INTRAVENOUS INJECTION IN WOUND SHOCK.

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THE founder of these lectures was never tired of insisting on the importance of clinical measurements of the blood pressure, and himself devoted much valuable work to the design of appropriate methods of performing such estimations, as well as to methods of determining the haemoglobin percentage contained in the blood. It is therefore not inappropriate that I should ask your attention to the part played by changes in the blood pressure in wound shock, and to the importance of the supply of oxygen to the tissues.

The name "wound shock" was given by Captain Cowell to that state, resulting from injury, which shows itself as a general depression of vital activities, and may end in death if not combated. The names "surgical" and "traumatic" shock have also been used, but "wound" shock seems to be, on the whole, preferable.

Two stages are usually met with in the development of this state, which stages have been called "primary" and "secondary" shock. Either of these may be absent, and the former may pass insensibly into the latter.

DEFINITION.

Primary shock occurs immediately on receipt of the wound, and is in many ways similar to an exaggerated fainting. The collapse and fall of blood pressure is of benefit in that it tends to lessen haemorrhage. If the patient is kept warm and quiet during transit to the casualty clearing station the blood pressure may return to normal. On the other hand, after partial recovery, secondary shock may present itself with renewed low blood pressure and the various results of this condition. The low blood pressure and its consequences are the most general and obvious signs of the state of secondary shock, and it is with these that we are concerned in this place. When I refer to wound shock, it is to be understood that it is the secondary state which is under consideration, as being that requiring treatment.

NATURE OF WOUND SHOCK.

What is the actual nature of wound shock, and especially what is the immediate cause of the low blood pressure apart from haemorrhage, is still obscure.

Conditions which can be Excluded.

It will clear the way, however, if I mention briefly some suggestions that can be at once put on one side.

Acapnia (diminished carbon dioxide in the blood)—because the respiration is not of such a kind as to result in excessive removal of carbon dioxide.

Adrenal exhaustion—because adrenaline is present in excess when shock comes on.

Exhaustion of nerve centres—because reflexes are not diminished to any important degree except when the blood pressure has remained at a low level sufficiently long to paralyse the centres from want of oxygen.

Inefficient action of the heart—because when the arterioles are constricted by a dose of adrenaline the heart is quite able to raise the blood pressure to a high level.

Paralysis of arterioles or veins, especially of the abdominal area—because direct observation in the course of abdominal operations fails to show any abnormal distension.

The Hypothesis of "Exaemia."

The view which finds most favour is that of an accumulation and stasis of blood in capillary areas, so that it is removed from currency as effectively as if lost to the exterior. The name "exaemia" has been proposed by Major Cannon on this hypothesis. Whether there has been haemorrhage or not, then, there is a deficiency of blood in circulation, and the natural result of this is a low

arterial pressure and a failure to supply the tissues with their normal requirements in oxygen.

But why is a low blood pressure the cause of such serious results as to need correction as soon as possible? It will be clear that the due supply of blood to the organs of the body depends upon an adequate pressure. The blood conveys oxygen and removes carbon dioxide and other waste products. Gesell has shown that the blood flow through an organ is reduced more by a fall from a high pressure to a moderate one than by a further fall of the same extent, and that, as the pressure falls, the blood supply is reduced to a greater proportion than the pressure itself. I have been able to confirm this statement, and the practical conclusion to be drawn is that even a moderate fall of blood pressure is not to be looked upon as of little consequence.

Effects of Insufficient Blood Supply Owing to Low Pressure.

The pathological changes which take place in cells when insufficiently supplied with blood are well known. I may mention the suppression of renal secretion, the failure of cardiac contraction below about 90 mm. Hg (Markwalder and Starling), and the changes in nerve cells. Recovery takes place if the pressure is restored without too long a delay. In cats I found that the vasomotor centre loses reflex excitability after one to two hours of an arterial pressure of 60 mm. The respiratory centre fails earlier (Pike and Stewart, Pilcher and Sollman).

A good blood supply is also necessary because various other injurious influences, such as cold, injury to muscles, asphyxia, anaesthetics, acid production, temporary obstruction of circulation to a large part of the body, may not be great enough to have serious consequences, each by itself alone, but becomes so when combined with a small loss of blood, itself also innocuous alone. Gas gangrene is stated to be held in check by a good circulation of blood. Finally, renal secretion is directly dependent on the arterial pressure, so that the elimination of acid and toxic products in the urine is retarded by a low pressure. Experimentally, one finds that the other symptoms of shock disappear when the blood pressure is raised. For example, the rapid shallow respiration after muscle injury is restored to normal when the blood pressure is raised by injection of gum solution.

