Remarks on the MEANING AND MECHANISM OF VISCERAL PAIN.

As shown by the study of visceral and other sympathetic (autonomic) reflexes.

By James Mackenzie, M.D., D.B.
BURNLEY.

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III.—The MECHANISM by which VISCERAL PAIN is PRODUCED.

Insensitiveness of the Viscera to ordinary Stimuli.

When all the facts concerning visceral pain are taken into consideration, it will be found that the usual conception of the manner in which pain is conveyed to the mind fails to explain the phenomena connected with the recognition of pain when it is due to affections of the viscera. To begin with, the viscera are insensitive to those stimuli which produce pain when applied to the external body wall. The visceral tissues can be cut, torn, and burnt, and the individual remains unconscious of any sensation. Nevertheless, we all know that the viscera are capable of giving rise to pain of the most excruciating character, so that the reason why the methods employed to produce pain in the tissues of the external body wall are not productive of visceral pain is manifestly that they are inadequate; and from this fact alone we are forced to conclude that a satisfactory explanation of how visceral pain arises has yet to be found.

Sensitive Tissues of the External Body Wall.

Before dealing with visceral pain it is necessary to comprehend the sensibility of the tissues forming the external body wall. How profoundly ignorant we are of this subject has recently been shown by the investigations of Head and his colleagues. For the purpose of this study I shall briefly refer to a few points the misunderstanding of which has so often led astray the clinical observer.

If we take the abdominal wall we find three great layers endowed with exquisite sensibility to pain. The first of these, the skin, I need not dwell upon, save to point out how its sensibility frequently becomes increased in visceral disease, and how this increased sensibility is united to an exalted muscular reflex. The second of these sensitive layers is formed by the flat muscles of the abdomen and is the most important, and the one most commonly affected in visceral disease, its sensibility being very readily increased. Muscular hyperalgesia is such a striking phenomenon, so frequently present, and plays such an important part in the protective mechanism, that it is to find its absence a measure of the health or disease of the viscera. One can read elaborate treaties devoted to special organs in which this symptom is the most striking and the most instructive feature, but its presence is nevertheless overlooked or misinterpreted. If any one will take an ordinary case of stomach ulcer, appendicitis, gall stone or renal colic, or enlarged liver, and note the tenderness of the abdominal wall and observe how this deep tenderness extends around and forward the site of the organ affected, he will begin to appreciate the nature and significance of this symptom. With a little care one will be able to distinguish these symptoms from cutaneous hyperalgesia and from the pain arising from the deeper tissues. The third sensitive layer is one of which anatomists and physiologists were quite ignorant when I first found it out clinically. It is the layer of loose connective tissue lying immediately outside the peritoneum. I suspected, its presence for a long time as I frequently could get exquisite tenderness in pushing my fingers between the recti muscles; but the pain was not localized and the patient experienced no pain. When Mr. Caird gently tore through the loose connective tissue the patient experienced most exquisite pain. After the peritoneum was exposed it was incised and afterwards stitched and the patient felt no pain. This observation I have verified on several occasions. I consulted several anatomists but found they had no knowledge of any nerve distribution in this region. Subsequently Ramström made a careful histological examination of the abdominal wall of the man and other mammals and showed that it was supplied with nerves and nerve endings, the nerves being derived from those which supply the muscles of the belly wall.

This observation may probably afford a clue to the confused statements that exist in regard to the sensibility of the peritoneum. I can only say that, I have on numerous occasions in the course of operations I have scratched and splintered the serous surface of the peritoneum on conscious subjects, and have never known the slightest sensation elicited. One can understand, that if the inflamed peritoneum failed to affect this remarkable nervous layer. Peritonitis, however, so readily produces muscular hyperalgesia and tonic muscular contractions (viscero-muscular reflex), that the pain and tenderness is demonstrably, in the majority of cases, a symptom.

With the recognition of these sensitive structures—frequently rendered exquisitely sensitive to painful stimuli in visceral disease—the question of how it is possible to judge of the sensibility of the viscera by external examination. When, therefore, we find the surgeon or physician demonstrating the sensibility of the viscera, it will be realised that he is stimulating, in his examination, those extremely sensitive structures of the external abdominal wall, and referring the pain he elicits to an organ that is totally insensitive to any such stimulation.

Artificial Production of Visceral Pain.

