have described so far the sympathetic reflexes have been produced by stimulation of the external body wall. The chief nerve supply of many of the viscera is from the sympathetic, and the reflexes obtained from their stimulation are the essential object of this study.

Before dealing with the complicated reflexes produced by diseases of the viscera, a preliminary study of the sensation of cold felt after drinking cold water opens up a new aspect of visceral sensations, and paves the way for a truer conception of the symptoms present in visceral disease.

After I had been observing for some years the result of visceral stimulation, I had come to the conclusion that pain was almost the only definite sensation visceral stimulation was capable of producing; and this pain I had concluded, from reasons to be given later, was not due to

direct stimulation of a viscus, but to stimulation of the pain centres in the spinal cord. The very definite sensation of cold following the ingestion of cold fluids into the stomach forming such a marked exception, and necessitated, therefore, a particular investigation. The sensation of cold after drinking a glass of cold water is not always felt, for reasons that I shall explain later. But, when it is felt, the first point to be noticed is a distinct delay after the cold fluid has reached the stomach before the sensation of cold is felt. The second point is that the sensation is not felt in the neighbourhood of the cardiac end of the stomach, but in the anterior wall of the abdomen, as low sometimes as the umbilicus. At first I thought, perhaps, this distant localization of the sensation might be an evidence of dilated stomach, but I soon found that the remote sensation was perceptible in perfectly healthy people. The sensation when perceived has a tendency to radiate in a downward direction only, not spreading laterally. The sensation is not a vague, indefinite one, but can be referred with great precision to the area in which it is felt. When I reflected on the nature of the sensation on myself I was conscious that it resembled occasionally the sensation I have described as "autonomic." It occurred to me, then, to see if there were any signs of pilomotor reaction. In this, however, I was not at first successful, though finally I have seen a few cases where a faint reaction could be detected, as the following observation testifies:

I was examining, with Dr. Grant, of Colne, a man with pleuritic effusion. When the patient was stripping I observed he had an extremely lively pilomotor reaction, the goose-skin appearing on the slightest stimulation. Thinking he would be a good subject to test, I told Dr. Grant to watch for the appearance of goose-skin on the front of the abdomen while the patient drank a glass of cold water. I also watched, and after he drank the water I saw the hair follicles protrude over an area corresponding with that dotted in Fig. 2. Dr. Grant at the same time pointed to this area and remarked, "There it is." I then asked the patient if he felt the sensation of cold, and he said "Yes." I said: "Put your finger where you felt the cold," and he immediately passed his finger over the region in which we had seen the goose-skin.

I find this visible reaction is very rare, and can only be shown in patients with a very lively pilomotor reflex. In Fig. 2 the outline of the stomach of a healthy person has been drawn for me by Professor Cunningham, whose investigation into this matter has shown that the usual stereotyped notion of the shape and position of the normal stomach is very inaccurate. It will be noticed from the position of the area in which cold was felt that the sensation cannot have arisen directly from contact of the cold water with the gastric mucous membrane, so that an explanation of its occurrence has to be sought. For the reasons already given I had come to the conclusion that the sensation I have called autonomic is independent of the goose-skin. On reflecting on the functions of the sympathetic nerves to the skin I recalled the fact that not only did they contain the pilomotor nerves, but they also contained the vaso-constrictor nerves. As the sensation of cold is due to the nerve endings being deprived of blood, the question arose, Did not this sense of cold come from the stimulation of the vaso-constrictor nerves, causing a local cutaneous ischaemia and the resultant sensation of cold? This suggested the following line of investigation, which gave a confirmatory answer. If the individual be cold and chilly at the time, no cold sensation is felt after drinking cold water, because already the vaso-constrictors had been stimulated. If in a person who feels the cold sensation after drinking cold water—it is best felt after a warm meal—the skin over the area where the cold sensation is felt be cooled, as by applying the cold tumbler to his skin, then the cold sensation is not felt after drinking cold water, for the reason that the blood vessels are already contracted when the cold water reaches the stomach. If, on the other hand, the dilatation of the blood vessels be favoured, as by applying a

Fig. 2 shows the outline of a normal stomach and the dotted area shows the region in which cold was felt and the protrusion of hair follicles was seen after drinking cold water.

hot cloth over the area where the cold sensation is felt, the cold sensation is no longer felt after drinking a glass of cold water, for the reason that the local heat has caused a dilatation of the blood vessels which the central stimulation was powerless to overcome.