It appears, indeed, that what we call wound shock is the result of a more or less complex combination of various deleterious factors, not always the same, but always exaggerated by haemorrhage, which is rarely absent, though sometimes not great.

Since the introduction of the Riva-Rocci instrument and its modifications, of which the "Tycos" is very easy to use and keep in order, the measurement of the blood pressure has become a simple matter and ought to become a routine practice.

MEANS TO RAISE BLOOD PRESSURE IN WOUND SHOCK.

What means shall be used, then, to raise the blood pressure in shock? I would point out, to begin with, that a high blood pressure is not our object for its own sake. We wish to increase the blood supply and oxygen supply to the tissues, especially to vital organs such as the nerve centres and the heart. For this reason the use of vaso-constrictor drugs is to be deprecated. Apart from their transitory effect, the result is actually a lessened blood supply to the tissues, because the rise of blood pressure is obtained by narrowing the arterioles which convey the blood. The correct way is to increase the volume of blood in circulation, which involves a raised arterial pressure without decrease of peripheral blood flow.

It is natural to assume that transfusion of blood itself is the best way to do this. I do not propose to discuss this matter at length. A detailed memorandum will shortly be published by the Shock Committee of the Medical Research Committee. Donors are not always available in sufficient number, however, and it is a difficult matter to keep on hand preserved blood or suspensions of corpuscles in sufficient quantity to meet emergencies. A substitute, if efficient, is highly desirable, especially if of such a kind as to be available in unlimited amounts. I may anticipate a little here to remark that, somewhat to my surprise, blood has not shown itself, experimentally, to be so far superior to certain artificial solutions as would have been

expected. If a given case failed to respond to gum, blood was also ineffective. It is probable that, under ordinary conditions, we possess a reserve of haemoglobin, so that the tissues are sufficiently supplied with oxygen by a diluted blood, so long as the body is at rest. Captain Bazett has found cases doing well with a very low haemoglobin value. Another experimental fact seems of some significance: a dilute blood is more effective under a high pressure than a normal blood under a low pressure. This is no doubt connected with the fact above mentioned, that a high pressure is relatively more effective than a low pressure, a fall of one-third means a fall in blood supply by two-thirds or more.

Various Fluids Proposed and Used.

Ringer's solution, although naturally one of the first to be tried, has been found to be useless, both experimentally and in actual practice. It leaves the vessels in the course of half an hour or so, while the blood pressure returns to its former level or even lower. Why is this? Such saline solutions have two obvious defects when compared with blood. These are (1) a low viscosity, so that a given volume is much less effective than its equivalent in blood, even in its immediate effect, and (2) the absence of a colloid with an osmotic pressure. The value of the latter is somewhat difficult to explain shortly. Since the blood vessels are freely permeable to water and salts, while impermeable to colloids, the osmotic pressure of the latter is active and prevents the escape of fluid to the tissues by its attraction for water. Thus the colloids of the blood must not be diminished in strength, for otherwise they do not keep the water from being filtered out in excessive amount by the arterial pressure.

Hypertonic Saline.—This has been used with the object of preventing this escape of fluid by means of the osmotic pressure of the salt. But it will do this only so long as the salt content in the blood remains higher than that of the tissue fluid. Since salts diffuse through the walls of the blood vessels at a great rate, their concentration rapidly becomes equal on both sides, and then the conditions are the same as with Ringer's solution. Experimentally I have found that 2 per cent. sodium chloride is very little, if any, superior to isotonic saline for the purpose in view. It may be mentioned that its value in cholera may be due to other causes, which do not concern us here. Hypertonic saline produces oedema of a perfused organ just as isotonic saline does. Moreover, the injection of hypertonic solutions of any kind requires care; I have seen unpleasant symptoms, such as gasping respiration and slowing of the heart, in cats.

Addition of calcium has been recommended for two reasons. It acts as a vaso-constrictor. But this is very transitory, and we have seen that it is undesirable. It has been stated to decrease the permeability of the blood vessels, and so prevent oedema and transudation in various situations. I have, however, been unable to detect any difference between the rate at which Ringer's solution with and without excess of calcium leaves the circulation, and Cushny has tested the effect on transudations without obtaining any effect.

