x-ray examination shows that there is no actual injury to the spine.

In many cases faeces and urine are at first passed involuntarily. The initial incontinence does not last more than a few hours. It may then be replaced by retention for twenty-four hours, and this is sometimes followed by difficulty in micturition for two or three days, but the condition of the bladder is generally normal by the time the patient reaches England.

2. HYSTERICAL SYMPTOMS GRAFTED ON TO ORGANIC BASIS OF CEREBRAL OR SPINAL CONCUSSION.

In the confused mental condition which follows shell shock a man is abnormally suggestible, particularly if he is already exhausted owing to the stress and strain of active service. The organic paraplegia which is the result of transient structural changes in the spinal cord produced by concussion disappears with the return of the cord to its normal condition; it is then often replaced by hysterical paraplegia. Finding that he is unable to move his legs when he first regains consciousness, a man becomes convinced that he is paralysed and makes no further efforts; the paralysis thus produced by auto-suggestion can be removed by persuasion or a counter-suggestion. In the same way, when one side of the brain has been chiefly affected by the concussion, an initially organic hemiplegia merges into hysterical hemiplegia. I have watched several cases, in which all the physical signs of organic paraplegia or hemiplegia were at first present, but have gradually disappeared in the course of a few days or weeks, although the paralysis has remained, until by suggestion or persuasion it has been cured in a few minutes. Sometimes, however, some organic signs remain, and suggestion then can only produce an incomplete cure, a slightly spastic gait or some slowness and lack of accuracy in the first movements of a limb being left as the permanent result of the shell shock.

As complete or almost complete recovery from the organic symptoms occurs in the vast majority of cases, the prognosis can be regarded as good, and an attempt should be made as soon as the initial stupor has passed away to persuade the patient to walk. It is extremely difficult so long as any organic signs persist to judge to what extent the symptoms are organic in origin, but experience has shown that some physical signs of organic disease, such as an extensor plantar reflex, greatly exaggerated knee-jerks and true ankle-clonus, and unilateral absence of the abdominal reflex, may still be present when the character of the gait and its rapid improvement with persuasion and re-education show that the symptoms are almost entirely hysterical.

Apart from the hysterical manifestations which result from the perpetuation of symptoms produced by transient organic lesions of the central nervous system, others may be produced by auto-suggestion without any primary organic condition. These hysterical manifestations are very varied, and it is at first difficult to explain why one man should become blind, another deaf and dumb, and another hemiplegic under apparently identical conditions. From careful inquiry into the history of numerous cases I have come to the conclusion that the variability of the symptoms can best be explained in the following way. As a result of the various factors which give rise to shell shock all the functions of the body are in abeyance for a period which varies in different cases; the patient cannot see or hear or feel, he cannot talk, he cannot move, and his mind is a complete blank. In many cases all these lost functions gradually return in the course of a few hours, though some come back more rapidly than others; the patient is then in much the same condition as a man who has been concussed by falling on his head, with a number of symptoms, such as headache, difficulty in concentration, and lack of energy, but there is no paralysis nor loss of any of the special senses. In other cases, as consciousness returns, the patient's mind becomes fixed on some part of his body which is painful, the pain being the first impression powerful enough to attract his awakening attention; or the temporary inability to see or hear or speak, which generally remains unnoticed when consciousness first returns because of the absence of any desire to see or hear or speak, is suddenly realized owing to a special call being made on one of these functions. The patient's dawning intelligence becomes fixed upon this single missing function, and he suggests to himself that the disability will be

permanent. The fact that the other functions are missing remains unnoticed, and after a time they spontaneously return. The persistent localized loss of function is thus due to auto-suggestion leading to the perpetuation of what would otherwise be a very temporary incapacity; it can thus correctly be described as hysterical.

Less frequently the impressions received by the patient between the moment the explosion occurs and the moment when consciousness is lost give the key to the symptoms. The first thought of a man on regaining consciousness after being deafened by the noise or "struck dumb" with terror when the explosion took place may result in the suggestion of deafness or dumbness.

Treatment.

