are infected; the ureters are never free from *B. coli* if the bladder is infected. In the spontaneous infections, by tying off the bladder and ureters separately, Helmholtz has shown that the bladder is often infected, while one or both ureters are free from infection, and that although pyelitis and pyelonephritis may appear, kidney abscesses do not occur in the spontaneous infection.

It seems worth while to turn from the consideration of children to review briefly *B. coli* urinary infections in adults. After puberty such infections are far less common than in childhood, and a marked disproportion exists between the sexes. In men, apart from calculus, prostatic abnormalities, and urethral stricture, *B. coli* infections of the bladder or ureters are rare. In women, on the other hand, the *B. coli* infection is by no means uncommon. The associated conditions are pregnancy, gynaecological operations, the trauma of the honeymoon, and long periods of retention such as may occur on long car or railway journeys.

Further, such infections—provided that the infecting organism is the *B. coli* only—produce but little upset, and are probably frequently missed. The facts of this brief statement seem to point very definitely to an ascending rather than to a blood infection, and support the clinical finding of children's physicians that pyelitis is generally an ascending infection with a correspondingly greater incidence in girls. If these infections (*B. coli*) were blood-borne, then men would be not less susceptible than women, and evidence of disturbance in other organs of the body would be common and not infrequently severe.

Certain figures have been obtained from the Children's Hospital in Birmingham. Starting from the year 1925 117 consecutive and unselected cases of pyelitis were taken with the object of tracing the children, re-examining them, and determining as far as possible their present condition. In this way it is hoped to throw some light on the etiology of the condition.

Age.	No.	Male.	Female.	Average Age.	Acute Cases.	Died.
0 to 2 years ...	47	7	40	1½ years	33	7
2 to 12 years ...	70	18	52	6½ years*	31	2

* The average age among boys was 7½ years.

Of the seven deaths that occurred during the first two years all were in girls. Three were cases of pyelonephritis; one had kidney abscesses; one pneumococcal septicaemia; one infection of a congenital hydronephrosis; and one pyelonephritis and thrombosis of the left renal vein. This death rate (9 in 117 cases) is 7.7 per cent., or 3 per cent. in patients over 2 years of age. It must be remembered that these figures are taken from those ill enough to be admitted to a hospital, which suggests that many milder cases occur which do not need admission, and that therefore this is a higher death rate than the real mortality of all cases of pyelitis. On the other hand, several of the chronic cases showed evidence of nephritis while in hospital—the presence of tube casts in the urine, raised blood urea, or a poor urea concentration capacity. The cases in the above series are being followed up to determine the present condition of the children. It is proposed to examine the urine, the renal function, and the cardio-vascular systems.

Conclusions.

As a clinician I am familiar with a *B. coli* infection of the urine, a condition which is frequent in children, commoner in girls than in boys, appearing in acute, chronic, and recurrent forms, but which is relatively seldom fatal. This condition has been called pyelitis, and although I am not in a position to prove that it is always a pyelitis, I feel that I can prove that it is not always part of a septicaemia or evidence of a nephritis.

It seems that the pathologist has experience only of a selected group of patients out of the many who have *B. coli* infections of the urinary tract—the more severe

cases which are septicaemias, and in which the colon bacillus is seldom if ever the primary infecting organism. It is hardly likely that a severe septicaemic condition in children, with renal infection and possibly abscess formation, could have a mortality as low as 3 per cent. after the age of 2, and it is significant that the collection of 78 post-mortem records took no less than twelve years at two large children's hospitals, whereas, clinically, *B. coli* infections are common.

I am deeply indebted to Dr. A. V. Neale for the work he has done in following up cases and in getting out the original figures for cases of pyelitis at the Children's Hospital, Birmingham.

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BACILLUS COLI INFECTIONS.*

BY

DAVID NABARRO, M.D., F.R.C.P.,

DIRECTOR OF THE PATHOLOGICAL DEPARTMENT, HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET.

