Later it also takes on malignant changes, growing more rapidly, invading its capsule and the renal vein, and disseminating. It is remarkable that two growths in the same tract should share this somewhat rare characteristic, but it only makes the importance of an early diagnosis more self-evident, for in the early stage the treatment is that of a non-malignant neoplasm, is easy and satisfactory, and a complete cure can generally be achieved, whilst later the growth becomes malignant and the prognosis proportionately unfavourable.

Nature is, as it were, in each of these cases holding out to us in the early stages the option of successful treatment, if we are but wise enough and shrewd enough to avail ourselves of the opportunity, but she will just as certainly snatch away the proffered chance if we do not seize and secure it, and the indication which she gives us of this dangerous condition is the preliminary haemorrhage which is often so transitory.

To recapitulate, I have tried to show that haematuria is frequently the only symptom of a growth of the urinary tract; that following this expression of its presence it may retire into absolute quiescence for a long period, during which it is probably increasing in size and advancing towards malignancy; that when it reasserts itself, whether by a second haemorrhage, or by pain, or dysuria, or the presence of a lump, it may have passed beyond the operable stage, and that, if the growth should prove to be of the upper urinary tract, the only time at which a diagnosis of the anatomical site can be made is during the period of actual bleeding.

The moral is obvious, but I fear is often missed, and this I wish to impress on your minds. Haematuria is not a symptom to be treated *per se*. It is a red danger sign, urgently demanding an accurate diagnosis—first as regards its anatomical point of origin, and secondly as regards its pathological cause. It is an easy thing to put a patient suffering from acute abdominal pain to bed, and give a hypodermic injection of morphine. Such a course will be followed by relief of the pain; but the profession has long ago learnt the hazard of such a course so long as any doubt remains in regard to the diagnosis. Similarly, it is an easy matter to put a man suffering from haematuria to bed, apply cold, and administer certain reputed haemostatics. Such a course may be rewarded by a cessation of the haematuria, and the medical attendant will have the gratitude of his patient, but surely, on contemplation, must have the mortification of realizing that he has done him a great disservice. Much better had it even been if he had kept him in active life, and rather sought to perpetuate the haemorrhage than to allay it, till such time as a cystoscopic examination could be arranged, and the source of the haemorrhage accurately located. Once the haemorrhage is stopped the opportunity has passed, possibly for a long period, and unless some gross swelling of one kidney can be palpated, or the patient is persuaded to submit to a cystoscopy, which may reveal some causative bladder condition, the golden opportunity has gone by and may not recur till much valuable time has been lost.

Instances of such misguided treatment are unfortunately only too frequent in any urinary practice. I will cite a single case which I have seen comparatively recently. A man had had a short sharp haemorrhage from the bladder three years previously for which he had been treated by his medical attendant with cessation of the haemorrhage. From this point onwards there was no symptom at all till he began to suffer from discomfort in the bladder region and the sensation of incomplete emptying of the bladder even when he had just urinated. Cystoscopy revealed a growth of such large dimensions that examination was difficult owing to the instrument plunging amongst the fronds of a papilloma, which on account of its size had to be removed by suprapubic cystotomy, and when this was done there was revealed a pair of lesser "kiss-cancers" on the opposite bladder wall. If this patient had undergone cystoscopy three years previously his condition would probably have been treated rapidly and easily by diathermy, and the open operation would have been unnecessary.

As the growth gets older the attacks of haematuria tend to become more prolonged, severe, and frequent. On certain occasions I have had to undertake the examination of patients who have been under treatment for continuous haematuria for weeks, a few of these having become abso-

lutely blanched by loss of blood. In one instance a medical attendant informed me that he had attempted to knock off portions of growth by introducing a metal instrument and twisting it about in the bladder—a practice which is condoned in textbooks belonging to a past generation, but which obviously must be condemned in view of the possibility of ocular demonstration by modern methods.

These are the grosser errors, but I have nevertheless been much impressed with the late stage at which urinary growths reach the surgeon, and the consequent difficulty of obtaining good results in these cases. Indeed, if good results are to be obtained, the cases must come up at the first onset of symptoms.

That other urologists find the same trouble I am convinced. Braasch, in an analysis of a series of 83 cases of hypernephroma of the kidney, found that as an average haematuria had existed for more than a year in 77 per cent. before other symptoms precipitated treatment.