Acidosis.

Alkaline solutions (sodium bicarbonate) are advocated on the ground that "acidosis" is found to be present in wound shock (Cannon). A brief consideration of this matter is necessary. The blood, of course, never becomes really acid. What happens is that a part of its normal bicarbonate content becomes neutralized by combination with some fixed acid (lactic, etc.) produced in the tissues on account of defective oxygen supply. The point is, does this involve an increase of the hydrogen ion concentration? Is there any real increase in acidity? Some observers have thought such a change to be the essential cause of shock. We may note that the various results described as produced by acidosis are those due to rise in the hydrogen ion concentration. In experiments made to test the question, I have found that as much as one third to one-half of the bicarbonate can be combined with fixed acid without the production of any increase in the hydrogen ion concentration of the blood.

What is the explanation of this? The first effect of the introduction of acid into the blood is to drive off carbon dioxide from a part of the bicarbonate, thus temporarily

raising the hydrogen ion by excess of carbonic acid. But as soon as such blood reaches the respiratory centre, hyperpnoea is caused and the excess carbon dioxide is rapidly removed by the increased ventilation of the lungs. Normally, as Haldane and Priestley have shown, the respiratory centre is extraordinarily sensitive to hydrogen ions and responds by a vigorous discharge.

But, it will be said, suppose the centre is less sensitive, owing to a dose of morphine, for example. Can the "acidity" of the blood rise to a serious extent? I have also tested this possibility. As Lawrence Henderson has shown, as long as any bicarbonate remains there can only be a small rise in the hydrogen ion concentration of the blood, or any similar solution, since the carbon dioxide for the most part cannot remain in solution. The actual change in the blood in my experiments was not greater than the difference between the values of concentrations of hydrogen ion between 1.58×10^{-7} and 1.26×10^{-7} normal. This is extremely small and would be produced by the addition of 0.01 gram of lactic acid to about 10,000 litres of water. To change the more acid blood into normal blood would require merely the reduction of the alveolar content in carbon dioxide to one-half its normal value, a change easily effected by respiration. Henderson and Haggard point out that to maintain the hydrogen ion constant when the Van Slyke value falls from 63 to 42, a marked "acidosis," requires only 50 per cent. more ventilation of the lungs, and that people living at high altitudes have a "normal" hydrogen ion concentration although their carbon dioxide level is very different from that at ordinary barometric pressure.

We may next consider briefly whether the physiological results ascribed to acidosis could be produced by so small a rise in hydrogen ion concentration as may occur.

Stimulation of Nerve Centres.—With the exception of the respiratory centre, the bulbar centres are not easily stimulated by acid. We know that the vasomotor centre is stimulated in asphyxia by the carbon dioxide in the blood, but Mathison has shown that a fairly strong acid injection is required to do this.

The Heart.—Patterson showed that the heart is affected deleteriously by respiration of carbon dioxide of 5 per cent., but not below this value. This is equivalent to neutralizing more than two-thirds of the bicarbonate by acid, supposing that the respiratory centre were inactive. Moreover, the effect of acid is antagonized by very small amounts of adrenaline.

The Arterioles.—Very weak acid (1 in 10,000) causes dilatation. But the hydrogen ion concentration of Ringer's solution is raised by this addition to more than 1,000 times that possible in acidosis.

Capillary blood vessels. Severini stated, were dilated by carbon dioxide, but Roy and Graham Brown failed to confirm the statement. Dale and Richards have brought forward indirect evidence that acid has not this effect.

Transport of Oxygen.—As Barcroft showed the presence of acid in the blood, while it does not much affect the amount taken up by haemoglobin at the alveolar tension of oxygen, reduces the amount held by it at the oxygen tension in the tissues. Consideration will show that this is really an advantage, since the blood arrives at the tissues with practically as much oxygen as normally, while it leaves the tissues with less. The state of acidosis provides the tissues with an increased supply of oxygen.

Viscosity of Blood.—Although statements have been made that acid increases this property, I have been unable to detect any change, even on saturation with carbon dioxide.

Red corpuscles. Hamburger showed, swell in the presence of carbon dioxide. That this does not produce a rise in viscosity is possibly to be explained by the fact that they do not increase in diameter, but become more spherical.

