THE INTERPRETATION OF GASTRIC SYMPTOMS.

ABSTRACT OF THE CROONIAN LECTURES DELIVERED BEFORE THE
ROYAL COLLEGE OF PHYSICIANS OF LONDON,

BY

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LECTURE I.

AFTER a short survey of the views that had been advanced by older writers, Dr. Bolton said that the conception of dyspepsia had returned to that of two hundred years ago, and that it was now widely regarded as signifying a group of symptoms resulting from functional disturbance of the stomach as a primary affection or due to organic disease; and the leading idea to be kept in mind in investigating cases should be the exclusion of organic disease. The first object in diagnosis was to ascertain the part of the gastric mechanism that was upset and the disturbance in action that it showed, and then to discover the cause of the disturbance. A thorough examination of the symptoms of the patient afforded the earliest and most delicate index of this disturbed action. Neglect of this was the greatest source of danger of missing serious organic disease. Although at first sight the varied symptoms of which patients with dyspepsia complained might seem to defy classification careful observation showed that there were several different combinations constantly recurring, and he believed it possible to classify dyspepsia into such symptom-groups, to explain them in terms of physiology, and so to build up a rational pathological physiology of the stomach.

The observations recorded were based on a series of 1,009 cases, but before proceeding with their analysis it was necessary to explain his views on the mechanism of the production of pain. Modern research had shown that the symptoms of dyspepsia were not due primarily to alterations in the chemical process of digestion but to alteration in the motor functions; and it was now generally agreed that visceral symptoms were in general almost entirely muscular in origin. The muscular sensations might be grouped as (1) minor sensations—for example, the feeling of tightness, fullness, or vague discomfort, etc., (2) pain of varying degree; there was no real difference between the two, the sensations sometimes passing on to pain or alternating with it. Both were due to excessive muscular tension, which was the resultant of two forces—stretching and muscular contraction. Normally great variations in contraction tension did not occur, and Sherrington had explained this by demonstrating the ability of the muscle to lengthen and shorten without apparent alteration of the contraction tension. The mechanism on which this postural activity depended, however, might be interfered with, and the most important cause of such interference was irritability of the neuro-muscular mechanism; sensitiveness of the nervous system varied in individuals, and was a large factor in the production of pain.

Local pain undoubtedly occurred; the minor sensations, when exaggerated into pain, were certainly examples of local pain, but although local pain originating in the oesophagus was fairly well localized, local gastric pain was, as a rule, too diffuse to be very helpful. Referred pain, on the other hand, was of much greater importance, because it was the chief gastric pain, and the position was constant and localized. In analysing his cases he had found that the areas of cutaneous hyperaesthesia mapped out by Head were of little help, as they were uncertain and irregular in occurrence. He divided the body into areas separated by transverse lines; the sternal region, extending from the root of the neck to the ensiform cartilage, represented the oesophagus, and was subdivided by a line across the fourth costal cartilage into upper and lower sternal areas. The area between the ensiform and the umbilicus he called the sterno-umbilical region; the transpyloric plane joining the ninth costal cartilage cut across the centre of this area, which could be subdivided into upper, middle, and lower

sterno-umbilical regions. Classifying the 624 cases of his series which showed pain in one area only, according to the site of pain, there were:

Sternal region:		
Upper, representing upper oesophagus ...	53	cases
Lower, representing lower oesophagus ...	119	"
Sterno-umbilical region:		
Upper, representing body and stomach...	223	"
Middle, representing pylorus ...	152	"
Lower, representing pylorus ...	77	"

The mechanism of the stomach was likely to be upset at the time at which it was subjected to the greatest stress; the oesophagus and body were therefore likely to be disturbed at an early stage during filling of the stomach, the pylorus at a later stage during emptying. If, therefore, pain in these areas really represented disturbances in the corresponding parts of the stomach it should be possible to correlate the position of the pain with the time of onset after a meal. The following figures showed that this was the case.