As a matter of fact the doctor is frequently not responsible for the delay, for patients often cannot be brought to realize the importance of the condition, so long as it is unaccompanied by pain or discomfort. I have on many occasions been astonished at the complacency with which patients, particularly amongst the uneducated classes, regard it, and have had on several occasions to use considerable pressure to persuade such to submit to a full examination of the urinary tract because they could not understand the importance of the condition. Bransford Lewis records the case of a man suffering from a hypernephroma of the kidney who carried about with him for six years a letter from his medical man to a consultant, in spite of the fact that blood was present in the urine all the time. Similar instances could be multiplied, though the duration in this case was extreme.

I have, however, laid emphasis on the responsibility of the medical attendant, because I consider the importance of an early cystoscopic examination has not been adequately brought home in the past. Had symptomless haematuria been as common as the acute appendix, it would have gone through the same phase that the acute abdomen experienced fifteen years ago, and would now be invariably submitted to immediate cystoscopy, just as the acute abdomen is invariably submitted to immediate laparotomy.

A SEROLOGICAL STUDY OF HAEMOLYTIC STREPTOCOCCI:

DIFFERENTIATION OF STREPTOCOCCUS PYOGENES FROM STREPTOCOCCUS SCARLATINAE.

BY

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ALTHOUGH definite progress has been made within the last twenty years, knowledge concerning individual races included within the family of bacteria presenting the common morphology of *Streptococcus* is still at an early stage. It is now fifteen years since streptococci commonly met with in disease were investigated by Andrews and Horder with regard to their biochemical characters (Gordon), their haemolytic power (Schottmüller), and their pathogenicity for laboratory animals, and differentiated into three chief classes of *salivarius*, *faecalis* and *pyogenes*. This classification has stood, and to-day the three groups of *salivarius* or *viridans*, *faecalis* or the enterococcus, and *pyogenes* or *haemolyticus* are widely recognized. As scarlet fever is a disease in which streptococci are constantly present, and have been suspected of primary etiological influence, a special study was made independently by Cumpston and myself of the biochemical characters of the streptococci present on the tonsil and fauces at the onset of scarlet fever. It was found that, as regards the characters in question, the particular streptococcus present there with the greatest constancy and in the greatest abundance could not be distinguished from specimens of *Streptococcus pyogenes* recovered from sources other than scarlatinal.

These past studies of streptococci, however, did not include a scrutiny of their serological characters. As recent investigations have shown in case of both the

pneumococcus and meningococcus that among cocci indistinguishable in biochemical or other respects a number of distinct and apparently fixed serological races or types exist which breed true, it was obviously desirable to investigate streptococci again from this point of view, and to attempt to define the degree of antigenic diversity obtaining amongst them. Accordingly, towards the end of 1919, a study of the serological characters of streptococci occurring in hospital cases was begun on behalf of the Medical Research Council. This survey is still in progress; while specimens of all classes of streptococcus have been included in the investigation, the hospital material examined hitherto has yielded so many more specimens of haemolytic streptococci than of the others that the observations with regard to this group are now sufficiently advanced to submit them to publication.

Preliminary Classification of the Streptococci.

Except in case of blood cultures which are made in broth in the ordinary way, the medium employed for primary isolation is blood agar prepared as follows:

Procedure.

An ordinary agar plate is poured and allowed to set, and then a melted slope of tryptic agar is mixed with a little blood from the finger and poured on the top of the agar. The thin surface layer of blood-tryptic agar thus superimposed is ample for differentiating haemolytic colonies from others, and the medium is far more transparent, and the differences between colonies more evident than when blood is distributed throughout the medium. After a night's growth at 37° C. the sharply defined halo around colonies of haemolytic streptococci is readily seen on holding the inverted plate against a white background. Colonies of pneumococci and of *Staphylococcus aureus* may also produce a zone of haemolysis, but generally it is of minor degree in this time, and both these cocci are easily distinguished from haemolytic streptococci by the characteristic appearance of their colonies.

A single colony of the streptococcus is now carefully selected and subcultured on to a slope of tryptic agar the condensation fluid of which contains a drop of blood. In case of the haemolytic streptococci this condensation fluid shows well marked evidence of haemolysis next morning. Streptococci of the *salivarius* and *faecalis* groups as a rule fail to haemolyse the blood even after several days, but when *S. faecalis* is freshly isolated from the blood stream or from pus it not infrequently produces haemolysis; this coccus, however, is readily detected by the tests applied at the next stage.