It is a curious coincidence that just twenty years ago, at the seventy-eighth Annual Meeting of this Association, held in London in 1910, one of the subjects for discussion was "Infections of the urinary tract by *Bacillus coli* in infancy and childhood." Whether it was by accident or by design that the subject of the present discussion, "*B. coli* infections in infancy and childhood," was chosen I do not know, but it will be of interest to compare the views prevalent in 1910 with those current to-day—twenty years after. It is perhaps significant that, whereas in 1910 the discussion was opened by a physician (Dr. Box) and a surgeon (Mr. Pardoe), this year the duty has been entrusted to a physician and a pathologist, which may be interpreted to mean that to-day the pathologist is called upon to take a larger share in the diagnosis than was formerly the case; but there is no doubt that the urological specialist can help very materially by cystoscopic examination and ureteric catheterization in clearing up these occasionally obscure cases.

One of the most commonly recognized diseases of infancy and childhood, which is generally held to be due to, or to be associated with, the *B. coli* in the majority of cases, is pyelitis, and it is a coincidence that Escherich, who discovered and named the *B. coli communis* in 1885, is generally credited with having introduced the concept "pyelitis" as a clinical entity into paediatrics in 1895. This statement is from Chown's paper—"Pyelitis in infancy"—but, as Chown points out, Escherich's cases of pyuria occurred in older girls, from 7 to 9 years of age, and were not cases of the so-called pyelitis of infancy which are held to occur with greatest frequency in children of under 2 years of age. It was Finkelstein who in 1896 drew attention to the condition in infants, and who concluded from his observations that the lesion was a primary pyelitis. From that time onwards the existence of a primary pyelitis has been recognized by clinicians, and has gone unchallenged until recent years. There is no doubt about an infection of the urinary tract of which patho-

*Read in opening a discussion in the Section of Diseases of Children at the Annual Meeting of the British Medical Association, Winnipeg, 1930.

logical evidence can be obtained by examination of the urine; further, there is no doubt that the causal organism of the infection is the *B. coli* in the majority of the cases; but there is little direct evidence, apparently, that the lesion is primarily an inflammation of the renal pelvis, and probably it starts as an interstitial nephritis.

There are many interesting topics here for consideration and discussion, but I can only refer to some of them.

PATHOGENICITY OF *B. COLI*.

How comes it that the *B. coli*, which is a normal and saprophytic inhabitant of the big bowel from the earliest days of extrauterine life, can become pathogenic?

One is reminded of the well-known definition of "dust" as "matter in the wrong place." When the *B. coli* gets into the wrong place (that is to say, when it leaves the colon) it may take on noxious or pathogenic properties. I need scarcely remind you that *B. coli* has active fermentative powers on sugars, alcohols, etc., and in particular that it ferments lactose with the production of acid and gas; the pathogenic intestinal organisms, such as the *B. typhosus*, *B. paratyphosus* A, B, and C, the Shiga-Flexner dysentery group of bacteria, on the other hand, do not ferment lactose, and are hence known as non-lactose fermenters. W. J. Wilson³ has recently written as follows:

"There is something more than chance behind the fact that the majority of the pathogenic races of the *coli*-typhoid group of bacteria are unable to ferment lactose. When a micro-organism becomes so definitely pathogenic as to be the causal micro-organism in a definite disease its cultural and, perhaps to a less degree, its serological characters become fixed. In the case of the *B. coli* group, the members of which are more saprophytic than parasitic, there is great variation in their action on sugars and also serologically."

I am personally not in agreement with this opinion; I hold the view that the cultural characters of an organism do not become fixed, but may undergo evolutionary changes, such as occur with all living things, and in the case of bacteria these changes may happen in a comparatively short space of time. To revert to the *B. coli* and its change from a non-pathogenic to a pathogenic condition. Normally in the bowel it is a harmless saprophyte, but in certain inflammations of the intestine the *B. coli* has been credited, rightly or wrongly, with a pathogenic role, as in cases of infective enteritis, and it may certainly give rise to cholangitis and cholecystitis, as well as to appendicitis, pelvic and abdominal abscesses, and to infections of the kidneys and urinary tract. In specific infections such as typhoid and dysentery the *B. coli* at times seems to acquire pathogenic properties, increasing the severity of the infection or giving rise to complications. Can it be that these various pathological conditions are due to different strains of the *coli* group of organisms? For example, the *B. coli communior* of Durham ferments saccharose, while the ordinary *B. coli* does not; the *B. lactis aerogenes* is non-motile and produces a mucoid growth on agar, and differs from *B. coli communis* in other respects. Then, again, it has been known for a considerable time that certain strains of *B. coli* are haemolytic, while others are not. Dudgeon, Wordley, and Bawtree⁴ in 1921 and 1922 made an extensive study of *B. coli* infections of the urinary tract in relation to haemolytic organisms. Among their conclusions these observers state:

1. Two types of *B. coli* are met with in urinary infections—haemolytic and non-haemolytic. The haemolytic is much commoner in infections in the male (72 per cent.) and the non-haemolytic in the female (70 per cent.), but as very few children are included in the total of 160 cases studied it would be of interest to find out whether similar results would be obtained in *coli* infections in children.