It is a curious fact that although the belief is so universally held that the viscera are endowed with "sensory" nerves, and that physiologists refer to afferent sympathetic nerves as "sensory" in function, not a single authentic observation has been recorded in support of these assertions. Of course, a great deal depends on what is considered evidence, many people being perfectly satisfied if they elicit pain by pressing over an organ. Physiologists have interpreted certain movements as an expression of pain after electrically stimulating an afferent sympathetic nerve. But this does not prove that pain was evoked, nor does it prove in what situation the pain was felt—origin—of the location of the pain is the key to the problem. It is because of the absence of the specification of the focus of the pain that Lennander’s otherwise important observation is rendered of little use in respect to this investigation.

That pain can be produced by visceral stimulation is easily demonstrated if one employs an adequate stimulus. It is now many years since I pointed out that certain pains of which we are conscious are associated with hollow muscular organs, and that by producing violent contraction of a hollow viscous pain can be elicited. The easiest way to do this is to give a descending enema of warm water and to retain the enema until painful peristalsis results. That the pain is really due to the contraction of the muscle wall of the bowel is evident from the fact that with the relaxation of the sphincter during the passage of the contents of the bowel are expelled with considerable force, and the pain at the same time subsides. Here it is evident that a considerable portion of the descending colon and rectum will be pierced but the pain is not felt along the position occupied by these structures, but, in the majority of people, it is referred across the middle line immediately above the pubis.

The following observation demonstrates an exactly similar series of facts:

I had occasion to resect a portion of the small intestine in a conscious subject whose abdominal cavity had been laid open. There were numerous peritoneal adhesions, and while I cut and tore these the patient was unconscious of any sensation. I cut and stitched the serous surfaces of parietal and visceral peritoneum: I tore adhesions: I cut and sutured the bowel and mesentery, and no sensation was felt. After preparing the upper part of the bowel it was wrapped in a warm cloth and laid on the side. During the subsequent steps the patient frequently moaned. I asked him if he felt the pain, and he replied that he did not feel the pain, and he indicated with his hand that it was across the middle line at the level of the umbilicus. I at first felt that it might be due to the part that I was manipulating, but the
pain was intermittent. Chancing to look at the prepared upper part of the bowel that lay on the left side of the abdomen, I observed that every few minutes a peristaltic wave passed over it, and when this occurred, the patient moaned in pain. I made certain that the pain was connected with the peristaltic wave, and also made sure the patient had no trouble as to the passage of urine. It was felt, with the result that here before my eyes was the cause of the pain which the patient felt, and yet the patient referred the site of the pain's pressure to an area 10 in. or 12 in. away from the contracting bowel.

The Relationship of the Site of Pain to the Site of the Lesion.

For many years I have kept notes of the position in which a great deal of pain fell in a great variety of diseases, and in course of time I have been able to identify the exact site of the lesion in cases that come to operation, or to post-mortem examination. The conclusion arrived at from the consideration of these cases was that the situation of the pain did not as a rule directly afford any clue to the situation of the lesion, but when the situation of the pain was immediately over the lesion, other evidences showed that the pain was not felt in the organ, but referred to the sensory nerves in the external body wall. I shall quote the proofs for these conclusions presently, but here I will describe the theory which explains the peculiar nature of visceral pain.

The Mechanism by which Pain is produced in Visceral Organs.

When a nerve that terminates in a sense organ is stimulated in any part of its course from the periphery to the brain, a stimulation is given to the brain of a kind similar to that which would have happened if the peripheral end-organ had been stimulated. Thus the stimulation of any part of the optic nerve or auditory nerve gives rise to the sensation of light or of sound. In the same manner, if a sensory nerve be stimulated in any part of its course through the brain, spinal cord, or trunk of the nerve, the resultant sensation is referred to the peripheral distribution of the nerve in the external body wall. In the normal life of man, a stream of energy is continuously passing down the afferent nerves to the spinal cord, and continuously altering upon the efferent nerves that run to muscles, blood vessels, and so forth, maintaining what we call "tone" in muscles and blood vessels. These processes are conducted so that they give rise to no appreciable sensation.