Rest in bed is required for the symptoms of shell shock which are the result of actual concussion. In civil practice it is a common event to see patients suffering from chronic headache after cerebral concussion, and chronic backache after spinal concussion, both of which might have been prevented by sufficient rest immediately after the injury. The same is true after shell shock and burial, and many men, who pass from one hospital to another for many months receiving all sorts of expensive treatment with little or no benefit, could have been rapidly cured by simple rest immediately after the injury. On the other hand, the rest must not be too prolonged, and it requires considerable experience to judge the right moment when such patients should be allowed to get up. If kept in bed too long, they are very liable to lose their power of standing and walking, as the care taken to keep them at rest may give them the idea that they are severely injured, and hysterical astasia-abasia or paraplegia develops. In order to prevent this, the patient should be made to get up to go to the lavatory and to have a bath from the first day, except when severe stupor is present, in which case he should get up as soon as it has sufficiently diminished. When the patient no longer complains of pain in the head or back, he should be encouraged to take exercise, the amount of which should be steadily increased. Massage often aggravates the pain, and it tends to increase the tendency to introspection.

The associated hysterical symptoms should be treated in the manner already described.

AN INVESTIGATION OF TRENCH NEPHRITIS BY MEANS OF PHENOLSULPHONEPHTHALEIN.

BY

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It is not always a very easy task to exhibit faithfully in tablet form work which has extended over twenty months. Nevertheless, the attempt has been made in this paper without, if possible, rendering the picture incomplete. For many facilities in connexion with the investigation I have to thank the officer in charge, Lieut.-Colonel J. Harley Brooks, M.D., R.A.M.C.

To American workers we are specially indebted for the advances in biochemistry relating to the renal functions which have been a feature of the past six or seven years, Folin and Denis, and Van Slyke, in particular, have done pioneer work, and produced indispensable tests for the various non-protein waste products of the blood and urine. A voluminous literature has already accumulated round this subject, which is steadily being pursued with excellent promise. One of the most fruitful means of investigation was undoubtedly supplied by the introduction of phenolsulphonephthalein as an index of renal function by Rowntree and Geraghty in 1910.¹

The technique of the test may be studied in the original; suffice it to say here that it consists in the subcutaneous injection of an alkaline solution of 6 mg. phthalein after preparation of the patient. The urine is collected after one hour and after two hours. A few drops of 25 per cent. NaHO solution is added to it, and the resulting pink colour, after dilution of all the urine with water up to a litre, or the equivalent of this dilution of a small quantity, is read off in the colorimeter, or against tubes containing

standard colour solutions of the dye. An excretion of 50 per cent. of the amount of dye injected may be set down as the normal average in one hour, and 25 per cent. in the second hour. Both the hourly and two-hourly percentages are usually taken, but after repeated trials I have found that ordinarily the first hour's percentage is sufficient. Indeed, if anything, it is the more searching test, as in the case of defective kidneys the second hour's excretion is often higher than that of the first. It is essentially the slowness of the elimination which characterizes renal defect.

Rowntree and Geraghty consider the phthalein test superior to methylene blue, indigo-carmin, rosaniline, and phloridzin, owing to (1) ease of application, (2) rapidity of action, and (3) reliability. These investigators also found the calculation of the urea output, total nitrogen, total solids, and quantity of the urine passed to be "of no value whatever as indicating the true renal activity." As regards other tests for renal function, besides being much more difficult, and tedious of execution, they are open to certain fallacies. The lactose test of Schlager, and the diastase test of Wohlgemuth have been chiefly used. As regards the first, it sometimes contravenes a result uniformly given by other tests. As regards the latter, recent work of McClure and Pratt² has shown enormous variation both in normal and pathological cases. Wohlgemuth placed the maximum normal limit at 64 diastatic units, but certain of the cases investigated showed anything up to 400 units. The dietary test introduced by Hedinger and Schlager in 1914, and its modification by Mosenthal, is no doubt of high value, if very tedious. Cases of severe anaemia, however, respond to it in the same manner as advanced nephritis.

The Non-protein Nitrogen of the Blood.