	Symptoms occurring	
	Early.	One hour or later after food.
Upper sternal ...	66.6%	12.5%
Lower sternal ...	30.1%	38.4%
Upper sterno-umbilical ...	27.8%	47.3%
Middle sterno-umbilical ...	12.8%	74.4%
Lower sterno-umbilical ...	2.7%	90.1%

It was therefore justifiable to conclude:

- (1) That pain occurring in the upper sternal region usually came on at once after food or irregularly, and was associated with disturbance of the upper oesophagus.
- (2) That pain in the lower sternal region came on at once or late, and was associated with the lower oesophagus.
- (3) That pain in the upper sterno-umbilical area was associated with the body, and might come on early, but more often late.
- (4) That pain in the middle and lower sterno-umbilical areas was associated with pyloric disturbance, and usually came on two hours or more after food.

There was another feature of gastric pain, and that was its tendency to shift forwards as the disease proceeded, and so to appear sooner after a meal than was originally the case. Although this was most noticeable in cases where pain first appeared late it was also to be noticed in all types of case, and in severe cases the pain might eventually become constant, the patient being free from pain only in the early morning before food was taken. This was due to an increased irritability of the neuro-muscular mechanism of the stomach. The normal muscular response of the stomach to food was dependent upon a nervous reflex, which with constant irritation responded more and more easily, until in severe cases the mere presence of food, however mild, would excite the abnormal movements responsible for the symptoms. The oesophagus and body of the stomach were liable to develop early and constant pain, not only in virtue of their position and functions, but also because they were better represented in the central nervous system and were more subject to its influence. This view was supported by analysis of the cases of irregular pain, which was more commonly due to disturbance of the body or oesophagus than to that of the pylorus. Pain coming on irregularly, either early or late after food, was equally distributed between the cardiac and pyloric ends, and sometimes depended on the particular meal taken; pain occurring at any time, either day or night, was certainly much more frequently associated with body and oesophagus, and was often caused by increased pressure due to posture in an irritable stomach (straining, stooping, lying down, etc.), and above all to emotional disturbance. Constant pain, even with a presumably empty stomach, was characteristic of a high degree of nervous instability of the stomach, particularly affecting oesophagus and body. Pain in the back, if present, was usually at the same level as that in the front or higher up; oesophageal pain extended from top to bottom of the scapulae; pain associated with the body from the sixth to the tenth dorsal spine; and pyloric pain from the eighth dorsal to the second lumbar spine. Localized points of pain occurred in two areas: (1) opposite the ninth costal cartilages, more frequently on the right side than the left, and pain appeared late and was associated with the pylorus; (2) over the nipple region, usually on the left side and indicating oesophageal origin.

LECTURE II.

Pain occurring in multiple areas was more difficult to classify, but the points were worthy of notice. The pain frequently began simultaneously in all positions, and when this happened the time of onset might be taken as indicating the origin, as in the single pain areas. The pain also often spread upwards or downwards during digestion. Upward spread usually meant a primary pyloric disturbance, whereas rapid downward spread usually pointed to considerable nervous instability.

Sensation of fullness, although primarily a symptom of body disorder occurring in 90 per cent. of cases with pain at the cardiac end, was found also in 80 per cent. of cases of pyloric pain. This was easily to be understood; the sensation depended on the volume of the gastric contents; if the irritable pylorus held up the gastric contents a sensation of fullness would result; if, however, the pyloric irritability showed itself late, when the contents had largely left the stomach, the sensations produced were those of hunger. Absence of pyloric relaxation was not necessarily accompanied by pyloric pain, as this only occurred when the pylorus or adjacent part of the vestibule became spasmodic, so that there was yet a third type of pyloric irritability, which was associated with the sensation of fullness but without pyloric pain. There was no doubt that these pyloric types constituted the most important group of sufferers from dyspepsia.