From these facts I deduced the conclusion that the sensation of cold is of the same nature as the autonomic sensation, and that both are due to the stimulation of vaso-constrictor nerve fibres in the spinal cord. We can now understand the remarkable delay that takes place after the cold water reaches the stomach before the cold sensation is appreciated. A stimulus passes to the sympathetic centres in the spinal cord. Then stimulation of the cells of origin of the vaso-constrictor results in the contraction of the blood vessels over a definite skin area. This affects the sensory nerves in the skin that respond to cold, and this sensation is then conveyed to the brain.

This reasoning also supplies the explanation of that paradoxical sensation to cold on the application of heat which has puzzled physiologists. Many people on entering a hot bath experience at first a sensation of cold. As this is invariably accompanied with marked goose-skin eruption, it is evident that the first effect of the heat is to stimulate the sympathetic centres in the cord, producing at first a strong pilomotor and vaso-constrictor action, which in a short time passes off.

II.—VISCERO-MOTOR AND VISCERO-SENSORY REFLEXES.

While physiologists have demonstrated many of the functions of the efferent fibres of the autonomic nerves by experimental stimulation, very little reliable work has been done in regard to the functions of the different fibres that pass from the viscera to the central nervous system. It is more than doubtful if all the deductions drawn by physiologists in this particular are justified. One cannot, for instance, be sure of the conclusion drawn from electrical stimulation whether pain is felt by the animal, and certainly one cannot tell where the pain is felt, so that the statement made by Langley "that the thoracic and abdominal sympathetic chain, the splanchnic, and inferior splanchnic nerves are all markedly sensory" may need very considerable modification.

For the elucidation of the functions of the nerves that pass from the viscera to the central nervous system, that is, the afferent sympathetic or autonomic nerves, careful clinical observations seem to offer the best means. While we may not be able to see the actual process of stimulation nevertheless the results of the stimulation may be readily recognized. By noting on the one hand the series of symptoms that may be present in a case of visceral disease, and by the careful observation of the state of the viscus on operation or on *post-mortem* examination, the nervous mechanism by which the symptoms are produced can be inferred with fair certainty. As the series of symptoms resemble, and are, in fact, due to a focal irritation of the cord, the precise seat in the cord can be inferred, and from these data the position and functions of the afferent sympathetic nerves elucidated.

The Reflex Phenomena in Visceral Disease result from a Focal Irritation of the Spinal Cord.

In the study of focal lesions of the central nervous system it is customary to bring together all the peripheral phenomena. When these are all carefully noted it may be found that some of these are situated in widely-separated parts of the body. When, however, the nervous connexions are studied it is found that in some limited area the nerves of these widely-separated parts are closely related; it is inferred that the lesion is situated in this limited area of the central nervous system. If the same method be applied to the investigation of the reflex symptoms present in visceral disease, the symptoms will be found to resemble focal lesions of the spinal cord. This aspect of the question was forced upon me by the following experience early in my investigations on this subject.

Shortly after I had discovered that visceral disease may produce definite areas of cutaneous hyperaesthesia, I saw in consultation a man with a marked hyperaesthetic band extending round the lower part of the chest to the epigastrium on the left side, with marked tenderness on pressure over the sixth, seventh, and eighth dorsal vertebrae. I could form no definite opinion as to the cause save that the symptoms pointed to some affection of the stomach. The patient con-

sulted an eminent neurologist, who had no hesitation in recognizing a local spinal affection due to vertebral disease, and had the patient encased in a plaster-of-paris jacket. A few months after, the patient died, and at the *post-mortem* examination the vertebrae were found quite healthy, but there was a cancer near the cardiac end of the stomach.