If, however, a morbid process in a viscous gives rise to an increased stimulus of the nerves passing from the viscous to the spinal cord, this increased stimulation affects neighbouring centres, and so stimulates sensory, motor, and other nerves that issue from this part of the cord. The stimulation of a sensory nerve will result in the production of pain referred to the peripheral distribution of the nerve whose spinal centre is stimulated, so that visceral pain is really a viscero-sensory reflex. If the visceral is a motor centre, then the contraction of the skeletal muscle results, and thus is produced the viscero-motor reflex.

The reasons why the pain is referred to portions of the body so far apart is because in the course of development the tissues that in a low scale of life immediately covered the organ have been displaced. Thus, the pain felt in the heart, the renal colic is due to the fact that in its journey down to the scrotum the coverings of the testicle receive a twang from the first lumbar nerve, and when the root of this nerve is stimulated, as in renal colic, the testicle is in a state of contraction and the skin of the scrotum hypogastric, but always the deep covering of the testicle, because the scrotum is supplied by the sacral nerves.

Referred Pain.

This view is the one practically adopted by all to account for what is called "referred pain." Ross described visceral pain in two sorts, one he called "organ" and "somatic" pain referred to some part of the body wall remote from the organ. But when the so-called "splanchnic pains" are critically examined they will be found to be of the same nature as somatic pain. Thus Ross said that the pain in the back in cases of gastric ulcer was referred or somatic, while the localized epigastric pain was local—in the organ itself—splanchnic. So convenient was he that he said that if he passed a needle through the site of the latter pain he would penetrate the ulcer. This view is one so commonly held that I shall deal in some detail with the pain of gastric ulcer, but here I may simply point out that in the movements of respiration and in the movements of the walls of the stomach the ulcer is bound to shift a little, and if the pain were in the ulcer the situation of the pain should be constantly varying, whereas it remains fixed even on very deep inspiration and expiration.

Radiation of Pain.

Perhaps the best evidence to be found as to the true nature of visceral pain is to observe how pain spreads. No attempt is ever made by writers to appreciate the meaning and significance of the spreading of pain. Thus in an elaborate monograph on gall stones, a "hypersensitive" gall bladder and a "tender liverItaly was spoken of, and the pain of an inflamed gall bladder is "diffused over a large area along and below the margin of the liver." In what tissues was this widely diffused pain felt? If the pain were in the gall bladder, how come it that it was felt in a region more extensive than that occupied by the gall bladder?

The diffusion of pain over a wider area than that occupied by the lesion originating the pain can be proved in many ways to be due to an extension of the irritation affecting the roots of sensory nerves in the spinal cord. Thus the extension of the painful area is frequently associated with hyperalgesia in the peristaltic waves in the body wall. The pain is often found to radiate along peculiar areas, inexplicable unless we recognize the relationship in the spinal cord of the nerves supplying these areas, with the corresponding nerve roots of the pectoris passes from the front of the chest into the axilla and down the arm—that is to say, into areas supplied by contiguous nerve roots (third, second, and first dorsal nerves); or the pain may be a distance from the affected organ and gradually approach it till the pain is felt in the tissues covering the organ, as when in angina pectoris the pain may at first be confined to the arm, but with increasing severity radiates to the front of the chest.

The radiation of pain that occurs in a skin lesion is also due to the strong stimulus spreading in the spinal cord, exactly in the manner I showed in the spreading of the autonomic sensation and pilomotor reflex. This is brought out very clearly in the following experience related by Sherrington: "By applying a mustard leaf over the front of the upper part of the sternum I can produce in myself the sensation of a patch of hot, unpleasantly tingling character, referred to the inner side of each upper arm, just above the inner ongrowth... In the associated sensations and the stimulus applied, as shown by delimitations of the cutaneous segmental nerve areas, both of them within the same segmental area." I have on several occasions been able to produce a goose-skin reflex in a limited area on the front of the chest over the second and third costal cartilages by stroking the inner and anterior surface of the arm above the elbow, and a limited area of goose-skin in the arm by stroking the front of the chest in the place just mentioned. From such facts as these we are justified in drawing the conclusion that Sherrington's experience demonstrates that the radiation of pain from a local cutaneous stimulus is due to an excitation of sensory cells in the spinal cord.

The Pain in Gastric Ulcer.