The purity of the culture having been verified by microscopical inspection and ensured when possible by subculturing from a single colony on the tryptic agar slope, the next step is to test the ability of the streptococcus aerobically to ferment raffinose and mannite, and anaerobically to reduce the colour of neutral red broth. The raffinose and mannite are each in 1 per cent. solution, the solvent being ordinary meat broth with 1 per cent. of Witte peptone and 3 per cent. of salt; this broth is previously freed of its natural sugar content by cultivating *B. coli* in it, and litmus is added as indicator. In case of the neutral red, ordinary meat broth is used with addition of peptone and salt as before, and a suitable depth of colour is obtained by adding 2 c.cm. of a 1 per cent. solution of neutral red (Grubler) per litre. The reactions in these three media can be read off after forty-eight hours at 37° C. In case of some delicate examples of *salivarius* obtained by blood culture in malignant endocarditis, it may be necessary to add a drop of ascitic fluid to each tube in order to obtain growth. The reactions of the three chief classes of streptococcus in these tests is as follows:

Class.	Raffinose.	Mannite.	Neutral Red.
Pyogenes	—	?	—
Salivarius	+	—	+
Faecalis	—	+	+

While the vast majority of haemolytic streptococci fail to change mannite, a few do so. *S. salivarius* is uniformly negative in mannite, and *S. faecalis* as constantly positive in this test. Both *salivarius* and *faecalis* reduce neutral red under anaerobic conditions, but this test is not absolutely necessary: as its haemolytic power differentiates *pyogenes* from the other groups, and the two fermentation tests distinguish between *salivarius* and *faecalis*. It is important not to mistake the bleaching that *S. faecalis* usually produces in broth tinted with litmus for acid production; if the tubes are shaken and allowed to stand the colour returns, and the neutral tint of the raffinose is then seen to be in strong contrast to the acidity of the mannite.

After its physiological characters have been tested in this way and its class determined, the serological characters of the streptococcus are submitted to investigation. Owing to the tendency of suspensions of many of the commonest haemolytic streptococci to undergo spontaneous agglutination, the criterion of mere agglutination was abandoned at an early stage of the

inquiry, and recourse had to the absorption of agglutinin test, which has been found to be of no less value in defining the streptococcus group than it proved previously for a similar purpose in case of meningococci.

Procedure when Applying the Absorption of Agglutinin Test to Haemolytic Streptococci.

The method employed was similar to that used when investigating meningococci. So far little or no difficulty has been experienced in applying the absorption test to streptococci of the *salivarius* and *faecalis* groups. In case of the haemolytic streptococci, however, the difficulties at first were considerable and delayed progress for several months. Eventually these difficulties were surmounted, but in its application to the commonest strains of haemolytic streptococci the absorption test is still far from easy, and occasionally calls for considerable patience. For this reason the following details with regard to technique may be useful.

Preparation of Suspensions.—In order to obtain a dense suspension of the streptococcus, surface plates of tryptic agar enriched with ascites fluid have been employed. After incubation for a night at 37° C., 2 to 3 c.cm. of distilled water is poured over each plate and the growth suspended therein. This suspension is examined microscopically, heated to 65° C. for one hour, and well shaken. One-tenth of a cubic centimetre of the suspension is then diluted and its density determined by a turbidity test similar to that employed when estimating the density of suspensions of meningococci. In the case of the majority of the haemolytic streptococci the sole use of this suspension was for saturation tests; the density required for this purpose being approximately 50,000 million particles per cubic centimetre. When working with the *salivarius* and *faecalis* groups far weaker suspensions than this suffice to remove the specific agglutinin from a serum. By adding the required amount of 8.5 per cent. saline the cocci used for saturation are suspended in 0.85 per cent. saline.

Selection of Type Strains.—The cocci used as index or type strains must satisfy two requirements: they must possess good agglutinating power, and they must make good suspensions, that is, suspensions of uniform turbidity that do not show macroscopically any auto-agglutination in twenty hours at 55° C. While haemolytic streptococci vary in agglutinating power the selection of a good strain for this purpose is comparatively easy by experiment. The majority of strains of the commonest type of haemolytic streptococcus, however, exhibit a strong tendency to spontaneous agglutination, and for this reason are unsuitable for use as type strains. It was by good fortune that the earliest haemolytic streptococcus selected as a type strain was found to form excellent suspensions that were free from this tendency to auto-agglutination. Later on, when another strain was substituted for it, the suspension was not satisfactory until the larger particles had been removed either by filtering the suspension through the thinnest filter paper, or by allowing it to stand in a cylindrical glass (a 100 c.cm. measure) for several hours so as to deposit these heavier particles. Having obtained a satisfactory type strain, it is advisable to make stock cultures of it at once, either on gelatine or egg medium, and to keep them at room temperature, so that should the strain after frequent subculture become supersensitive and take to agglutinating spontaneously, a fresh culture free from this fault can be obtained from the parent culture. This liability to auto-agglutination is especially prominent in specimens of the commonest type of *S. pyogenes*. So far, it appears to be much less developed in examples of other types of haemolytic streptococci; and in case of streptococci of the *salivarius* and *faecalis* groups up to the present little or no difficulty has been met with from this cause.