While in the present state of our knowledge it is not possible to recognize the origin of all the reflex phenomena present in every case of visceral disease, yet the method of looking upon these phenomena as focal lesions of the central nervous system sheds a light upon a great number of symptoms hitherto unobserved or misunderstood. Even when recognized and appreciated, it is not always possible to refer the symptoms to the special organ causing them, but the following observations will show that by the careful noting of the symptoms, and by the equally careful examination of the viscera when a surgical operation or a *post-mortem* examination affords the opportunity, a wide field for further clinical research is opened up.

OBSERVATION 1.—*Appendicitis.*

A female, aged 36. For a couple of years the patient had suffered from violent attacks of abdominal pain. I never saw her during an attack, but the following was the condition found after a severe attack. The abdominal wall over the right iliac fossa was hard and rigid, due to the contraction of the muscles. When the skin was lightly pinched there was no increased tenderness, but pressure on the rigid muscle was very painful. When the erector spinae muscles on both sides were lightly grasped in the lumbar region those of the right side were found very painful. The right thigh was slightly bent upon the abdomen, and could be extended only with difficulty, due to a tonic contraction of the psoas muscle. On walking a short distance the patient developed a stoop, due to the increased contraction of this muscle. There were frequent calls to micturition, the quantity passed at each time being small, and containing no abnormal constituents.

This description of the symptoms was confirmed by Mr. Caird, who operated on the patient. The following conditions were found at the operation: When the abdominal cavity was opened nothing abnormal could be detected. The parietal peritoneum was perfectly healthy, and only healthy coils of intestine were exposed to view. On separating these coils the appendix was found red and inflamed and adherent by soft red bands to the caecum, and separated from the bladder by coils of uninfamed intestine. The appendix was removed, and the patient made a good recovery, though it was a couple of months before all the symptoms quite disappeared—the last symptom to go being the slight contraction of the psoas muscle, which became more contracted on walking a short distance.

Grouping the reflex phenomena in this case we recognize: (1) A visceromotor reflex in the muscular contraction of the transversalis abdominis, the oblique and psoas muscles; (2) a viscerosensory reflex in the increased sensitiveness of the sensory nerves supplying the muscles over the right iliac fossa and the erector spinae; and (3) a hyperaesthesia of the bladder resulting in frequent micturition.

It is manifest from the condition found at the operation that these very definite symptoms could not have been caused by the implication of the structures in the inflammation which affected the appendix. If, on the other hand, we look into the origin of the nerves, motor and sensory, that supply these muscles and the sympathetic supplying the bladder, we find that they all arise from a limited area in or near the twelfth dorsal and first or second lumbar spinal segments. It becomes, then, a justifiable inference that the stimulus which produced these symptoms arose in the appendix, and that this stimulus was conveyed from the appendix by its sympathetic nerve supply to the spinal cord, and therefore the appendix is supplied by a sympathetic nerve that leaves the cord at the segments mentioned. Further, as the bladder nerve supply leaves the spinal cord at two regions—namely, with the sympathetic nerves from the upper lumbar regions and with the visceral sacral nerves—it follows that the afferent fibres of the bladder reach the spinal cord at the upper lumbar region.

In the following observation a description is given of the effects produced by a stimulation of the cord as definite as any physiological experiment:

OBSERVATION 2.—*Renal Colic.*

A man, aged 30, had suffered for a year from occasional attacks of renal colic, and one attack had been followed by haematuria. Being a very intelligent man, I told him to note every particular during an attack. The following is a summary of his statement—the original statement being illustrated by

the patient placing his hand over the regions mentioned: The pain suddenly seizes him with great severity in the right lumbar region, then after a few minutes it strikes into the front of the abdomen over the iliac fossa. Then the belly becomes hard and rigid. The pain then strikes down into the internal part of the groin, the testicle is felt to be drawn up, and the pain then shoots into the testicle. The facts here described were corroborated by him in a few subsequent attacks, each attack invariably pursuing the same sequence. My notes made after an attack describe an indefinite area of cutaneous hyperalgesia over the iliac fossa. Hardness and rigidity of the abdominal muscles over the right iliac fossa, with great tenderness in pressing over the muscles, and great tenderness on pressing the testicle and the right erector spinae muscles in the lumbar region. Here the symptoms pointed to a localized stimulation of the spinal cord at the origin of the sensory nerves supplying the skin over the right iliac region, the testicle, and the abdominal and erector spinae muscles, and at the origin of the motor nerves supplying these abdominal muscles and the cremaster muscle. These nerves issue from the spinal cord by the twelfth dorsal and first lumbar roots. The area stimulated in the cord, it will be observed, is not confined to one segment, but passes along a path which affects only a limited series of nerve roots in several segments—a curious feature to which I shall revert in dealing with the radiation of pain.