The study of the pain in affections of the stomach and bowels affords evidence for demonstrating the nature of visceral pain, and at the same time shows the practical importance of this method of observing visceral pain. In this part of Lancashire gastric ulcer is a disease of extraordinary frequency. For many years it has been my habit to note the situation in which pain was felt most severe in the "angina" pain in the back. I soon found that the great majority of these patients referred the pain with great precision to some region in the epigastrium. Now the fact that gastric ulcers are situated frequently just off the true axis of the stomach, suggests the possibility of a greater distance from the epigastrium, raised my suspicion that the pain could not be felt in the ulcer. Examining these cases more carefully, I found this localized pain was frequently associated with great tenderness of the skin.
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and of a limited portion of the upper part of the recti muscles. Watching cases that ultimately came to operation, or that died and on which I had a post-mortem examination, I found that the ulcer bore no relation to the site of the pain, but that when the ulcer was near the cardiac end of the stomach the localized pain and cutaneous and muscular hyperalgesia was situated high in the epigastrium, whereas when the pylorus the pain, etc., was situated low down in the epigastric region. The following typical instances not only illustrate this point, but demonstrate the practical utility of the method.

I was called into consultation to see a patient twenty hours after perforation of a gastric ulcer had taken place; she had suffered for several weeks from pain after food, and located the site of this pain with great precision in the upper part of the epigastrium over the xiphisternum (area A, Fig. 4).

I reasoned from this that the perforated ulcer would be near the cardia end of the stomach. The incision opening the abdominal cavity was, however, carried down as far as possible. On opening the abdomen there was found a large quantity of fluid, and a considerable quantity of flaky lymph covered most of the exposed organs. The stomach was carefully searched, and we found it rather firmly adherent at the cardiac end and to the posterior wall of the abdomen. We inspected the whole of the stomach except the adherent part, and searched for adhesions around the ulcer. We were not able to break down these adhesions, as it would have been impossible to drag this portion of the organ sufficiently far out to enable it to be stitched. The abdomen was very effi-

Fig. 4.—The area A shows the site of ulcer, the stomach, A: B, when the ulcer was at the pylorus, C: D, when the ulcer was in the lesser curvature, D: E, when the ulcer was at the pylorus, C: F, when the ulcer was at the pylorus, C: F, when the ulcer was at the pylorus.

ciently flushed, the wound stitched up, and the patient made well and discharged after an interval of two weeks. Approximately the site of the ulcer corresponded to the area A, Fig. 4.

A girl, aged 14 years, who had had pain after food for many months referred the site of the pain, with great precision, to a spot in the middle of the epigastric region (area B, Fig. 4). She was suddenly taken with collapse and severe pain over the upper part of the abdomen. There could be no doubt that it was a case of perforation of the stomach. Within eight hours we opened the abdomen, and, as I had noted the situation of the pain previous to the rupture, I suggested that the ulcer would probably be found in the middle of the stomach. The incision was therefore made well to the left of the middle line. The perforation was at once met with in the middle of the stomach (area B, Fig. 4), on the lesser curvature. It was stitched up, but there was no ex- cellent recovery.

In another patient, who had suffered for years from gastric ulcer (pain and vomiting of blood) the pain was always felt at the lower part of the epigastrium. She died of phthisis. At the post-mortem examination there was found a small blister at the lower part of the epigastrum (area C, Fig. 4). She was wont to apply a small blister over the place she felt the pain, and to note this area and its relation to the ulcer. The ulcer was found in the pylorus corresponding to the area marked C, Fig. 4.

Another case had been under my care for ten years for repeated attacks of epigastric pain. She consulted an eminent surgeon, who wrote to me stating that the patient had an ulcer in the middle of the stomach and on the posterior wall, and he recommended an operation for her relief. I re-examined the patient, and made the following note: That, inasmuch as the pain is situated at the lowest part of the epigastric region, and as there is also here a limited area of tenderness in the skin, the ulcer should be found at the abdominal orifice. This view was verified at the operation subsequently performed.

Pain in Peristalsis of the Bowel.