Preparation of Agglutinating Serum.

Rabbits of from 1,000 to 2,000 grams were used, and the injections given intravenously at intervals of forty-eight hours, dosage being controlled by the animal's weight. The primary dose was 500 million of the killed suspension; and the final dose from 10,000 to 20,000 million. Haemolytic streptococci are weaker in agglutinating power to the rabbit than specimens of the *salivarius* and *faecalis* groups. In case of the former a titre of 1 in 400 is usually as much as can be obtained, though 1 in 800 is sometimes possible, especially with the rarer types, whereas in case of the non-haemolytic streptococci serums with titres of 1 in 1,000 to 1 in 2,000 are easy to prepare.

Example of an Absorption Test.

The following are required: (1) A fresh suspension (50,000 million per c.cm.) in saline of each of the cocci to be tested and similar suspensions of the coccus homologous to the serum, and of a coccus of known heterologous type for use as controls.

(2) Sufficient of a dilution (one thirty-second of its full titre) of the type agglutinating serum to allow of 1 c.cm. for saturation with each of the cocci to be tested, and of 3 c.cm. in addition for the three controls—namely: (a) For dilution with saline only; (b) for saturation with the homologous coccus; and (c) for saturation with the heterologous coccus. (3) A centrifuge tube for each of the cocci to be tested and for the three controls. (4) A water bath at 37° C. for standing the centrifuge tubes in while saturation is in progress. (5) Racks of small tubes (3 in. by $\frac{1}{2}$ in.) plugged with wool. (6) A 55° C. incubator.

Procedure.—One cubic centimetre of the diluted serum is placed in each centrifuge tube. One cubic centimetre of saline is added to the first, and a similar amount of each coccus suspension in turn to the rest. The centrifuge tubes are then shaken, placed in the 37° C. water bath and again shaken from time to time. After two hours at 37° C. the tubes are taken out and centrifuged till clear, after which the supernatant fluid of each is put up in four dilutions against an equal quantity ($\frac{1}{4}$ c.cm.) of a freshly made suspension (2,000 million per cubic centimetre) of the index coccus homologous to the serum. Two controls of this index suspension are also put up, one against saline, the other against normal serum diluted in the same way as the type serum. The racks are placed in the 55° C. incubator and the result read off next morning.

It is essential that the suspension of the index coccus should not be agglutinated in the controls of saline and of normal serum, and that the agglutinin should be removed by saturation with the homologous coccus, but unaffected by saturation with the coccus of known heterologous type. As a rule, cocci of the same type as the coccus homologous to the serum remove the agglutinin quite as completely as the homologous coccus. If there should be any doubt as to this absorption the test is repeated. The following is an example of the result of a saturation test carried out in this manner:

Type Serum and Coccus S.P.T.(1), Strain M.

No.		1:50	1:100	1:200	1:400	
1	Normal serum	—	—	—	—	controls.
2	Type serum unsaturated ...	+	+	+	(+)	
3	Type serum saturated with homologous coccus	—	—	—	—	
4	Type serum saturated with heterologous coccus	+	+	+	+	
5	Type serum saturated with Coccus A	+	+	+	+	
6	Type serum saturated with Coccus B	—	—	—	—	
7	Type serum saturated with Coccus C	(+)	—	—	—	

+ = Well-marked agglutination.

As regards the controls, No. 1 proves that the index suspension is satisfactory since this has not agglutinated with normal serum; No. 2 shows that the agglutinin of the type serum is active; and No. 3 and No. 4 show that this agglutinin is absorbed by the homologous coccus, while it is unaffected by saturation with the heterologous coccus. Of the remaining three cocci, A fails to remove the agglutinin and is therefore of heterologous type, while both B and C have absorbed it, and therefore are homologues of the type coccus and agglutinin here employed. In the case of Coccus C, the saturation can if desired be repeated, since a trace of agglutinin still remains unabsorbed in the first dilution; but this is hardly necessary, since over three-quarters of type agglutinin has been absorbed; a degree of reduction that no coccus of heterologous type could effect.

Serological Types of Haemolytic Streptococci.