In regard to the immediate cause of the symptoms, I reasoned that there was a calculus lodged somewhere about the pelvis of the kidney, and that its presence acted like a foreign body, sending a wave of strong peristalsis down the ureter, the gradual passage of the peristalsis sending strong stimuli to a descending region of the spinal cord. The fact that the pain always started at the same place indicated that the stone remained fixed in its position, a view confirmed by the fact that there was never any evidence of the calculus having reached the bladder. The reasons I had for the assumption that the stone remained in the pelvis will be gathered as I develop my argument. An x-ray photograph failed to reveal the stone. Such being my opinion, I sent the patient to Mr. Wright, who, agreeing with my diagnosis, operated in 1903, and found a small calculus about the size of a pin's head adherent to the wall of a calyx, opposite the junction of the middle and lower third of the kidney. This was removed and the patient made a good recovery, and has remained quite free from all symptoms.

The inference from this case is that the afferent sympathetic supply to the pelvis of the kidney and the ureter originates in the spinal cord in the twelfth lumbar and first dorsal segments.

It is well known to physiologists that the efferent sympathetic nerve supply to the viscera is not constant, that the nerves to a certain area may come from a segment higher or lower than the usual supply. The same variability seems to affect the afferent sympathetic nerves, and can be demonstrated clinically, as in the following observation, and is, no doubt, one of the reasons of the inconstancy of clinical phenomena:

OBSERVATION 3.—*Renal Colic.*

Male, born 1864, consulted me in October, 1900, complaining of severe spasms of pain from which he had been suffering for five days. He had had similar attacks twelve years before. He refers the pain with great definiteness to the area shaded

in Fig. 3, this area corresponding to a region of deep cutaneous hyperalgesia—that is, the skin here is very tender if gently raised and lightly pinched, but shows no increased sensitiveness to light scratching with a pin-head. This area of tenderness extended round to the spine. I was in doubt as to the cause of these attacks of pain. The onset and character of the sensation corresponded to an attack of renal colic, but I had never seen a case with the pain and tenderness so high. Under treatment (rest and opium) the attacks subsided. He again consulted me for a similar series of attacks in October, 1903. He had had an occasional

attack in the interval, but they were becoming more frequent. There was still present the characteristic area of deep cutaneous hyperalgesia as in Fig. 3. During one of these attacks the pain suddenly passed into the left lumbar region, and then round to the front of the abdomen to the groin and into the left testicle. At the same time he was conscious of the testicle being forcibly drawn up. When I examined him there was much tenderness on pressing the lumbar muscles and the left testicle. Under rest and opium the pain subsided, and two days later in voiding urine he passed a small calculus. There was complete freedom from pain until October, 1905, when he again had a few attacks of

pain referred to the area shaded in Fig. 3. This pain passed downwards to the groin and testicle, and again he was conscious of the testicle being firmly drawn up. He rested in bed four hours, and upon micturating he passed another small calculus. He has remained free from any further attack.

I could quote numerous cases illustrating other equally instructive phenomena, but I limit myself to these three cases as they show so strikingly the results of spinal stimulation in the visceromotor reflex (not only in the rigidity of the abdominal muscles but in the contraction of the psoas muscle and in the retraction of the testicle by the contraction of the cremaster muscle) and in the sensory disturbances shown by the tender testicle and in the hyperalgesic area shaded in Fig 3, parts remote from the organ originating the stimulus.

Irritable Sensory Foci in the Cord Due to Visceral Disease.