2. It was unusual to obtain both these types of *B. coli* associated in any particular case, or for a haemolytic infection to be followed by a non-haemolytic, or vice versa.

3. Haemolytic *B. coli* occur in the normal stools of adults and children, but with increased frequency in cases of diarrhoea and colitis. No evidence was obtained, however, of direct relationship between the urinary and intestinal haemolytic *B. coli* in any particular case.

4. Few positive blood cultures were obtained, and in no case was a haemolytic *B. coli* obtained from the blood stream in a human subject.

5. Living colon bacilli, haemolytic and non-haemolytic, were inoculated into rabbits without serious ill-effect, and renal infections were not obtained, although various strains of urinary and faecal *B. coli* were used.

6. Some "normal" blood serums agglutinated *B. coli* antigens, but a much higher percentage of positive results was obtained with the serums of "*coli*" cases.

INFECTION OF URINARY PASSAGES.

Along which route or routes does *B. coli* travel from its normal habitat to the urinary passages? There are three possible routes: (1) directly via the urethra; (2) via the blood stream; (3) via the lymphatics. Let us examine briefly the evidence found for and against these.

The Urethral Route.

For many years it was held that the infection was an ascending one via the urethra, and the fact that girls suffer much more frequently than boys lends support to this thesis. Box, in 1910, adopted this view; of 107 cases to which he refers, 85 occurred in girls—a proportion of nearly 4 to 1. It is a prevalent belief that the so-called pyelitis of infants affects baby girls almost exclusively. Chown, Wilson and Schloss,⁵ and others, maintain that the disease does not affect little girls so preponderantly as is generally held, and among the possible sources of error which are doubtless sometimes overlooked are: a catarrhal vaginitis, itself secondary to some acute febrile condition; a specific vaginitis which is usually associated with a urethritis; contamination of the urine with faecal matter; and non-specific vulvo-vaginitis due to worms or some other cause. Chown mentions the first three of these possible sources of error, and I have myself seen all four operative in different cases.

Blood-borne Infections.

With regard to infection via the blood stream, several years ago I made blood cultures of a number of cases of pyuria and bacilluria in older children with negative results. Helmholtz and his co-workers have made extended investigation on the filtering action of the kidneys after the intravenous injection of bacteria; in a recent paper⁶ he has given a summary of these investigations, with various conclusions deducible from them. He was able to produce pyelitis in rabbits by both haematogenous and ascending infection, so that his experiments are not of much value in determining the probable mode of infection in infancy. He found that bacilluria induced by the intravenous injection of colon bacilli does not, as a rule, tend to become localized to the bladder once the infection has disappeared from the upper urinary passages. Many laboratory rabbits were found to have a spontaneous bacilluria, and his observations led him to conclude that in the rabbit the infection is of the ascending type. He is of the opinion that in children infections with the colon bacillus take place in the same way.

Bugbee,⁷ on the other hand, does not agree that the infection in children is mainly of the ascending type, but that, as in adults, there are two types of infection—namely, those in which there is no urinary stasis, and others in which a lesion is present which interferes with complete drainage. In the type of case without urinary stasis the colon bacillus is the causal organism, which Bugbee thinks is produced in very large numbers owing to some intestinal disturbance, and then gets to the kidneys via the blood stream. The majority of these acute infections clear up rapidly, especially if the gastro-intestinal tract is treated at the same time as the renal condition; but if they do not, and especially if they tend to become chronic, cystoscopic investigations should be carried out. Wilson and Schloss, in their paper already referred to, state that the main argument in favour of an ascending infection is the greater frequency of pyelitis in females, but in their series of cases, as in Chown's, the difference in favour of females is not so great as it is usually stated to be. The anatomical lesions

they describe in the kidneys, which will be referred to later, rather favour a blood-borne infection. They also quote Brewer,⁸ who, on clinical and experimental evidence, showed that ascending infections of the kidneys always arose from obstruction and stasis. In such cases the inflammation was not confined to the kidney tissue, but involved also the ureters and pelvis.