From the observation of a large number of cases of obstruction of the bowel, I found that if the obstruction were in the small intestine the violent pain was usually referred to the middle of the abdomen below the umbilical region. When, however, the pain descended to the hypogastric region then the pain was located in some part of the large intestine. This is simply due to the fact that above the seat of obstruction the violent peristalsis produces pain, whereas below the seat of obstruction the bowel does not contract. This view is corroborated by the observation I have already cited where the small intestine was in course of an operation for resection, and by the results of a distending enema. It can also be observed in certain cases of diarrhoea. Thus, in a patient to whom I had given large doses of digitalis pain of great severity was felt in the lower part of the epigastrium, with intervals of relief of the ulcer being more marked in the middle line until it was felt immediately above the pubis. Coincident with the pain reaching this situation, an urgent desire for defaecation was observed, and on the ulcer being exposed by the evacuation of a large and loose motion. It is to be justifiably inferred from this case that violent peristalsis had been set up in the upper part of the small intestine, that the peristaltic rhythm reached the distal intestine and large intestine, and that although different parts of the bowel must have contracted in different parts of the abdomen, the entire contents of the lower segments of the abdomen, descending as the stimulus, from descending coils of intestine, reached successively lower portions of the spinal cord.

From the foregoing considerations the legitimate conclusion to be drawn is that all pains arising from viscera supplied only from the autonomic nervous system are part of a reflex mechanism (viscero-sensory reflex).

IV. — THE MECHANISM BY WHICH THE SYMPTOMS IN ANGINA PECTORIS ARE PRODUCED.

In seeking an illustration of the application of the principles I have endeavoured to enunciate, I have chosen the subject of angina pectoris, the diagnosis of which has been referred with certainty to the organ at fault, and because the complex of symptoms that are included in an attack of angina pectoris are capable of being analysed with great precision on account of the great muscular and sensory nerves, whose centres in the spinal cord and medulla are in close relationship to the centres of the autonomic nerves of the heart. The cases I cite demonstrate that the term "angina pectoris" includes a number of reflexes, and I give in detail the more conspicuous of these, namely, sensory reflexes, when the pain and hyperalgesia affect the chest, arm, head, and neck; motor reflexes, resulting in spasm of the intramural muscles; secretory reflexes, as shown by profuse secretion of saliva and urine. Some cases show other reflexes, as the respiratory, but the discussion of these would lead me beyond the subject I had in writing this series of papers.

Notwithstanding the numerous papers devoted to the consideration of angina pectoris, practically none have dealt with the analysis of the symptoms present during an attack. Angina pectoris is so often surrounded by such tragic circumstances, that it forms a suitable theme for turgid eloquence, and on that account we too often get the "lurid" description and an impressionist artist instead of the plain, matter-of-fact description of an accurate observer. A careful sifting of all the details brings out the fact that the essential principles underlying the pains associated with the attack of"angina pectoris" are demonstrated by those from any other hollow muscular organ. So terrifying is the attack to the patient that perception of the details of his suffering are generally confused, so that often no clear account can be obtained from his description; but if he is intelligent and is asked to note particulars in future attacks, he will often be able to throw a very valuable light on the onset and character of the sensations he experiences. The observations of patients made by the physician during an attack also afford great help in this respect.

The Viscero-Sensory Reflex in Dilatation of the Heart and Liver.

Before dealing with the more characteristic attacks of heart pain which go by the name of angina pectoris, I wish first to draw attention to the very distinct sensory evidences that arise from the dilatation of the heart. These sensory symptoms are practically identical with those that are in cases of distension of any other viscera, as the stomach, bladder, or liver. To illustrate this I select cases where the dilatation of the heart occurs rapidly, and is followed by a rapid distension of the liver such as we often find following intracardiac pericarditis. In certain of these cases the rhythm of the heart starts suddenly at the ventricle (or more probably at the fibres joining auricle and ventricle). The heart at once beats with great rapidity, and the circulation, and in consequence we have very rapidly-developed great dilatation of the heart, fullness of the
veins, enlargement of the liver, and dropy. I have seen a number of these cases, and in two particularly I had observed some fifteen to twenty attacks, of which the following is a good example:

Observation 1.—The patient may be in good health and no ascertainability be detected save in some cases, the occurrence of a ventricular extra systole. Suddenly the heart’s rate becomes greatly accelerated—to 180 beats and more per minute. In a few hours’ time the patient’s face becomes dusky, the lips become swollen and livid, and there appear great shortness of breath on exertion, marked increase in the size of the heart, distension and pulsation of the veins of the neck, and enlargement and pulsation of the liver. The jugular and liver pulsation are of the ventricular type. Passive pressure on the rib-cage may be felt over the heart. The skin and deeper tissues of the left chest are extremely tender on pressure in these regions. These phenomena come over in fits, if at all. If the mass is so palpable that it forms the axillary fold it will be found extremely tender. The skin of the left side of the neck may also be tender, and if the left sternomastoid muscle and the left trapezius muscle above the middle of the scapula are lightly grasped they may be found exquisitely sensitive. The skin and muscle over the liver will also be found extremely sensitive to pressure, and the parts hyperalgesic extended much larger area than the enlarged liver. If the heart’s rate revert to the normal the patient at once experiences great relief and in a few hours all signs of the circling disturbances disappear.