Swelling of Colloids.—Martin Fischer has advocated a series of theories of oedema and nephritis, etc., on the basis of the swelling of colloids and cells by acid. But his experiments show that a concentration of lactic acid greater than N/80 is necessary to affect fibrin or muscle. This has a hydrogen ion concentration more than 10,000 times that possible in blood.

Oxidation Processes.—Some oxidation processes are depressed by acid, but others are not, and the increase found experimentally in sea-urchin eggs was produced by comparatively strong alkali. Lactic acid is rapidly oxidized

in muscle in acid medium, provided that oxygen is freely supplied.

In *diabetes* there is a low bicarbonate reserve, but the blood pressure is not low, while the state could scarcely be called one of shock. Poulton has shown that there is no increase in the hydrogen ion concentration in coma.

Experimental Injection of Acid.—Sometimes, especially in unhealthy animals, the introduction of acid leads to progressive fall of blood pressure to a shock level. But, on the other hand, large quantities may be injected without result, as Dale and Richards have shown. I find no difference between the effects of acid and neutral phosphates in equal amounts.

Conclusions as to Acidosis.

On the whole, I am compelled to conclude that "acidosis" is not in itself a serious factor in shock, and that alkaline injections are not called for. The existence of a decreased bicarbonate content is, however, a sign of defective oxygen supply. In various forms of experimental shock I have found the injection of bicarbonate solutions of small and temporary value only. What effect was produced might have been equally well due to the volume of fluid introduced. If other reasons are thought to require the use of alkali, it is best given by stomach or rectum. The effective way of treating the production of acid in the tissues is by increasing their supply of oxygen from the blood. This suggests that a slight increase of acidity may really be of benefit, since it stimulates the respiratory centre to increased ventilation of the lungs.

Solutions of salts in general are merely of temporary value, and liable to be followed by a greater fall of blood pressure.

REASONS FOR USING A COLLOID: GUM ARABIC.

A colloid must be added to remedy the defects of such solutions. What substances are available and possible for the purpose?

Since such a colloid must possess an osmotic pressure, starch and agar can be excluded at once. Dextrin is deficient in viscosity. Proteins are inadmissible on account of anaphylaxis. They have also an injurious effect on the kidney. We are left with gelatin and gum arabic, both of which satisfy requirements both as to viscosity and osmotic pressure. There are objections to gelatin on account of its liability to contain tetanus spores. But the more serious objection is its liability to cause intravascular clotting, as found by Dale and Richards. Fortunately, gum has none of these defects. A solution of 6 per cent. strength has been found, both in the case of wounded men and in lower animals, to maintain the blood pressure indefinitely. It does not leave the blood vessels. Gum is quite innocuous, even in a volume equal to one-half of the total blood volume, or an injection of more than a litre and a half in man. It produces no haemolysis nor agglutination in man and does not increase the viscosity of the blood. Since it contains no protein, anaphylaxis in case of a later injection would not be expected, and, tested on guinea-pigs, was found not to occur.

Although gum seems rather a strange substance to introduce into the blood, it is chemically a very inert substance and is not really foreign to animal metabolism. It consists of derivatives of galactose and of arabinose. Galactose is a natural sugar present in milk. Arabinose appears in the urine in pentosuria and appears to arise from galactose by removal of carbon dioxide (Neuberg).

Since commercial products contain small amounts of calcium and potassium salts, there is no need to add them. All that is necessary is the addition of 0.9 per cent. of sodium chloride, and tap water may be used. The solution must be filtered through flannel or other convenient medium and then sterilized. A strength of 6 per cent. is probably the best for routine use, and arrangements are made for its supply through the usual mechanism of the Army Medical Department. In practice, even 3 per cent. has been found greatly superior to saline solutions, but it is clear that its osmotic pressure is not the optimal one.

The value of gum infusions is, naturally, most striking and rapid after haemorrhage. But practical experience, as shown, amongst others, in the cases reported by Captains Cowell and Drummond and Taylor, has demonstrated its utility in various other forms of shock. It is not to be expected to be of avail when the bulbar centres have

permanently lost their excitability; but even blood is useless in such cases. Hesitation might be felt in transfusing blood in a case apparently hopeless, and one advantage of gum is that no restriction in its use need be felt. A case is reported by Captain Cowell, pulseless and moribund on arrival at the casualty clearing station, restored permanently by gum. The dangers of prolonged low blood pressure justify the contention of Colonel Fiaschi and Captain Bullock, who insist on the importance of early intravenous injection, as soon as possible after the injury. There is, of course, some risk of increasing haemorrhage. Drummond and Taylor advocate the use of the tourniquet in the case of wounds of limbs. If there is internal bleeding, it may unfortunately be necessary to defer intravenous injection until operation is commenced.