Relief of Pain.—The symptoms of functional disorder of the stomach occurred at different phases in functional activity, and ceased when the work of the particular part affected was finished. Factors causing the disappearance of pain were therefore as important as those causing it in explaining the mechanical disorder giving rise to it. Three common ways of obtaining relief were by food, by eructation, and by vomiting. Of the cases which were completely relieved by food more than half fell into the group of pyloric pain (mid and lower sterno-umbilical areas); but on analysing the time of onset it was found that in the large majority of all cases where pain was completely relieved by food the pain appeared late; so that it was probable that even those cases in which the pain was located in the cardiac or oesophageal areas were mostly secondary to a primary pyloric disturbance. On the other hand, patients who were not relieved by food were mostly the subjects of early and irregular pain. Two factors were involved in the causation of cardiac pain—the irritant nature of the gastric contents and an overaction of the neuro-muscular mechanism. The taking of food brought into play the mechanism for inhibiting muscular movements seen during normal filling of the stomach; this inhibition was naturally less effective in cases where the central nervous system was unduly irritable, and as it was the primary cardiac and oesophageal cases in which such irritability was most common, these were naturally the cases that showed least relief by food. On the other hand, the irritant nature of the gastric contents tended to exhibit itself chiefly during the later stages of digestion, when the more digestible portion of the meal had been allowed to leave the stomach; in these cases food diluted the residual contents of the stomach, and gave relief by increasing the bulk and also by diluting and neutralizing the free acid if present.

Eructation of gas was so constant a symptom as to be of little diagnostic help; the gas was practically always air swallowed with food, with saliva, or voluntarily; it did, however, indicate, when excessive, an unstable nervous system. Eructation of fluid was much less dependent on the nervous system, and gave some help. On the whole, acid eructations were associated more commonly with pyloric cases, and bitter or tasteless eructation with cardiac or oesophageal cases. The distinction was due to the fact that in the former group the function of the pyloric sphincter as a regulator of gastric acidity was interfered with, and hyperacidity of the gastric contents resulted.

Vomiting.—Nausea occurred so irregularly and in such a multitude of conditions as to be of little diagnostic importance. Vomiting, however, was of the greatest importance; it occurred in 22.8 per cent. of the whole series of 1,009 cases, and was therefore much less frequent

a symptom than pain, and indicated a high degree of irritation of the stomach. To assess its significance it was essential to take careful note of its origin and onset, for the reflex tended to become more excitable, and the vomiting then lost its initial character. It was also frequently induced by reflexes from all parts of the body, by affections of the central nervous system, and by blood poisons, so that the indications of a gastric origin required close attention. It occurred in about the same proportion of cases in the pyloric and cardiac groups, but much less frequently in the oesophageal group. The main cause of vomiting was pain. In 63 per cent. of his cases which showed vomiting the act occurred at the height of the pain, and in these there was rather a higher proportion of pyloric cases than cardiac; oesophageal pain was the least likely to cause vomiting. The next most active cause of vomiting was regurgitation of fluid from the stomach to oesophagus; 11.7 per cent. of the cases were due to this cause. The regurgitating fluid irritated the fauces and caused retching; this condition was found much more frequently in oesophageal cases, and was especially common in neurotic subjects. The third cause was the voluntary one in which the patient made himself vomit to relieve his symptoms. Sometimes the habit was continued as an involuntary one, and the patient then complained of it as his chief symptom. This group contained but few with oesophageal symptoms. These three factors—pain, regurgitation of fluid, and voluntary vomiting—accounted for 85 per cent. of his cases.

Wasting was an important symptom in cancer and pyloric obstruction, and also in certain remote diseases with gastric symptoms. Functional disturbances of the stomach, including uncomplicated ulcer, did not cause wasting; but this symptom might be associated with it in three conditions: (1) severe vomiting, (2) voluntary reduction of food to relieve symptoms or because the patient was afraid to eat, (3) loss of appetite with nausea. All these were indications of a neurotic individual. The wasting impaired the nervous system, and symptoms were aggravated.

Appetite was good in most of the pyloric cases; these included the most robust individuals and contained the smallest number of neurotics. Among cardiac and oesophageal cases about half had a fair or poor appetite.