The Lymphatic Route.

The third possible mode of infection is via the lymphatics. In order to explain the more frequent occurrence of right-sided lesions, Franke suggested a direct lymphatic extension from the caecum. Chown questions the tenability of this hypothesis, and suggests the possibility of the weight of an enlarged liver pressing on the right kidney, which might lead to stasis and so to increased permeability of the kidney should a bacteraemia be present. Whereas Chown's acute or subacute cases show the frequency of bilateral renal involvement with a tendency to more severe lesions on the right side, John Fraser of Edinburgh found a great frequency on the left side, which he explained by direct extension from the overlying colon. Another view is that the infection of the bladder may be direct (in girls), and that it reaches the kidney via the peri-ureteral lymphatics.

PATHOLOGY OF THE DISEASE.

With regard to the pathological anatomy of the malady, it was originally thought to be a cystitis (Escherich) or a primary pyelitis, with later on a possible involvement of the kidneys (Finkelstein and others). In 1910 Jeffreys,⁹ Thiemich,¹⁰ and Forbes¹¹ all reported cases in which suppurative lesions were present in the kidneys, with, in some cases, a normal pelvic mucous membrane. Forbes describes two post-mortem examinations on infants with pyelitis, aged 4 and 7 months respectively, who had suffered from diarrhoea and vomiting. He regards these as primarily gastro-intestinal infections, later giving rise to general systemic infection including the pelves of the kidneys and a descending infection of the urinary tract. In two other cases with enlarged kidney in which operations were performed, abscesses were found in the kidney substance.

More recently, Chown, Wilson and Schloss, Bugbee, Helmholtz, and others have emphasized the fact that the commonest lesion in the type of case under consideration is a diffuse interstitial nephritis which may give rise to suppurative foci of varying size; pyelitis may at times be present in addition, and rarely a cystitis. This diffuse nephritis would explain the tenderness and pain which is sometimes present in these cases, and which is probably greater than a simple pyelitis could produce. It is therefore more correct to call the condition pyelonephritis than a simple pyelitis.

BACTERIOLOGY.

As regards the bacteriology of the condition, there is no doubt that the organism most frequently isolated from the urine in these cases is the *B. coli communis*, either alone or associated with *B. proteus* or streptococcus; these organisms may rarely be present alone. Other organisms I have encountered in the urine of these patients are *B. lactis aerogenes*, *B. pyocyaneus*, *B. coli anaerogenes* (this in the light of subsequent knowledge was probably a Sonne dysentery bacillus), a Shiga-like bacillus, *B. faecalis alkaligenes*, and staphylococci. The very fact that such a variety of organisms may be isolated from the urine raises a doubt whether these are the actual cause of the disease or merely secondary invaders. Certainly in a number of cases the disease appears to follow an intestinal upset and to present itself to the physician in the guise of an acute infection somewhat like a typhoid or paratyphoid fever. This may possibly be the stage of bacteraemia, and it may be that during the process of eliminating the bacteria the kidneys develop the condition clinically known as "pyelitis." Perhaps some anatomical abnormality may be a contributing factor even in the patients who rapidly get well; it is certainly a cause of some of the cases of so-called chronic pyelitis or of a

persistent or intermittent pyuria. Dr. Woolstein in 4,900 post-mortem examinations found congenital anomalies of the urinary tract in 117 (2.5 per cent.). Dr. Sheldon, registrar at the Great Ormond Street Hospital, has kindly analysed for me 400 recent consecutive post-mortem examinations, with the result that 10 showed similar congenital abnormalities—again a percentage of 2.5. My colleague Mr. Oswald Addison, who has for many years made a special study of genito-urinary disease in children, has kindly given me permission to quote some of his cases.

CASE I.

One of these was a girl, aged 11 years, who was admitted to the Children's Hospital on account of pain in the right loin of three days' duration. She had had nine similar attacks since she was 6 years old. The urine was acid, and contained many pus cells and *B. coli*. On cystoscopic examination there was a slight basal cystitis; the right ureter was red and oedematous, the left normal. Some weeks later pyelography showed the appearance of hydronephrosis on the right side, and at operation an aberrant artery was found running across the front of the renal pelvis. This was ligatured and divided, with the result that when seen three months later the child had had no recurrence of her symptoms, and a catheter specimen of the urine was sterile.