The stimulus that has had so marked an effect upon the spinal cord not only produced these characteristic reflexes but left the area stimulated in a condition of excessive irritability. Thus the hyperalgesia of skin and muscle that was so marked a feature in my examinations is due to the fact that a stimulus, which would normally produce no painful sensation in reaching the spinal cord, excites an abnormally sensitive centre, with the result that the sensation of pain is felt. That this is the explanation is shown by the further fact that a stimulus reaching this excitable area in the cord from other sources also produces pain which is referred to the hyperalgesic tissues (skin or muscle):

Thus in a case of gall-stone colic, where there was jaundice, there was also extreme hyperalgesia of the skin of the upper part of the abdomen, especially marked in the epigastrium. This persisted for some days after the stone had been passed and found in the stool. During the time the hyperalgesia persisted, food taken into the stomach produced severe pain referred to the epigastrium. With the disappearance of the hyperalgesia of the skin the pain on taking food ceased.

Here there seems little doubt that the stimulation set up by the ingestion of food, which passes to the spinal cord normally unperceived, reached that portion of the cord which had been abnormally excited by the gall-stone colic, and had affected the hypersensitive centres of the cutaneous nerves for pain which supply the epigastric region.

I have lately been observing another remarkable manner in which these abnormally sensitive foci in the cord can be stimulated. My attention was directed to this aspect of the question by the following experience:

A lady who suffered from endometritis experienced pain in her back across the top of the sacrum, with tenderness and stiffness of the muscles of the back in the lumbar region. She told me that if she were startled, as by the banging of a door, a pain would suddenly shoot into this tender region of the back.

I have made inquiries of a number of other patients and have found abundant corroboration of this experience—so much so that many people in whom there is a hyperalgesic area (cutaneous, or deeper) experience a sudden pain in that region when startled. Thus, one patient who suffers from a gastric ulcer was frightened, on her way to consult me, by being accosted by a drunken man, and she felt a severe pain in the epigastrium at the same time. In her there was a great tenderness of the skin and muscles of the epigastrium on light pressure. Another patient with a dilated heart and great tenderness of the left side of the chest described how some one unexpectedly laid a hand upon her shoulder, so that she started, and at the same time a severe pain struck into her left breast. (In the section dealing with angina pectoris instances will be quoted where attacks of angina pectoris were induced by peripheral stimuli affecting irritable portions of the cord.)

The explanation I give for the occurrence of these pains is that, when startled, a stimulus passes down certain tracts in the spinal cord, affecting normally the centres of the muscular nerve supply, as evidenced by the sudden contraction of nearly all the muscles of the body. The stimulus is not of sufficient strength to affect the sensory nerves in a healthy cord, but when there are abnormally irritable foci in passing through these, the stimulus affects the excitable sensory nerve centres, and the pain so arising is referred to the peripheral distribution of the nerves stimulated. It may be that the pain is produced

by a stronger and painful contraction of the excitable and hyperalgesic muscles.

Irritable Motor Foci in the Cord due to Visceral Disease.

A somewhat similar result follows on extra stimulation of motor nerves whose centres are excited by visceral stimulation. When there is an exalted visceromotor reflex, the muscles are in a permanently more contracted condition than that which the normal tonicity maintains, as evidenced in the flat muscles of the abdomen by the greater or less hardness with which we are all familiar. This is due to their being exercised in their functions as part of the protective mechanism. If now they be exercised in their other functions by assisting in the movements of the body, the combined result of these two stimuli is to produce a continuous shortening of the muscle. This was remarked in Observation 1, when the psoas muscle caused the patient to stoop when she walked a short distance. In another patient who suffered from renal colic, after an attack had passed there always persisted for a few days a slight tenderness and rigidity of the lower part of the right rectus muscle. When going about after a few hours the whole of the muscle became so contracted that he could not straighten himself but walked with his body slightly bent. After a short rest the contracted muscle would slightly relax. A similar condition is found in those cases of "lumbago" where the pain and stiffness of the muscles arise from some pelvic trouble—endometritis, haemorrhoids, etc.

Exaggerated Reflexes due to Irritable Foci in the Cord.