Sex of Patient and Shape of Stomach.—In males the pyloric region was affected twice as often as the body; in females the pyloric region and the body were affected to an equal degree. With regard to shape of the organ it was not justifiable to look upon any form of dyspepsia as due to any particular shape of stomach. Normal individuals varied about a certain average as regards position and shape of stomach, and also as regards each of its functions; the type of stomach affected must produce some modification in the processes resulting from any disturbances, but all people, whatever the sex or the shape of the stomach, were liable to the same affections, and any differences in individuals in liability to any particular affection depended on the make-up of the nervous system and the habit of the individual. The greater nervous tendency of the female was shown by comparing the two sexes as regards the time of onset of symptoms; the female showed in every position of pain a much greater tendency than the male to feel the pain quite early.

Organic Lesions.—Gastritis and uncomplicated ulcer were the only two organic lesions that need be mentioned. Gastritis was present in some degree in all chronic ulcers, but if it produced any symptoms they were indistinguishable from those due to irritability of the body of the stomach, except by the type of vomiting and examination of the gastric contents. Ulcer, on the other hand, was of great importance for the present purpose because we knew the position, and could therefore locate the irritable focus producing the symptoms. Duodenal ulcers must be considered with gastric ulcers, as whichever side of the pylorus the ulcer was situated the effect on the pylorus was the same. In duodenal ulcer 87 per cent. of cases of isolated pain exhibited pyloric pain, 12 per cent. showed cardiac pain, whilst in exceptional cases there was no pain, but merely a sensation of fullness and regurgitation. This entirely agreed with

the conception of pyloric irritability previously described. Of 59 cases of gastric ulcer 23 were found by the surgeon to be pyloric and 36 in the body; in the pyloric group there was pyloric pain in 88.8 per cent., whilst in the cardiac group there was pyloric pain in only 40 per cent. and cardiac pain in 60 per cent. That a certain number of ulcers of the body caused cardiac pain had been noted by various people, the explanation being that an ulcer on the lesser curvature in the vestibule might give rise to irritability of the pylorus through the myenteric plexus. These results indicated that the pain in ulcer was not produced by irritation by gastric contents of afferent nerve fibres in the base of the ulcer, as in that case the referred pain should always indicate accurately the position of the ulcer; rather the pain indicated the segment of the stomach irritated. Duodenal and pyloric ulcers acted as a focus of irritation to the pylorus with secondary cardiac symptoms, so that the pain was usually pyloric and only occasionally cardiac. Ulcer of the body irritated the cardiac portion and pain was usually cardiac, but in a smaller proportion might by its position irritate the pylorus and produce pyloric pain. The pain of ulcer was thus of precisely the same nature as that of functional disturbance, and it obeyed the same laws, so that it was impossible to separate them clinically.

Reflex Effects on the Stomach.—Our knowledge of reflex dyspepsia as a result of disorder to some other organ was fragmentary, but from a clinical point of view the most important sources of origin of such reflexes were the biliary apparatus and intestines. With regard to gall-stones, he had found that in a series of 59 cases that had been operated upon the greater number suffered from gastric symptoms originating in the body; this agreed with general medical opinion and was in conformity with a number of observations recorded on the gastric acidity in gall-bladder conditions. It was much more difficult to come to any conclusion on the question of reflex irritation from the intestine; but, with regard to appendicitis, he agreed with those who held that chronic appendicitis did not exist except as the end-result of an acute attack. In a series of cases of appendicectomy for gastric symptoms in which removal of the appendix produced no effect, an analysis of the position of the pain gave results not unlike those in whom operation had been postponed for a supposed but non-existent ulcer.

LECTURE III.

The symptoms of functional disorder of the stomach could thus be classified into three groups or syndromes: pyloric, cardiac, and oesophageal, each connected with a different part of the gastric mechanism; it remained to consider what alterations in the mechanism were responsible for the production of these symptom-groups and the cause of those alterations.

Pyloric Syndromes.