CASE II.

A similar case, that of a girl aged 8 years, was in Great Ormond Street Hospital under the care of Dr. Hutchison in 1923. She had attacks of renal colic complicating a hydronephrosis. At the first investigation the urine was sterile, but nine days later streptococci were present but no pus. At operation an aberrant vessel found running across the middle of the pelvis was ligatured and divided as in the previous case. Several years later a pyelogram revealed the hydronephrosis as large as it was at the operation, but the child had had no more attacks of colic, and the urine was sterile.

CASE III.

Another case of Mr. Addison's was that of a girl with three years' history of acute right-sided colic. A hydronephrosis was present, with pus cells and *B. coli* in the urine. At operation an aberrant artery was found running across the ureter about half an inch below its pelvic orifice to the lower pole of the kidney. This was divided, and eighteen months later there were no symptoms and the urine was sterile.

Another group of cases in which at different times a diagnosis of pyelitis, renal infantilism, or idiopathic dilatation of the ureters was made has been shown to be due to the presence of a valve-like fold of mucous membrane in the prostatic urethra, resulting in obstruction to the normal outflow of urine. Young, Frontz, and Baldwin¹² were the first to draw particular attention to the existence and the effects of this abnormality, and recently Drs. Poynton and Sheldon, in a paper entitled "Dilatation of the bladder and ureters in childhood,"¹³ have reported a series of 24 cases, many of them with pyuria and infection, in which hypertrophy of the verumontanum, a urethral "valve," or some other congenital abnormality was at the root of the trouble. They point out that the true state of affairs may be easily overlooked if the whole genito-urinary tract is not removed *in toto* and subsequently carefully dissected out. Lastly, it should be remembered that an abnormality, such as a dilated ureter, may be unilateral.

TREATMENT.

Dr. Wilkinson has made adequate reference to the treatment of these cases, so there will be only a few points, mainly of a bacteriological nature, to which I need refer. As is well known, these cases do well if given plenty of fluid to drink and if the urine is made and kept alkaline. This treatment, however, does not always clear up the condition of bacilluria, which can then sometimes be made to respond to alternations of reaction in the urine. The sudden transition from a very alkaline to an acid urine will sometimes clear micro-organisms from a urine when the previous treatment with a urine alkalizer has failed. Urinary antiseptics are sometimes given; it must be remembered that hexamine will act only in an acid urine. It is possible that when this drug is being administered many organisms may still be present in the urine but fail to grow on culture; this may be because they are dead or perhaps only

inhibited by the antiseptic present. At a discussion on the treatment of pyuria in children, held at the Royal Society of Medicine in 1927, Drs. Hare, Lepper, and Martland¹⁴ gave an account of work they had done on the reaction of the urine in relation to the treatment of *B. coli* infections with alkalis and with hexamine. These observers found that although the administration of alkalis relieves the symptoms, the patients are not cured thereby, for the alkalis have no lethal effect on the bacteria, nor do they act by neutralizing an acidosis. They alter the hydrogen-ion concentration of the urine, which may act beneficially in one of two ways: (1) the alkaline urine may be less irritating to inflamed surfaces than an acid one; (2) the hydrogen-ion concentration may be an important factor in determining the rate and force of the muscular contractions by which urine is propelled from the pelvis and the kidney to the bladder.

Hexamine, as is generally known, acts as a urinary antiseptic by breaking down into formaldehyde, which is lethal to coliform bacilli. Two factors are of importance in connexion with hexamine treatment—namely, the secretion of an acid urine, and the relative vulnerability of the invading bacillus to formaldehyde. Drs. Hare, Lepper, and Martland found that the greatest concentration of formaldehyde in the urine of their cases was 1 in 20,000, whereas anything less than 1 in 5,000 is said not to be bactericidal. On studying twelve strains of *B. coli*, however, they found considerable variation in the susceptibility of the action of formaldehyde on the bacilli, and, further, that it was only when the pH of the urine had fallen to 4 that effective doses of formaldehyde were liberated in the urine. It appeared that small doses of hexamine were preferable to large ones, as the former caused less alteration in the pH, and that considerably more formaldehyde was liberated at body heat than at the room temperature.