All the haemolytic streptococci submitted to serological investigation had been found to exhibit the cultural and biochemical characters of *S. pyogenes*. By the absorption of agglutinin test these streptococci have been resolved so far into three different types. In considering the frequency and distribution of these types it will be convenient to deal with the streptococci according to the sources from which they were isolated, and to take them in the following order:

1. Haemolytic streptococci from the tissues in ordinary hospital cases.
2. Those from cases of puerperal sepsis.
3. Those from the respiratory tract in various conditions.
4. Those from the tonsil at the onset of scarlet fever.

1. Haemolytic Streptococci from the Tissues of Ordinary Cases.

Either localized streptococcal infections or cases of streptococcal septicaemia or meningitis furnished all of

the 68 streptococci now under review. The actual sources and the number of specimens from each were as follows: Cellulitis 15, erysipelas 3, abscess 9, arthritis 5, meningitis 8, empyema 4, osteitis or osteomyelitis 3, otitis media 2, peritonitis 1, ophthalmitis 1, and impetigo 1. Streptococci were obtained by blood culture during life from one case of pyrexia of uncertain origin, from two cases of cellulitis, from a case of mastoiditis, and from one of pyelitis. Eleven streptococci were recovered *post mortem* from the heart's blood of the following cases: Trauma with septic wounds 2, septicaemia after hysterectomy for cancer 1, terminal septicaemia in pernicious anaemia 1, in secondary anaemia 1, in nephritis 2, in bronchopneumonia 2, in strangulated hernia 1, and in a case of gangrene of the leg.

No fewer than 66 of these 68 haemolytic streptococci were found to absorb the specific agglutinin prepared against one of them, and the group which they form was accordingly designated Type I. The two non-absorbing streptococci were injected into rabbits and agglutinin prepared against each, with the result that the cocci were found to represent two different types. The first of these streptococci, designated Type II, had been obtained in pure culture from the heart's blood of a rapidly fatal case of influenzal pneumonia. The last streptococcus, Type III, had been isolated from an ear discharge developed a few days before death by a girl of 9 in the last stages of rheumatic endocarditis, and was also recovered from the bronchial secretion after death.

2. Haemolytic Streptococci from Cases of Puerperal Sepsis.

Streptococci possessing the cultural and fermentative characters of *S. pyogenes* were isolated from ten cases of puerperal sepsis and examined. The actual sources from which they came were as follows: Cervical secretion 2, blood culture during life 5, blood culture after death 2, and one streptococcus came from the peritoneal pus in a case of abortion. On submitting them to the absorption of agglutinin test all of these ten streptococci proved to be specimens of Type I.

3. Haemolytic Streptococci from the Respiratory Tract.

Streptococci with the characters of *S. pyogenes* were isolated from the following materials: One specimen each from nasal secretion in chronic rhinitis and from laryngeal secretion in Ludwig's angina; two specimens from tuberculous sputum, and two more from the post-nasal secretion in chronic post-nasal catarrh. On submitting them to the absorption of agglutinin test all of these six streptococci proved to be examples of Type I.

Bronchial Secretion.—In order to determine the serological characters of haemolytic streptococci occurring in bronchial secretion this material was obtained *post mortem* at the bifurcation of the trachea and examined in 27 cases. No fewer than eighteen of these specimens of bronchial secretion failed to yield haemolytic streptococci. Although twenty of the cadavers showed pulmonary lesions, haemolytic streptococci were only isolated in nine instances. The positive cases were as follows:

(1) A girl of 9, with rheumatic "pancarditis" and terminal bronchopneumonia; (2) a man of 24 with acute pleurisy and myocarditis, fatal within forty-eight hours; (3) a child of 6 with bronchitis and empyema; (4) two men, one of 57 the other of 58, with septic pneumonia associated with breaking down of carcinoma in the lung; (5) a baby of 1 year and 3 months who had succumbed to acute bronchopneumonia—in this case the bronchial secretion showed chiefly *B. influenzae*, but a haemolytic streptococcus was associated with it, both in the bronchial secretion and in the heart's blood; (6) a man of 35 with tuberculous bronchopneumonia and meningitis; (7) a girl of 24 with morbus cordis and bronchopneumonia; (8) a man of 23 with bronchiectasis and amyloid disease of the kidneys, liver and spleen.

Out of the 9 haemolytic streptococci thus obtained from bronchial secretion no fewer than 8 were found by the absorption of agglutinin test to be examples of Type I. The single exception came from Case (1): It proved to be a specimen of Type III, and identical with a haemolytic streptococcus obtained from the ear discharge of this same patient a few days before death.