Renal efficiency means above all else the power of the kidneys to eliminate adequately the non-protein or in-coagulable nitrogenous bodies—urea, uric acid, creatinin, etc.—which accumulate in the blood not only under ordinary conditions, but also under exceptional circumstances of diet, exercise, etc. Accordingly, a great many investigations have been made with the view of estimating the various movements, so to speak, of these substances, and the significance attaching to them in the various conditions of disease. In health great fluctuations are found in the urea concentration of the blood, diet being an influential factor. But in renal disease also, as shown by Folin, Widal and Javal, and others, the urea of the blood may be made to fluctuate at will by varying the protein intake. A reasonable upper normal limit for urea is 30–40 mg. per 100 c.cm. of blood, for uric acid about 3 mg., and for creatinin about 2.5 mg. For the total non-protein nitrogen about 30 mg. per 100 c.cm. of blood is a reasonable upper normal limit, the urea nitrogen being about half the total, or 15 mg. In acute or far-advanced cases of nephritis the urea of the blood may mount up to hundreds of milligrams per 100 c.cm., but in the earlier chronic stages the figures may easily approximate to normal, and continue so indefinitely under appropriate diet. No information as to the state of the kidneys would be obtained in such cases from an examination of the blood alone, yet renal deficiency would certainly be indicated by the phthalein test. A notable advance was, however, made by Ambard, who arrived at certain laws as to the ratio between the concentration of urea in the blood and the rate of its excretion by the kidney per unit of time. He believed he had found that normally a constant relationship exists betwixt these two factors—the constant or coefficient of Ambard. This law has been subjected to very searching tests, one of the most recent being by Addis and Watanbe,³ who found variations in the constant in health under conditions of increased urea derived either from food or from disintegration of tissue protein, or preformed from the alimentary tract. Apart from this, however, in renal disease there is a relative increase in the urea concentration in the blood and a relative decrease in the rate of excretion. There is a general consensus of opinion that in nephritis Ambard's coefficient and the phthalein test give fairly parallel results, and of the two the phthalein is the more reliable.

Phenolsulphonaphthalein has also been used in this investigation as an indicator for the hydrogen ion concentration of the blood and the alveolar carbon dioxide tension after the method of Sørensen, using acid and

alkaline phosphate mixtures as standard solutions. The phthalein is specially adapted for this purpose, as, according to Levy, Rowntree and Marriott, it is the best indicator for minute differences in the H ion concentration between $10^{-6.4}$ and $10^{-8.4}$ (passing through neutrality). Full instructions for carrying out the tests have been given by Marriott.⁴

In the case of the blood it is necessary to indicate the H ion concentration in terms of the reserve alkalinity of the serum after driving off the CO_2 by a current of air. This is expressed (after the notation of Sørensen) as R p H. The serum is dialyzed through a celloidin sac into a saline solution of the indicator, the CO_2 is driven off, and the colour compared with those of standard tubes. The process requires to be done most carefully, owing to the great delicacy of the reagents.* Normally, the reserve alkalinity is R p H 8.5 or very nearly. I examined eight cases in the earlier chronic stage of the disease, and obtained values from R p H 8 to normal. On the other hand, the estimation of the alveolar CO_2 is very easily performed, and for routine ward work most handy. The air is collected by the Plesch method, the respirations into the bag (containing 1,000 c.cm. air) occupying twenty-five seconds. The respired air is then bubbled through a standard alkaline phthalein solution, and when the change of colour is complete, the tube is compared with a graded series of standard phosphate-phthalein tubes.† The entire test may be completed within five minutes, but the patient must first be taught to breathe properly.

In the nephritis cases no low tensions were found except in a few presenting either pulmonary or circulatory disturbance. Thus a case with cardiac dilatation (right sided) gave a reading of 30 mm. Hg (the normal being 40–45). But little evidence of acidosis is forthcoming from the renal condition in the post-acute stages.

General Results of the Phthalein Test.

The cases herein referred to were young soldiers discharged from hospitals abroad after the acute symptoms had subsided. Acute cases occurring at home, either in the young or middle aged, are not included. As a matter of fact, the test is useless in acute cases. The number of cases has been large, an entire ward being utilized in connexion with this investigation. The complete results are based on 42 selected cases. The routine consisted in making the test soon after the patient's admission, and repeating it at intervals of about three weeks. Concomitantly the blood pressure was recorded. The examination of the urinary sediment, tube casts, blood cells, etc., was conducted by the pathologist, Dr. Rowlands.