Experiments with Gum Solution.

On account of the fact that gum showed itself to be useful in wound shock generally, I have made some experiments on cats in order to investigate its effect in states of low blood pressure other than those due to haemorrhage alone. We may remember that there is reason to believe that in all such cases blood is out of currency somewhere and can be replaced by an appropriate solution, allowing recovery to take place in due time.

A shock-like condition may be produced experimentally by prolonged cold, by asphyxia, by local anaemia on reopening the blood current, and sometimes by injection of acid. In all cases the state is much exaggerated by slight haemorrhage and is effectively treated by gum injection. Erlanger and his colleagues have recently found that gum holds fluid in the vessels in all forms of shock with which they worked, that due to exposure and manipulation of the intestines, in addition to that of temporary anaemia of a part of the body. I may remark that, although intestinal trauma is a common mode of inducing experimental "shock," it seems to me that it is rather dissimilar to the actual wound shock met with after shell wounds.

SHOCK IN INJURIES OF MUSCLES.

Probably the most interesting form of experimental shock is that due to crushing of muscles. The experiments were commenced in conjunction with Major Cannon and continued, from another point of view, since his departure. The appearance of the injured muscle reminded us very strikingly of that of muscles in recent shell wounds as we had seen them in France, and the general phenomena are more like those of wound shock than most forms of experimental shock are. General Cutlibert Wallace has called attention to the greater liability to operative shock when large masses of muscle are cut. Compound fractures and multiple wounds are commonly followed by more or less severe shock.

In a typical experiment severe mutilation of the thigh muscles in decerebrate cats, or cats under urethane or ether, results in a primary fall of blood pressure, which may or may not be partially recovered from. This fall is usually followed by a further progressive fall, which can be counteracted by gum with return of the blood pressure permanently to the normal height. The phenomena appear to be due to the absorption of some depressant substance from the injured tissue, since they occur when the spinal cord has been divided in order to exclude nervous reflexes. This substance is either oxidized or eliminated if the blood pressure is high enough. It is not lactic acid, as would naturally be supposed, since the injection of lactic acid during the state of low pressure is rather beneficial than otherwise, and bicarbonate injections are almost useless. Massage of the injured muscles results in a further fall of blood pressure, with dilatation of the intestinal vessels. This fact is of interest in connexion with the great benefit known to follow the immobilization of fractured thighs by the use of the Thomas splint during their transit to the casualty clearing station.

Respiratory Disturbance in Shock.

A remark may be made on the peculiar form of respiration shown in these cases of muscle injury. It has often been noticed that wound shock is associated with a rapid but shallow breathing, occasionally interrupted by a deep sigh. This is also the case in cats, where the rapid return to normal when the blood pressure is raised by gum is

very striking. The cause and nature of the phenomenon require investigation. It may also be seen after haemorrhage, but, so far as my experiments go, a mere fall of blood pressure, as by inhibition of the heart or the injection of a dose of acetyl-choline, does not produce it. It has some significance in connexion with acidosis, because it is quite different from the rapid but deep breathing caused by rise in hydrogen ion concentration. A condition similar to the respiration of shock has been described by Haldane in late stages after gassing, and ascribed to an exaggeration of the Hering-Breuer inhibition of inspiration.

Conditions in which Gum Injections are Valuable.

Some cases treated with gum injections by Fraser and Cowell and by Drummond and Taylor may be briefly mentioned in order to indicate the variety of states in which it may be of service to practise such injections. Severe haemorrhage from abdominal wounds and from arteries; cases in which haemorrhage and shock were not excessive, but in which a dangerous fall of blood pressure followed operation; other cases in which there was severe shock, but only slight haemorrhage, were all treated with success. Some of these were complicated by gas gangrene, and one case of this infection in which there was neither shock nor haemorrhage, but a blood pressure of only 70 mm. Hg, recovered after the blood pressure had been restored by gum.

GENERAL CONCLUSION.