The tenderness of the skin and muscles in the regions described above may be found in patients during the early stage of dilatation of the heart or of the liver from any cause and is very common in heart failure secondary to mitral disease. In some, one can tell when improvement is taking place by noting the diminution of this tenderness.

There can be little doubt as to the mechanism by which the hyperalgesia of the tissues in the three regions is brought about. The relationship of the dilatation of the heart and liver with these sensory phenomena was undoubtedly that of cause and effect. The tenderness to pressure of the tissues in the left chest was due to the stimulation of the afferent sympathetic nerves by the hyperalgesia. These nerves stimulated the sensory centres of the third and fourth dorsal nerves in the spinal cord, so that a stimulus reaching them from their peripheral distribution gave rise to a painful impression of the heart or of the liver from any cause and is very common in heart failure secondary to mitral disease. In some, one can tell when improvement is taking place by noting the diminution of this tenderness.

The Manner in which the Distribution of the Upper Dorsal Nerves are Modified in the Course of Development.

In all cases the pain felt in affections of the heart, the manner in which the upper dorsal nerves come to be distributed should be borne in mind. Ross has pointed out that in the primitive vertebrates, before the development of the limbs, each spinal nerve is distributed segmentally round one half of the body. The upper dorsal nerves are therefore entirely distributed over the thorax and to the tissues covering the heart. The upper limbs are laid out from the trunk in their development, drag with them away from the chest portions of the upper dorsal nerves, so that parts of the first and second dorsal nerves are distributed to the upper arm and inner surface of the upper arm. Thus, suppose a pain originating in the heart and stimulating the first and second dorsal nerve, it would be felt in the lower vertebrate over the heart, whereas even it would be felt in the upper arm or in the forearm.

The Pain of Angina Pectoris is a Viscero-sensory Reflex.

The usual description given of the pain in angina pectoris is that it is felt in the heart and shoots into the arm, or that there are two pains, a local pain in the heart and a referred pain in the arm. If, however, a careful analysis be made of all the symptoms present, facts will be found that practically demonstrate that in angina pectoris there is but one kind of pain, and that its production is in accordance with the law laid down by me in attempts to establish in this series of papers, namely, that it is a viscero-sensory reflex. It is not in every case one able to demonstrate the proofs of this hypothesis, but the facts derived from suitable cases afford legitimate conclusions applicable to all cases. Shortly, these facts are, that the pain in the very gravest cases may be felt in regions distant from the heart, that this pain is identical in character with that felt over the heart, that the pain may originally start in parts distant from the heart and gradually approach and settle over the heart, and lastly, that the tissues of the external body wall over the heart may be found extremely hyperalgesic after the pain has passed away. From this last fact it is inferred that, inasmuch as the seat of pain corresponds to the region of hyperalgesia, therefore the pain was felt by the hyperalgesic nerves. To assume otherwise is to ignore a principle that explains satisfactorily the sensation of pain wherever arising.

The following observations illustrate this point. They are examples taken from a large number of cases that demonstrate the same feature. For the sake of brevity only those points bearing upon this argument are referred to.

Observation 2.—Female, aged 30, suffering from stenosis of the aortic, mitral, and tricuspid valves, was seized with a violent pain referred to the outer part of the chest wall. The pain passed off, but a sense of soreness and smarting remained over the part in which the pain was felt. On examining her I found a portion of the skin of the chest extremely tender to touch, corresponding to the area shaded in Fig. 6.

A few days later she began to suffer from attacks of pain in the left breast and down the inner side of the left arm, and on examination I found that the hyperalgesia had extended and occupied an area similar to that shaded in Fig. 7. These attacks of pain became so severe on the slightest exertion that she was obliged to keep to her bed. She partially recovered from these attacks, but they recurred with increased severity. When suffering the most severe attacks the hyperalgesia embraced nearly the whole of the left chest and inside of the left arm and part of the right chest. The left sterno-mastoid muscle and trapezius also became very tender, and the patient would sometimes complain of pain on the inner surface of the right forearm, and here also I found a patch of cutaneous hyperalgesia. Two years and a half after the first attack of pain following from a series of violent attacks, when, on getting out of bed she fell forward and died immediately.