The causes of these were: (1) Indigestible and irritating food; the function of the pylorus was to hold up portions which required further disintegration, so that these irritants led to deficient pyloric relaxation. (2) Hyperacidity of gastric contents, which resulted from delayed pyloric relaxation itself, maintained the irritability, and induced spasm. The facility with which these two causes produced their effect depended upon the stability of the nervous system, which might be affected adversely by (1) a direct effect upon the myenteric plexus by a chronic ulcer or very rarely by cancer; (2) by reflex irritation from elsewhere in the alimentary system; and (3) general conditions, such as neurasthenia, although these produced their effect most often in the other syndromes.

Effects of the pyloric irritability were the same whatever the cause: the pylorus was interfered with in its double capacity (1) as a regulator of the output of food, and (2) as a regulator of the acidity of the gastric contents. The pyloric sphincter determined the rate at which food left the stomach; at the beginning of digestion it relaxed enough to allow liquids and finely divided solids to pass, other material being shot back into the pyloric vestibule for further disintegration; the gastric contents thus became more irritating as digestion proceeded. If indigestible and

irritating food were taken the factors bringing about pyloric relaxation became less effective, the pylorus refused to relax, and finally became spasmodic; peristalsis then increased in vigour, as in the case of all opposed muscles, so that the internal pressure was raised. If when the spasm came on the greater part of the food had left the stomach the exaggerated movements of the stomach were of the same nature as the normal hunger contractions of the empty stomach, and pain was blended with the sensation of emptiness or hunger. If the gastric contents at the time of pylorus spasm were considerable the pain was associated with a feeling of fullness. As the cardiac sphincter relaxed there might be occasional regurgitation of acid fluid into the oesophagus, with a burning sensation in the throat, and the fluid might reach the mouth and be spat out. As the second function of the pylorus in regulating the acidity of the gastric contents by permitting the regurgitation of alkaline duodenal contents had recently been denied, it was necessary to give a brief description of the foundations on which this idea was based. Beaumont was the first to recognize bile in the stomach, but no attention was paid to it until Boldyreff clearly established the spontaneous regurgitation of bile and intestinal juices into the empty stomach of both dog and man. Boldyreff proved conclusively that if acid were introduced into the stomach it was neutralized by regurgitation of pancreatic juice; he thought the process of regurgitation neutralized the gastric contents down to 0.15 per cent. as the optimum acidity for digestion by trypsin. That this neutralization also occurred as a normal process in the digesting stomach in man had later been demonstrated by estimations of the chlorides in the gastric contents after fractional test meals. In the normal subject the acid of the contents gradually rose to somewhere about 0.2 per cent. at the height of digestion and then gradually fell towards zero as the stomach emptied; if gastric juice of constant strength continued to be secreted throughout the curve must continue to rise steadily, but if secretion stopped when the acid peak was reached the acid concentration of the gastric contents would remain at that level and the curve would appear as a horizontal line; if the gastric juice fell off in acidity the curve would lie between the two levels, and experiments by Roseman on dogs suggested that such a fall in the acidity of the gastric juice did actually occur, but the lowest percentage reached was 0.319 per cent. HCl, so that it was impossible for gastric juice to act as a diluent of gastric contents which had, on an average, only an acidity of 0.2 per cent. HCl.

The only other process which could bring down the acid of the gastric contents was neutralization. Chloride estimations by the fractional method showed that, as the acid curve fell, the curve of neutral chloride increased *pari passu*, the total chloride curve remaining unaffected. The conclusion was that the true secretory curve was not the acid curve, but followed closely the total chloride curve; and that the acid curve represented the process of neutralization, which in turn depended upon relaxation of the pyloric sphincter. The hypothesis was formed that in pyloric irritability the pylorus refused to relax at the usual time and neutralization failed to occur; the course of the acid curve then depended on the secretory activity of the stomach and the behaviour of the pylorus; it might continue to rise as in the "climbing" curve, or it might draw a horizontal line, or, if the pylorus relaxed occasionally, it might fall with each relaxation and rise again as the pylorus tightened up. There were a number of facts confirming this conclusion.