Tonsils.—The tonsil has been investigated for haemolytic streptococci by two different procedures—namely, either by direct examination of the freshly excised tonsil, or by swabs taken in the ordinary way. The opportunity of examining the freshly excised tonsils I owe to the

courtesy of Mr. T. H. Just, F.R.C.S., who removed them in course of his routine duties.

The tonsil was held in a piece of clean filter paper and its surface seared with a hot iron, the capsule slit open with a sterile knife, and three loopfuls of the contents distributed in 3 c.cm. of broth. A drop of this broth was then spread over the surface of a blood-tryagar plate, and any haemolytic colonies isolated and examined. When dealing with swabs, the swab was stood in a tube containing 3 or 4 c.cm. of broth and well shaken; a drop of the broth was then carefully spread over a blood-tryagar plate. The results were as follows:

Results.

Excised Tonsils.—Out of 24 tonsils removed from children for hypertrophy, and showing no definite naked-eye evidence of sepsis, 8 yielded a growth of haemolytic streptococci. Five of these streptococci proved to be specimens of Type I, one was a specimen of Type II, and two were specimens of Type III. Definitely septic (purulent) tonsils were examined after removal from two patients, the first of whom had developed rheumatic symptoms and endocarditis; in both cases the tonsils were heavily infected with a haemolytic streptococcus of Type I.

Swabs taken of the tonsil in four cases of acute tonsillitis yielded in three instances specimens of *S. haemolyticus* Type I, and in the fourth a haemolytic streptococcus apparently different from all the three defined types and not yet identified. A case of follicular tonsillitis and two cases of early measles accompanied by angina each gave a specimen of *S. haemolyticus* Type I. In three cases of diphtheria a haemolytic streptococcus accompanying the Klebs-Loeffler bacillus was a specimen of Type I. During an outbreak of infectious catarrhal sore throat in a school, six children in the acute stage and twelve convalescent children were swabbed by my colleague Dr. Richard Armstrong, and a special search made for haemolytic streptococci on blood-tryagar plates. Only one case was positive, and the streptococcus there present proved to be a specimen of Type I.

Summary.—Out of a total of 21 haemolytic streptococci isolated from the tonsil and investigated 17 proved to be specimens of Type I, 1 of Type II, and 2 of Type III; one specimen could not be identified with any of these types. Including the haemolytic streptococci from all parts of the respiratory tract a total of 36 specimens have been investigated, of which 31 proved to be specimens of Type I, 1 of Type II, 3 of Type III, and one could not be identified.

The distribution of serological types among all the haemolytic streptococci examined up to this point is as follows:

Source.	Specimens.	Type I.	Type II.	Type III.
General	68	66	1	1
Puerperal sepsis ...	10	10	0	0
Respiratory tract ...	36	31	1	3
Total	114	107	2	4

The outstanding feature of these results is the pre-dominance of Type I, which undoubtedly represents the commonest form of *Streptococcus pyogenes*. It is of interest to recall that Hammerton examined six specimens of this streptococcus serologically and found them identical, and further, that in a recent monograph Douglas, Fleming, and Colebrook report a similar serological identity among twenty-four specimens of *S. pyogenes* isolated from war wounds. The last observers also found that the mannite-fermenting form of *S. pyogenes* is serologically identical with strains not fermenting mannite—a point which I can confirm, as 3 of my 107 specimens of Type I fermented mannite, while the remaining 104 failed to do so.

A further point calling for notice is that specimens of all the types of haemolytic streptococci were obtained from the respiratory tract. The two specimens of Type II came respectively from the heart's blood of a fatal case of influenza pneumonia and from a hypertrophied tonsil. The four specimens of Type III came from three patients—two specimens from hypertrophied tonsils, the other two from the ear discharge and bronchial secretion respectively of a girl of 9 who succumbed to rheumatic carditis. It may be mentioned that among 125 haemolytic streptococci obtained chiefly from the respiratory tract during an outbreak of bronchopneumonia, Dochez, Avery, and Lancefield distinguished at least four different types by agglutination and by protection tests, and consider that further types exist in this locality.