The fact that in this case the attacks of pain were followed by a hyperalgesia of the skin in the region where the pain was felt, and the further fact that the pain started at a distance from the cardiac region, and was often felt most severely at a distance from the heart,
proves that the cardiac pain in this case was a viscero-sensory reflex, and that the pain felt over the precordial was a pain of the same nature.

Observation 9.—Female, aged 56, with high blood pressure, suffers from pain in the foot (gout), and has had several severe attacks of true angina pectoris, when the pain is referred to the left chest and shoulder. After the attack she passes a large quantity of clear urine, and the skin and mucous membrane of the neck become hyperaemic and the skin and deeper tissues were extremely tender to the slightest pressure. In one attack the pain was felt in a limited area over the sternum, and the sterno-mastoid muscles become very painful on pressure. In one attack the pain felt in a limited area over the sternum, and the sterno-mastoid muscles become very painful on pressure. In one attack the pain was felt from the skin to the foot (gout), and there he exerts his left hand and arm. He lay back, cross-legged, and told me he felt as if a weight were pressing on the heart (verified by subsequent post-mortem examination). The blood pressure was 150 mm. Hg. During the following weeks the pain in the left arm increased in severity, and gradually extended up the arm till it was felt in the axillae, and finally it invaded the left chest. At first the pain was only felt when rising, and to pass rapidly up the arm, but latterly it seized him with such severity and suddenness that, the arm pain was the first thing he knew. It usually began in the arm with the greatest severity either over the heart or in the inner surface of the left arm immediately above the internal con- dyle. I particularly asked him to note in his frequent attacks if there was a difference between the chest pain and arm pain, and his reply was that there was no difference in the character of the pain, but, if anything, the arm pain was the worst. Sometimes the pain was very severe up the left side of the neck and behind the left ear. Under treatment he seemed to improve considerably. During January these attacks again came on. During some of the attacks the pain was so great that he felt he would faint and wished to die. The pain was equally severe in chest and arm, and saliva sometimes dribbled from his mouth. On February 12th the least exertion was sufficient to induce a severe attack of pain, and from 3 p.m. till 7 p.m. he was scarcely free, and ultimately became unconscious. When I saw him next day he was having another series of attacks. I found his left arm very still, and helping himself to food entirely with his right hand. He told me he dare not move his left arm, as even the act of lifting the left hand to his mouth was sufficient to induce an attack. His pulse was extremely soft and weak. His blood pressure had fallen to 85 mm. Hg. During the following night he had another series of attacks, became unconscious, and expired.

I omit many details in this case on purpose to empha- size observations in which the pain was felt in a form of angina pectoris. It seems to me that no other explanation save that of the viscero-sensory reflex can satisfactorily account for the pains in this case, and that the radiation of the pain from the neck to the hand practically of the same nature as the cardiac radiation of the pain from the chest to the hand. The pain in the neck and behind the ear on the same hypothesis would be induced by the stimulus passing from the heart by the vagus, a view that would also explain the increased flow of saliva during some of the attacks points to which I shall afterwards revert.

The two following observations of angina pectoris which I witnessed, illustrate true heart pains of the most severe type at places remote from the heart.

Observation 5.—Male, aged 14, suffering from adhesive mediastinitis, with enormous enlargement of the heart; seen with Dr. Agnew. The patient lay propped up in bed. I was gently testing the sensitivity of the skin outside and under the left nipple the patient was suddenly seized with an attack of a great sob and a sensation of tightness coming on when he lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead. In a few minutes the pain was not severe, but the lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead. In a few minutes the pain was not severe, but the patient lay propped up in bed. He was gently testing the sensitivity of the skin outside and under the left nipple the patient was suddenly seized with an attack of a great sob and a sensation of tightness coming on when he lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead. In a few minutes the patient lay propped up in bed. He was gently testing the sensitivity of the skin outside and under the left nipple the patient was suddenly seized with an attack of a great sob and a sensation of tightness coming on when he lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead. In a few minutes the patient lay propped up in bed. He was gently testing the sensitivity of the skin outside and under the left nipple the patient was suddenly seized with an attack of a great sob and a sensation of tightness coming on when he lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead. In a few minutes the patient lay propped up in bed. He was gently testing the sensitivity of the skin outside and under the left nipple the patient was suddenly seized with an attack of a great sob and a sensation of tightness coming on when he lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead. In a few minutes the pain was not severe, but the lay back, cross-legged, and told me he felt as if a weight were pressing on the heart. His pulse became very soft and his face pale, with beads of perspiration on his forehead.
The British Medical Association.