In what may be termed the second state of trench nephritis the urine is usually abundant, often considerably in excess of the normal, with a rather low specific gravity, though in some the specific gravity is normal. Albumin may be present in high percentage or but slight. At first blood is very frequently present, but it generally disappears a long time before the albuminuria. Tube casts are almost constantly found, generally of the granular or hyaline varieties. As recovery proceeds, the quantity of urine diminishes. Perhaps the most striking thing about the phthalein test is that it bears no relation whatever to the quantity of albumin or the presence of tube casts. A patient with slight albuminuria *minus* casts may give only an excretion of 20 per cent. in the hour, whereas a case in which the urine is loaded with albumin and containing numerous casts may give a 50 per cent. excretion. At first this was a very puzzling phenomenon, but the progress of the case always justified the verdict of the phthalein, given thus early, as to the ultimate result. As soon, therefore, as such patients are admitted to hospital we can make a prognosis from this test without reference to any other factor in the case. It is needless to expatiate on the value of this.

Certain observers—Pepper and Austin, Baetjer, Sellards—have alleged that cases of severe parenchymatous nephritis are occasionally encountered in which there is hyper-permeability on the part of the kidney to the substances used as functional tests, including phthalein. Pepper and Austin give two such cases having phthalein excretions of 50 per cent. and 46 per cent. respectively in

* These, with the celloidin tubes, were made by Martindale.

† These were prepared by Baird and Tatlock.

one hour. Deficient chloride elimination was observed also. Sellards has one case; Baetjer has four (also with deficient chloride elimination) in which he also noted the fluid balance, the elimination of lactose and potassium iodide, and the percentage of rest nitrogen in the blood. Baetjer adds, however, that a high excretion of phthalein may justify a good prognosis in these, as "none of them have yet come to autopsy."⁵ A very comprehensive study in relation to this point was made by Thayer and Snowden,⁶ who recorded the complete results in 54 cases of chronic nephritis right up to the necropsy, and declared that in not a single instance did they fail to find a material diminution of the phthalein. The progressive diminution of the phthalein excretion with the advance of the disease was definite and striking. They observed, however, that cardiac disease with chronic passive congestion often causes a considerable reduction of the phthalein output. This point is important. I have found a reduced phthalein elimination in cases presenting want of oxygen, howsoever induced, or in which the alveolar carbon dioxide tension was low. Kendall,⁷ in a suggestive paper, records experiments which seem to show that oxygen protects the dye, and that it is destroyed by the reducing substances of the body. So far as trench nephritis is concerned, high excretion of the dye has never been encountered in cases which did badly. On the contrary, they all made good recoveries. The elimination of chlorides and sulphates was normal in all such cases examined.

The cases in the second month of the disease showed phthalein elimination varying from 15 to 50 per cent. or over in one hour. Needless to say, the early high percentage cases do well, and some, though by no means all, also lose their albumin quickly. For the others, which form the great majority, the third month is rather critical. It may be best to summarize the matter, and indicate a classification which is the outcome of long-continued observation of the cases.

1. If, within three months from the onset of the disease, the phthalein excretion rises to 40 per cent. or over in one hour, recovery will be good, even should albuminuria continue for another two months or possibly longer. For part of this time casts may also be present.

2. If, at the end of the third month, the phthalein excretion be under 30 per cent. in one hour, notwithstanding a slight degree of albuminuria, or with intermitting albuminuria, recovery will be protracted, and in some of the cases unsatisfactory.

3. If, at the end of four months, the phthalein excretion reaches 40 per cent. or over, ultimate recovery is the rule, even should the albuminuria last for several months longer.

4. If the excretion remains persistently low (15 to 30 per cent.) up to the fourth or fifth month, the prognosis is unfavourable without reference to the presence or degree of albuminuria. Several such cases which reported themselves after eight to nine months still presented a low index of elimination and slight albuminuria. As to the final issue, it is difficult to say, but the fact that they all had either normal blood pressures, or slightly over, seems to presage in some of these a favourable result.