4. Haemolytic Streptococci from the Fauces at the Onset of Scarlet Fever.

Having prepared the way by these control observations, I was now in a position to investigate the serological characters of haemolytic streptococci occurring in the tonsillar and faucial secretion at the onset of scarlet fever. From previous observations made on behalf of the Local Government Board it was known that at the earliest stage of scarlet fever a streptococcus indistinguishable from *S. pyogenes* in cultural and biochemical respects and virulent to the mouse occurs there with great constancy and abundance. It was of much interest, therefore, to see if this scarlatinal streptococcus is serologically identical with any of the defined types of haemolytic streptococci, and the present investigation appeared to be the more timely since observations recently published in America by Tunncliffe and Bliss had indicated that this scarlatinal streptococcus is serologically distinct from *S. pyogenes*.

For the present purpose it was indispensable to obtain material from cases of scarlet fever within the first week, and so typically clinically as to be beyond all doubt. Through the courtesy of Dr. Foord Caiger and the assistant medical officers of the South-Western Fever Hospital, I was provided with swabs from ten such early cases of scarlet fever. These swabs were treated in the same way as those described in the preceding section. Nine of them gave a profuse growth of colonies of haemolytic streptococci which in four cases far excelled all other bacteria in abundance on the plates. From different parts of each positive plate two haemolytic colonies were subcultured and the cultural and biochemical characters of each streptococcus examined, with the result that all were found to be indistinguishable from *S. pyogenes* in these respects. Two of the streptococci that formed the best suspensions—each from a different case—were injected into rabbits and agglutinin prepared against each of them.

It was found that none of these 18 scarlatinal streptococci absorbed the agglutinin of either Type I or Type II *S. haemolyticus*.

On proceeding to carry out absorption tests with the agglutinin prepared against the two selected scarlatinal streptococci it was found that these two streptococci were identical, since each absorbed the agglutinin of the other equally as well as its own. Of the 18 scarlatinal streptococci 16 were found to absorb this agglutinin, and among these 16 was at least one streptococcus from each of the 9 positive cases. Specimens of each of the three defined types of haemolytic streptococci were now put up against the agglutinin of the scarlatinal streptococci, with the result that while Types I and II failed to remove it, Type III absorbed the agglutinin equally as well as the scarlatinal streptococci. It would appear, therefore, that the scarlatinal streptococci are identical with Type III.

Two of the haemolytic streptococci isolated from the scarlatinal throat failed to absorb the agglutinin from the serum prepared against the scarlatinal cocci, and also failed to absorb the agglutinin of the three types of *S. haemolyticus* previously defined. These two streptococci, therefore, are as yet unidentified.

SUMMARY.

1. By the absorption of agglutinin test haemolytic streptococci have been differentiated up to the present into three distinct groups or types.

2. Of these Type I is by far the largest. To this serological group belong the vast majority of specimens of haemolytic streptococci from localized or general streptococcal infections, from cases of puerperal sepsis, and from infections of the respiratory passages other than scarlet fever. Type I, in fact, represents *Streptococcus pyogenes*.

3. So far Type II is rare: only two specimens of it have been obtained.

4. Type III is chiefly to be found in the secretion on the tonsil and fauces in scarlet fever. Serologically this *Streptococcus scarlatinae* is quite distinct from *Streptococcus pyogenes*. The observations of Tunncliffe and Bliss to that effect are confirmed.

In view of this serological individuality of the haemolytic streptococcus present in the angina of scarlet fever it is clear that we must be prepared to revise our views on its significance in that disease. The opinion that this streptococcus represents merely a secondary infection in scarlet fever was based mainly on the view that it is

indistinguishable from specimens of *S. pyogenes* recovered from sources other than scarlatinal. This view is now untenable. The possibility, therefore, must be realized that the streptococcus in question may ultimately be established as the essential cause of scarlet fever. Its exact significance, and also its practical application as regards the diagnosis and specific treatment of scarlet fever have still to be decided. As the problem is one of considerable practical interest and importance, it is hoped that the present communication may be of use to others who may have the opportunity and inclination to investigate the matter.

In conclusion, I wish gratefully to acknowledge the help received from my colleagues at St. Bartholomew's and from Dr. Caiger in obtaining material for this investigation, and also to record the valuable assistance of Mr. J. Heagerty, my laboratory assistant, in applying the absorption test to the relatively large number of haemolytic streptococci that it has been necessary to examine.

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Remarks

ON

POSTURAL OR SO-CALLED STATIC DEFORMITIES.

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(Concluded from page 590.)

II.