[June 30, 1906.]

Summation of Stimuli as a Cause of Angina Pectoris.

The fundamental functions of the heart muscle correspond to those of other involuntary muscles that form the walls of hollow organs; these actions being modified to suit its special work. Like the other viscera, the heart is insensitive when stimulated in a manner that produces no sensation; it is only when the interference arises from an abnormal body wall. I have pointed out that a prolonged strong contraction of a hollow organ can produce pain, and that this is undoubtedly the case of the severe pain of renal gall stone and bowel colic. Can the rise in pain in a similar manner? On account of the modification of its functions the heart cannot pass into a prolonged state of contraction. Immediately it contracts the function of contractility is at first abolished, and the muscle passes at once into a state of relaxation, and for this reason the pain cannot be produced by a "spasm of the heart." But I suggest that the heart muscle may produce pain when it is confronted with work greater than what it can readily overcome—a cause which produces severe peristalsis and pain in other hollow viscera. But the pain in the heart arises by a slightly different mechanism. A skeletal muscle will contract if a stimulus of sufficient strength be applied to its nerve. If the stimulus is too weak no contraction follows, but if this weak stimulus be frequently and rapidly repeated then the muscle contracts in accordance with the law of summation of the stimuli; these functions being one at a time of the summation of stimuli. If we study such a case as is recorded in Observation 10 the pain was manifestly due to the heart, and no other cause. I suggest that the heart muscle induces pain in the principle of the summation of stimuli. If we study such a case as is recorded in Observation 10 the pain was manifestly due to the heart, and no other cause.

Presidential Address

ON THE PAST, PRESENT, AND FUTURE OF THE BRITISH MEDICAL ASSOCIATION.

Delivered at the Annual Meeting of the Metropolitan Counties Branch.

By HUGH R. KEB, F.R.C.S. EDIN.; PRESIDENT OF THE BRANCH.

The first pleasing duty I have to perform on taking this chair is to thank you most sincerely for the great honour you have conferred upon me by electing me as your President. I can assure you I thoroughly appreciate the distinction; and though I feel how impossible it is for me to hope to compare favourably with my eminent predecessors, I gladly promise, trusting to your indulgence to overlook my shortcomings, that I will do my best to sustain the credit and high position of this Branch and to promote the interests of the great Association of which it forms so important a part.

I found it a most difficult task to select a subject suitable for my address to you, and I must ask your forgiveness if I succeed in bringing you little that is fresh, and have again to traverse the paths which have been trod by many of my predecessors. After much thought and many doubts, I have taken for the title of my address, The Past, Present, and Future of the British Medical Association.

I did not know this title had ever been taken before, until I was looking up the records of former addresses, when I found that it was the subject of Sir R. Quain's address in 1873.

On making this discovery I was at first inclined to choose another subject, but on second thoughts it seemed to me it would not be inopportune, considering the vast changes which have taken place in the position and constitution of the Association in the last thirty years, to review our position both past and present, and see if we

Other Reflexes occurring during an Attack of Angina Pectoris.

Other very striking phenomena are sometimes met with during an attack of angina pectoris. During or after an attack an abundant flow of saliva and the secretion of large quantities of pale urine may occur; both symptoms I suggest are due to reflex stimulation of the floor of the fourth ventricle (see Observations 3 and 4).

Observation 12.—A man, aged 40 years, of gouty diathesis, complained of pain, induced often by the slightest exertion, which arose in the left breast, passed up the arm, and extended down the inner surface of the left arm to the little finger. During an attack an abundant flow of saliva took place into the left side of the mouth. These attacks became so frequent that he could only walk a very short distance without inducing an attack. He dropped dead while at his work, and on post-mortem examination I found extreme calcareous degeneration of the coronary arteries.

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