The general practical conclusion to be drawn from the various considerations brought forward is, I think, that the main factor in the successful treatment of wound shock is to ensure an adequate supply of blood—that is, of oxygen—to vital organs, especially to the nerve centres. This is most simply done by intravenous injection of gum solution, which does not appear to be, in most cases, inferior to blood. When very great haemorrhage has occurred, it would seem reasonable that blood transfusion should be preferred.

If the use of sodium bicarbonate is thought necessary, it is best given by stomach or rectum. But it has not yet been demonstrated that the symptoms relieved by bicarbonate would not be more effectively cured by raising the blood pressure. In principle it would seem to be a mistake to reduce the slight increase of acidity in the blood, since this is of value in stimulating the respiratory centre, and there is no evidence that the slight increase of hydrogen ion concentration which is present in some cases of acidosis, but not always, is in any degree harmful in itself.

A Collective Investigation OF TEN THOUSAND RECRUITS WITH DOUBTFUL HEART CONDITIONS.

*Conducted at the National Hospital for Diseases of the Heart by C. CHAPMAN GIBBES, R. O. MOON, S. RUSSELL WELLS, P. HAMILL, F. W. PRICE, and J. STRICKLAND GOODALL.**

*Preliminary Report, compiled by
S. RUSSELL WELLS, M.D., B.Sc.*

In February, 1916, by desire of the War Office, the honorary medical staff of the National Hospital for Diseases of the Heart undertook to act as expert referees on all cases of doubtful cardiac conditions referred to them by the various recruiting boards of the metropolitan area.

Methods Employed.

In every case an exhaustive medical history was taken, inquiry was made into subjective symptoms complained of, and the ordinary clinical examination by inspection, palpation, percussion, and auscultation was undertaken. In addition to this the urine of every recruit was examined, the pulse, blood pressure, and the respiration was taken in

the recumbent position before and immediately after a standardized piece of exercise, and again after three minutes' rest in the recumbent position. Each case was electro-cardiographed, and the heart was examined by means of the *x* rays. As the result of these various methods of examination a diagnosis was arrived at, and the medical boards were advised as to the category for service for which, in the opinion of the examining physician, the recruit was fitted, the responsibility for the actual classification adopted necessarily resting with the medical boards. The subjoined form, which was filled up in the case of every recruit examined at the hospital, a copy of which was transmitted to the medical board sending him for examination, will show the character of the inquiry.

REPORT ON CARDIAC CONDITION OF RECRUIT.

Name Date
Occupation Age
Recruit's Statement

Previous Diseases :

Specific Fevers	Growing Pains
Rheumatic Fever	Diphtheria
Chorea	Influenza
Tonsillitis	Haemorrhages
Other Diseases	

Habits :

Exercises
Alcohol
Tobacco

Subjective Symptoms :

Breathlessness	Faintness
Pain	Sleeplessness
Palpitation	Nocturnal Decubitus
Vertigo	Diuresis
Sense of Exhaustion	

Inspection :

Appearance	
Anaemia	Clubbing
Cyanosis	Jugulars
Pulsations and Impulses	Oedema
Vasomotor Disturbances	

Palpation.

Heart.—Rate	Thrills
Apex Beat.—Position	Character
Remarks	
Pulse.—Rate	Rhythm
Character	Volume
Vessel Walls	

Percussion.

Limits of cardiac dullness.
Right..... inches from mid sternal line.
Left inches from mid sternal line.
Remarks

Auscultation.

Heart sounds
Adventitious sounds

State of Other Organs

Urine.—Sp. gr. Albumin

Reaction to Standard Work.

Before Exercise :
Pulse..... Blood pressure..... Respiration.....
After Exercise :
Pulse..... Blood pressure..... Respiration.....
After Exercise (3 minutes).
Remarks
Work done foot lb. in seconds.

Electrocardiogram.

.....

X-ray Examination.

Remarks

DIAGNOSIS

RESULTS OF EXAMINATION:

So far as concerns his heart the above recruit is fit for

Signed

As the result of this work a large number of records have been accumulated, and it is felt that the material thus obtained, if carefully analysed, may assist in elucidating certain problems connected with affections of the heart.

* Dr. Moon left for army service in April, 1917; Dr. Hamill left for army service in July, 1916; Dr. Price was away on leave of absence for six months from the beginning of December, 1916.