1. Bile always appeared in the stomach from the beginning in the cases of excessive neutralization.
2. In organic obstruction of the pylorus by ulcer where regurgitation was prevented, the acid curve did not fall.
3. Where the pylorus is cut out or after gastro-enterostomy the total chloride curve is unaffected, but achlorhydria is established by free regurgitation.
4. In certain cases of pyloric hypertension atropine in addition to diminishing secretion converted a climbing curve into a normal one by allowing pyloric relaxation.
5. After recovery from dyspepsia the pylorus could be irritated by adding badly cooked split peas to the meal and a normal curve be transformed into a climbing one.
6. The rapid ups and downs that were sometimes seen in the acid curve could only be explained by the vagaries of a sphincter muscle.

Recently objections to the neutralization hypothesis had been brought forward, and it had been suggested that the stomach secreted a juice rich in neutral chlorides, which brought down the acid curve by dilution. MacLean had obtained from dogs, with a Pavlov pouch, acid curves of gastric juice showing a similar shape to those obtained from the digesting stomach in man during test meal examinations, and he concluded that the same processes were at work in both cases, but the lowest percentage of acid he obtained from a measurable quantity of gastric juice at the end of secretion was 0.2 per cent. HCl, and this would obviously produce no fall in the acidity of gastric contents which was not above 0.2 per cent., however much neutral chloride the juice might contain in addition to the acid. There were a number of observations which were inexplicable on MacLean's hypothesis, one example of which was an investigation on an hour-glass stomach in which no fall of acid was found in the contents of the upper sac, whilst a normal fall was found in the contents of the lower sac; it was impossible to suppose that in this case the upper sac was secreting acid and the lower sac salt. Further information on this point had been obtained by x-ray examinations, and with Salmond he had found that the normal condition was for the duodenal cap to be filled under pressure, not only by the stomach, but by antiperistalsis in the duodenum, which occurred in 93 per cent. of cases examined, and duodenal contents could be seen regurgitating into the stomach. Analysis of his cases strongly supported the view that the hypothesis formed as to the probable course of pathological events giving rise to the pyloric syndrome was correct. Pyloric hypertension as evidenced by deficient neutralization occurred in 76 per cent. of cases with pyloric pain, in 37 per cent. of cases with cardiac pain, and in 25 per cent. of cases with oesophageal pain.

Cardiac Syndrome.

In contradistinction to the pyloric syndrome symptoms were here manifested in both phases of gastric activity.

Causes.—During filling the first cause was bolting the food, which prevented the stomach from accommodating itself in the normal way; the second cause was irritability of the neuro-muscular mechanism, brought about as described in the pyloric syndrome. During emptying abnormal activity of the neuro-muscular mechanism again interfered with normal accommodation, the exciting cause being the irritant nature of the gastric contents.

Effects.—With too rapid filling of the normal stomach the contraction tension was raised and a sense of fullness resulted; when irritability had supervened a reflex tonic reaction was at once excited and a sense of fullness or pain was experienced within a few minutes. Although during actual eating pain might be relieved by vagal relaxation of the body, when the meal ended excessive contraction occurred. Such patients felt quite full after eating small amounts, and they reduced their food in consequence; there was thus no stimulus to the lengthening of the muscles, which then contracted all the more. No relief was obtained, therefore, from the diminished diet, and wasting occurred from insufficient food. During emptying increased irritability of the neuro-muscular mechanism produced an increase in the tonic contraction with symptoms which usually appeared between half an hour to two hours after eating. Owing to increased pressure in the body oesophageal regurgitation might occur here as in the pyloric syndrome.

Oesophageal Syndrome.

Oesophageal symptoms were accounted for by the regurgitation of material or gas from the stomach. This was normally only prevented by the tone of the cardiac sphincter. As long as the gastric contents were neutral regurgitation might occur without producing any sensations. In the later stages of digestion if the gastric contents were acid repeated regurgitation led to increased irritability of the mucous membrane and muscular coat of the oesophagus; ring spasms occurred, accompanied by aching or sensations of tightness, or burning in the lower

chest, and sometimes by severe pain at the ensiform. If the patient was neurotic symptoms were liable to occur whatever the reaction of the gastric contents.