Drs. Hare, Lepper, and Martland also draw attention to the fact that the ordinary routine adopted in collecting and testing the reaction of the urine is misleading in this connexion. Litmus is not a good indicator because it turns blue at pH 6.6, at which acid reaction symptoms are not relieved. The urine should be collected in a stoppered bottle under toluene (to prevent decomposition and loss of CO₂), and should have the pH tested with phenol red in an ordinary comparator box. One should perhaps add that all these observations were made upon adult patients, but there is no apparent reason why the results should not be applicable to children.

The value of vaccine treatment in these cases seems to be subject to a good deal of difference of opinion. Twenty years ago Dr. Box said that it was of no value, yet at the same meeting Dr. Forbes said that three out of four of his cases were benefited by vaccine treatment. Many clinicians are inclined to agree with Box in thinking that vaccines are not of very much value. Personally I believe that cases of a true infection, in which there is a reaction and the consequent presence of pus in the urine, are often benefited by a vaccine, while simple cases of bacilluria do not appear to respond so well to this treatment. Perhaps I may be permitted to quote a few remarks I made at a discussion held in 1914 at the Royal Society of Medicine on vaccines from the standpoint of the physician.

I referred to a patient of Dr. Poynton and Mr. Fairbank, a baby girl about 1 year of age, who was profoundly ill from some urinary tract infection. The kidneys were considerably enlarged and the case was regarded as one of pyelonephritis. There were many pus cells and organisms in the urine, and on culture three different intestinal organisms were isolated. The child appeared to be dying, and permission was given to try a vaccine. This had already been prepared from all three organisms in case it might be called for, and four injections in all were given. Already after the first injection the child's condition began to improve, and she was shortly afterwards discharged from hospital looking the picture of health, but with still a few pus cells and organisms in the urine.

A point in connexion with vaccine treatment to which I referred in my paper of 1914 is that the urine should be culturally examined from time to time in order to ascertain if the same organism is present. I can recall

a case in which four different organisms were isolated from the urine of a child at different times during the course of one year. These were a *B. coli anaerogenes*—probably this was what we now call the Sonne dysentery bacillus—streptococci, *B. proteus*, and *B. coli communis*; an autogenous vaccine appeared to clear the urine from the particular organism present at the time.

Another point to remember in treatment is that sometimes the infection will clear up either spontaneously or as the result of treatment, only to recur after a variable interval. In these chronic and recurrent cases some mechanical obstruction to the flow of urine or blood should be looked for, and will then probably be found. If the cause can be dealt with as in the cases to which I have referred the condition may be permanently remedied.

A line of treatment which holds out a certain amount of promise, but which so far as I know has not been given much of a trial by English-speaking physicians, is that by bacteriophage. Further, if it is a fact that a disordered condition of the bowel with the presence of an excessive number of *B. coli*, or of *B. coli* of an exalted virulence, is coincident with a pyelitis or a pyelonephritis, then attention should be directed to the bowels, which should be kept well oiled with liquid paraffin.

CONCLUSION.

Infections with *B. coli* in children are by no means rare; they often get well spontaneously; at other times they become chronic or tend to recur. Investigations should be made upon the properties of the organisms present as regards haemolytic power, serology, etc., to discover if these have any bearing on the clinical condition. In the chronic and recurring cases cystoscopy, pyelography, and if necessary catheterization of the ureters, should be carried out in order to ascertain if there is any abnormality present to account for the clinical condition.

These surgical procedures should not be so long delayed that the child's kidneys are found to be irreparably damaged when the biochemist makes an investigation of the blood urea and of the renal function. It will be deduced, therefore, from the foregoing observations that I am in agreement with Mr. George Waugh, a former colleague at the Great Ormond Street Hospital, who stated in 1927¹⁵ that every case of urinary tract infection should be investigated by a team of four—a physician, a surgeon, a bacteriologist, and a biochemist—though personally I should include a radiologist, and if the patient should unfortunately die, then also a pathologist to hunt carefully for anatomical abnormalities. If this were always done these cases would be more thoroughly and systematically investigated than in the past, and the results would be better than have hitherto been obtained.

I should like to express my thanks to my colleagues at the Hospital for Sick Children for permission to refer to the notes of their cases; to Dr. W. P. Sheldon for examining the post-mortem records and obtaining the figures for the incidence of anatomical abnormalities; and to Mr. Deryck Martin for his assistance with specimens and for preparing the lantern slides.

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