As regards the distribution of the cases, if we include in Class 1 those showing high elimination in the second month, a total of about 50 per cent. would be represented in this class. The cases in Class 2 proceed either to Class 3 or Class 4, between which the remaining 50 per cent. were fairly evenly distributed, if anything a slightly higher percentage being in Class 3.

A good many cases admitted were relapses after being sent back to active service from other centres. No doubt in these the albuminuria had disappeared at the time, but it is doubtful if the phthalein test (had it been made) would have been satisfactory. Even had it been, one is compelled to doubt if a return to active service is in any case warrantable. It is very probable that in a goodly percentage of the cases some antecedent kidney disability, or a tendency thereto, existed.

The phthalein test also serves as a very good guide to dieting. An excretion under 30 per cent. indicates a milk and vegetable diet; 30 to 35, the addition of fish or chicken; and over 35, ordinary diet with extra milk, provided the albuminuria is moderate and not increased by the diet, and blood is absent. All cases appear to derive benefit from an iron mixture.

Considerations as to the Pathology of the Disease.

What may be termed the clinical impression given by trench nephritis differs materially from that of ordinary parenchymatous nephritis. The subjective feeling of well-being, and the absence of the symptoms of ill health in the

vast majority, are characteristic. The disease may present two very puzzling features. One is the intermittence of the albuminuria which occurs in a few cases, even where the albuminuria is of a high grade. Complete absence of albumin may be recorded one day, and on the next or a few days thereafter perhaps as much as 1 to 1.5 per cent. may be present. Care, of course, must be taken lest an alkaline urine be present which fails to react with heat. The other curious condition is a persistent high degree of haematuria without albumin latterly (except such as is due to the blood). On these conditions speculation is perhaps better avoided. The long persistence of a high grade of albuminuria, with casts in some cases, might seem to create a need for revision of our ideas as to their significance. Again, except in the early stages, the blood pressure is nearly always within normal limits (110 to 135 mm. Hg), and, as we have seen, the kidneys may perform their functions perfectly as soon as the acute stage is over. The disease is doubtless due to an infection. Certain microscopical findings by Dunn and McNee⁸ can hardly be regarded in an etiological sense. I venture to suggest a comparison with acute pneumonia. Just as an entire lung may be involved in the acute stage, so, doubtless, the entire kidney is at first inflamed. When resolution occurs, a district or districts of kidney fail, just as may occur in a section of lung, which continues in the state of delayed resolution—that is, an epithelial overgrowth and desquamation. Such a lung may, of course, be perfectly competent to carry on normal respiration even under average conditions of exercise, and recovery of the damaged area may ultimately be complete. This view of the kidney lesion explains the presence of albumin and tube casts alongside a normal functioning power and a normal blood pressure. As regards the abundant secretion of urine, this would seem to depend on vaso-dilatation of the renal vessels, due to metabolic products.

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THE OCCURRENCE OF SPIROCHAETES IN THE URINE.

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A WIDESPREAD interest in the increasingly numerous group of diseases known to be caused by spirochaetes, and the consequent desire for a rapid and sure means of diagnosis, have brought forward the possibility of recognizing such cases by finding the spirochaetes in the urine.

I.—INTRODUCTORY.

That spirochaetes may actually be excreted by the kidney in diseases of spirochaetal origin is a fact resting on the reliable experimental evidence of the workers on spirochaetosis icterohaemorrhagica. Their animal experiments have demonstrated that spirochaetes occur in the urine which have the same pathogenic effect on guinea-pigs as the organisms found in the blood. Obviously a similar excretion may occur in other diseases, and thus afford an easy means of diagnosis.

Certain observations made recently at this hospital, however, show a source of error in a procedure of this kind. It was found, in brief, that:

1. Spirochaetes are not uncommon organisms in the urethra of men without history or symptoms of relapsing fever.

2. Many different varieties are found.

3. Some of the varieties seen are morphologically closely similar to pathogenic varieties.

4. The spirochaetes occur so definitely within the urethra that they are an obvious source of contamination in uncatheterized specimens of urine.

5. They are a sufficiently dangerous source of error, even in catheterized specimens, to deserve attention in careful work.

6. It is possible that a staining reaction or some other morphological character may be discovered to differentiate microscopically the common and harmless from the patho-