In all these hyperalgesic areas due to a focal irritation of the spinal cord the ordinary cutaneous reflex is more easily excited, and the muscular response more vigorous and often more prolonged than normal. It is now many years since Byrom Bramwell noticed the increased activity of the epigastric reflex in gastric ulcer. I need not labour this point, as the fact is so readily demonstrated, and every one is familiar with the hardening of the abdominal wall when any tender part is palpated with even a very gentle force. This springing up of the hardened muscle serves as an efficient protection of the underlying viscera, and the purpose of the cutaneous and muscular hyperalgesia is manifestly to render the reflex muscular contraction rapid and powerful. In severe cases this muscular contraction does not at once relax, but the muscle may remain contracted for long periods and even under deep anaesthesia. I have already pointed out elsewhere that small portions of the flat muscles of the abdomen may remain contracted, while the rest of the muscle presents no evidence of abnormal contraction. This limited contracted portion may simulate an abdominal tumour, and I have on several occasions seen expert surgeons explore the abdominal cavity in search of a tumour which they thought they had felt, but which, as a matter of fact, was but a contracted portion of a flat muscle of the abdominal wall.

Correspondence of Clinical Observation with Experimental Investigation.

I might shortly point out here how this view of the symptoms finds support from the results of physiological research. In a very suggestive paper by Sherrington, the principles of spinal reflexes are dealt with, and he demonstrates how the motor neurone—the final common path—is played upon by various categories of the reflex spinal arc.

He says, "Reflex arcs show, therefore, the general feature that the initial neurone is a private path exclusive for a single receptive point, and that finally the arcs embouch into a path leading to an effector organ, and that this final path is common to all receptive points wheresoever they may lie in the body, so long as they have any connexion at all with the effector organ in question. Before finally converging upon the motor neurone arcs usually converge to some degree by their private paths embouching upon internuncial paths common in various degree to groups of private paths. The terminal path may, to distinguish it from internuncial common paths, be called the final common path. The motor nerve to a muscle is a collection of such final common paths."

In the illustrations I have given I have shown how the muscle may be stimulated to contract (1) voluntarily, as in the movements of the body; (2) reflexly, in consequence of

stimulation of the skin, or of the sensory nerves in the muscle itself; (3) reflexly from the viscera (viscero-motor reflex); and (4) in consequence of an involuntary stimulus passing from the brain, as when startled.

(To be continued.)

Remarks ON CHOREA CONSIDERED AS CEREBRAL RHEUMATISM.

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A RELATION between chorea and rheumatism has long been recognized. In recent years the closeness of that relation has more and more been impressed on the minds of some careful clinical observers, so that it is now maintained by them that chorea is itself a variety of rheumatism which more particularly involves the brain.

I urged this opinion in a communication read before the International Medical Congress in Rome in 1894. Since that time I have continued to study the question, and increased clinical experience has tended to confirm my belief. The most recent researches on the pathology of rheumatism have added fresh and important evidence in favour of the rheumatic nature of chorea, but in spite of this many remain unconvinced of the constancy of the connexion. They accept the intimate relation and association of the two conditions, but are still unable to believe that the rheumatic element is the main factor in the pathology of all cases of chorea.

While they regard the question as unsettled, these authorities are as yet unable to point to any other causative factor as explaining the nature of such cases as they believe to be unconnected with rheumatism. They are ready to admit, since the toxic nature of the rheumatic factor has been clearly demonstrated, that the choreic state is possibly dependent on other varieties of toxin not yet detected. They thus deny, in the meantime, what we may term the unity of chorea.

The latest researches have disclosed many facts respecting rheumatism which had been unsuspected, showing that the effects of its toxicity are much more widely spread over the body than on articular or cardiac structures, and that thus the throat, the skin, and the brain may equally be sites for its manifestations. The symptoms of rheumatism in its widest sense are therefore found to vary according to the particular sites on which the toxic elements alight, and the special proneness of such parts to be involved.

The association of rheumatism with chorea is now acknowledged to be closer than was the case some years ago. The fact that several phases of rheumatic infection have been recognized in recent times has enlarged the outlook, so that we now speak of rheumatism of the skin, throat, or brain.