LEAD TETRA-ETHYL IN MOTOR SPIRIT.

COMMITTEE OF INQUIRY.

THE committee which, under the chairmanship of Sir FREDERICK WILLIS, is inquiring into the use of lead tetra-ethyl in motor spirit resumed its sittings on June 6th,* when Sir WILLIAM POPE, professor of chemistry at Cambridge University, gave evidence.

Sir William Pope was asked about certain ethyl tests which have been carried out in America on a monkey. He replied that in his view such experiments on animals did not afford guidance as to what was likely to happen in man. Other experiments in America, in which a number of garage men concerned in the use of ethyl petrol were compared with certain controls, struck him as having only a slight bearing on the case because the men using the ethyl petrol had, no doubt, been carefully cautioned and were aware that they were exposed to something more than the average risk. The important thing was to ascertain what was likely to happen to the careless garage hand. Asked whether he considered the amount of lead found in the faeces a good index to the lead in the body, he said that it left out of account the effect on the central nervous system. In his view lead poisoning might go on for twenty or thirty years. The fact that in America this substance had already been used for five years without any case of poisoning apparently occurring was not altogether reassuring to his mind; he attached a certain amount of importance to it, but he thought it very probable that public health supervision in the States was not as perfect as in this country. He believed that in the States lead poisoning was not notifiable as it was here, so that it was not, perhaps, so likely that the authorities would necessarily be acquainted with any cases occurring. He also fell foul of the description of the material as "tetra-ethyl lead"; it should be described as "lead tetra-ethyl." In reply to the chairman's question, he said that he believed the committee would find it very difficult in any reasonable time to answer what was set out in its terms of reference. His suggestion would be that stringent regulations should be drawn up, and a leaflet issued calling attention to the possible dangers.

In answer to Sir C. J. Martin the witness said that undoubtedly if the petrol containing lead tetra-ethyl were splashed about a great increase in the number of cases of poisoning would be found. In reply to Dr. W. E. Dixon, he said that he had himself made lead tetra-ethyl on a number of occasions during the last thirty years; neither he nor his assistants had suffered from lead poisoning, but they had taken no risks. Asked what became of the lead tetra-ethyl when it was absorbed in the body, he said that in his précis of evidence he had given an account of four men who died after such absorption. In two of these cases the volatile lead substance—presumably lead tetra-ethyl—was discovered in the brain; in the other two there was no volatile lead in the central nervous system. Possibly it was a question of length of time; it might have been absorbed in some non-volatile compound. In reply to Sir William Willcox, he said that the slow degeneration wrought by lead on the nervous system might take many years. He agreed that not only had the time factor to be taken into account, but also the possible idiosyncrasy; the careless worker had to be borne in mind.

At the close of his evidence Sir William Pope was again questioned by the chairman as to his evident scepticism with regard to the United States evidence. Sir Frederick Willis suggested that the five years' experience of the United States afforded a certain margin of safety whereby this country, following in its wake, might always have ample warning of any ill effects. Sir William Pope said that he was not altogether satisfied that this would divert any danger in this country. His reason for hesitation was the incomplete character of the United States health records as compared with those here.

Other witnesses examined at this sitting were Dr. H. B. Baker, professor of chemistry, Imperial College of Science and Technology, who expressed the view that there was a danger in lead tetra-ethyl in petrol, and suggested that a conclusive experiment might be made on those who suggested that no such danger existed, and Professor G. I. Finch, also of the Imperial College, who said that while a saving of many millions would be effected in the national petrol bill by the use of lead tetra-ethyl, he thought that, in the absence of proper regulations, it would involve very real dangers to the community, though it might be ten or fifteen years before the effects of the poisoning would be observed.

* Reports of the earlier proceedings have been published in the *British Medical Journal* of May 5th (p. 770) and May 19th (p. 871).