In the first part of this paper¹ I gave a brief account of the physiology of posture, based on the work of Sherrington, who has shown that the upright attitude or posture of the body is maintained by continuous tonic reflex muscular activity. It was seen that this "postural activity" is of a special kind, quite different from the muscular contraction which gives rise to movement; that it is capable of being maintained for long periods without fatigue; and that it is controlled by a special nervous mechanism of its own. Attention was directed to the profound influence which the higher parts of the central nervous system exert upon postural activity, both in health and disease, and I endeavoured to show the practical bearing of these observations on the etiology and treatment of curvatures of the spine. Postural deformities are due to deficient postural activity, and the following pages deal with the application of this principle to flat-foot and other deformities hitherto described as "static."

FLAT-FOOT.

There are still some people who believe that the arch of the foot is supported by ligaments, and that the muscles merely serve to move the foot in obedience to the will. This view is utterly opposed to our conception of the function of ligaments and of the physiology of posture.

The natural form of the foot as a whole is determined by the shape of the individual bones, whose articular surfaces are adapted to one another in what may be called the neutral position of the foot.

The ligaments keep the several bones in normal apposition, resisting gross displacements, and helping to restore the bones to their normal resting positions after the slight displacements which continually occur during ordinary use of the foot. To this extent, and to this extent only, the form of the foot is maintained by ligaments.

It is not the function of ligaments to withstand continuous strain; this is a function of muscles. The correct attitude of the feet in standing is a part of the postural reflex which maintains the body as a whole in the upright position. The mechanical force of gravity in the upright position tends to abduct and evert the feet, and this actually happens in a child learning to walk before the postural reflex is established. The postural reflex, in so far as it concerns the feet, consists of adduction and inversion—which does not mean that the feet are visibly held in that position, but that the tendency to passive abduction and eversion by the body weight is continuously resisted. Incidentally, the inner border of the foot is drawn upwards to a greater or less extent, so as to form an arch, and the body weight is taken up by the postural muscles and distributed to the outer border of the foot, the heads of the metatarsal bones and the heel.

From this time onwards the normal attitude of the foot, including the arch, is maintained by continuous reflex muscular activity. This postural activity, as we have seen, is of a special kind, capable of being maintained continuously for long periods without fatigue, and controlled by a special nervous mechanism of its own.

Flat-foot is either caused by, or accompanied by, deficient postural activity. Some of the conditions which may modify or inhibit the postural reflex have been considered in connexion with scoliosis. Mental fatigue or inertia, temperament, occupation (apart from prolonged standing), anaemia, constipation, adenoids, etc., all have a place in the etiology of flat-foot as in that of scoliosis. The deficiency of postural activity may be manifested generally or locally. Some patients develop postural scoliosis or kyphosis, others postural flat-foot, while in many cases scoliosis and flat-foot are associated in the same individual as parts of a general loss of tone. Not infrequently there are accompanying vasomotor disturbances—for example, flushing, profuse sweating, susceptibility to chilblains, oedema, etc., significant of the functional (perhaps sympathetic) origin of the deformity.

But, although postural activity is capable of being maintained for a long time without fatigue, there is a limit to the amount of strain that even a postural muscle can stand, and under modern conditions of civilization the strain thrown on the feet is often far in excess of anything that Nature intended. The result is that in many cases simply by continuous standing the postural reflex is at last tired out, and the body weight, overcoming the resistance of the muscles, passively abducts and everts the feet. Prolonged standing is thus one of the commonest causes of flat-foot in adults. It is hardly necessary to point out that conditions which give rise to a primary deficiency of postural activity may be, and frequently are, combined with occupations which entail long hours of standing, so that both causes may operate together, and no sharp dividing line can be drawn between these two groups of cases.

There is a third class of case in which the postural reflex is inhibited by some local condition. Pain in the foot inhibits the local postural reflex. Flat-foot, therefore, commonly follows sprains, fractures, or other injuries of the foot (traumatic flat-foot) and painful inflammatory conditions, such as gout, rheumatism, gonorrhoea, etc. (inflammatory flat-foot). With regard to the last named affection, it may be said that reflex inhibition from pain has far more to do with the causation of gonorrhoeal flat-foot than has any inflammatory softening of the ligaments, as commonly described in the textbooks.

Cases of flat-foot, therefore, fall roughly into three groups:

1. Those in which the immediate cause is deficient postural activity;
2. Those which are due to continuous strain by which the postural reflex is exhausted; and
3. Those in which the local postural reflex is inhibited by some painful condition of the foot itself.

Pain in the foot not only inhibits the local postural reflex, but it frequently induces an abduction-eversion spasm, which is a fixation of the flexion reflex commonly evoked by painful stimulation of the foot. Spasm, therefore, is

¹ BRITISH MEDICAL JOURNAL, April 23rd, 1921, p. 587.