It was at one time supposed to be possible to distinguish choreic endocarditis from rheumatic endocarditis, but no pathologist will now venture to discriminate between them. The researches of Poynton, Paine, Wasserman, Triboulet, Singer, and others have clearly proved that rheumatism is an infective malady, and in proof of this have brought to light the particular micrococci which generate the *materia peccans*. The two former observers have traced these microbes into many textures of the body, including the cerebral membranes and the cerebro-spinal fluid. Experiments on certain animals have added confirmation to the results obtained in human morbid anatomy. Further confirmation from the pathological side is, admittedly, difficult to secure, inasmuch as fatal results in cases of chorea are now infrequent, owing, as we may believe, to the improved treatment of rheumatism in modern times.

There is still some difference of opinion amongst bacteriologists as to the exact species of micrococcus which provides the source of rheumatic infection. This is not a clinical question, however. The latest opinion on the matter leads us to believe that the particular organism, termed *micrococcus* by Walker, *diplococcus* by Poynton and Paine, and *Streptococcus aus chorea* by Wasserman, is the actual infective and causal agent of acute rheumatism. This microbe closely resembles the *Streptococcus pyogenes* in its chief characters, and it has been detected in cases of chorea. The bacteriological difficulty may admit of explanation by the suggestion that there are varieties of species of the streptococcus, some more and some less virulent than others.

It is to be noted that no other variety of microbe, apart from accidental or mixed infection, has been detected in cases of rheumatism or chorea.

The infective nature of chorea is now accepted by the best authorities, even if the rheumatic theory does not appear to explain all cases. The older idea of the induction of chorea by mere nervous shock or fright, or its occurrence as one of the family of neuroses, has but few supporters to-day, and should be discarded. We nevertheless require, as I believe, to acknowledge a neurotic factor in a true conception of the pathology of chorea. No trustworthy authorities any longer accept the embolic theory as explanatory of the disorder. That the young and the female sex afford the greater number of examples of it is probably due to the fact that in these subjects the rheumatic toxin is more apt to spread widely, and to act with greater intensity than in adults, as we know to be the case from clinical and *post-mortem* observation. The adolescent brain is also more unstable than the fully developed one.

Much evidence in favour of the rheumatic nature of chorea has been adduced from a study of the earlier and later life-history of patients and their families in which the disorder has occurred. Thus, it is distinctly more frequently met with in families prone to rheumatism. It may precede by months or years an onset of rheumatic fever, or may supervene during an attack. It may also occur subsequently to such an attack with or without overt rheumatic complications.

The proclivity to rheumatism, although widely-spread, is not universal. It pertains to certain families and individuals diathetically so disposed. The disease occurs markedly on the nervous and unstable members of a family. My own statistics show a family or personal history of rheumatism in 85 per cent. of cases of chorea, and I believe that a larger percentage could be discovered if it was possible to secure accurate histories of past attacks of the disease. The fact that rheumatic fever is so often undetected in children or forgotten by their parents, especially in the case of poor people, adds to the difficulty of tracing the evidence of the disease in many families.

We have to bear in mind that the occurrence of chorea may be the sole manifestation of an attack of rheumatism in the absence of any concomitants, beyond possibly some degree of cardiac dilatation. It is thus a true cerebral rheumatism. This fact has not failed to inspire observers with doubt and incredulity as to the true rheumatic nature of the disorder. It is surely worthy of note that in first attacks of rheumatism and in first attacks of chorea there is not seldom to be observed a distinct degree of cardiac dilatation sometimes independent of pyrexia, pericarditis, or appreciable endocarditis.¹ This condition appears to be due to rheumatic toxæmia, which induces a measure of myocarditis. In some of these cases the more ordinary rheumatic symptoms may supervene.

That there is something specific in the nature of the rheumatic toxin as introduced by the particular infecting microbe is certain. We do not meet with acute rheumatism or chorea, as clinically recognized, in cases of ordinary streptococcal infection or in strictly pyæmic states, and we must therefore differ from the view so strongly held on this point by Singer of Vienna. Those who still disbelieve in the occurrence of a non-rheumatic chorea have yet to demonstrate the specific infecting agent which is causative.

I have elsewhere published the evidence which has convinced me of the view I hold,² and my object now is to urge a further and wider consideration of this question.