Urinary infections in children 1985

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Introduction

Urinary infection is a common and recurrent condition and occurs sporadically throughout life. It is of special significance in children for three reasons. First, recurrent symptoms are troublesome and may be perpetuated into adult female 'cystitis'; second it may indicate unsuspected structural defects that require surgical correction; third and most important is its causative relationship, in association with vesico-ureteric reflux (VUR), with the renal scarring of chronic atrophic pyelonephritis or reflux nephropathy, which is a major cause of both end-stage renal disease and of hypertension in the child and young adult. It is in infancy and childhood that the recognition and correct management of urinary infection offers the greatest opportunity for the prevention of serious infective renal damage.

Winsbury White (1926) writing about urinary infection in children in the first volume of the *Postgraduate Medical Journal* described the full spectrum of clinical presentation from relatively symptomless bacteriuria to acute pyelonephritis. He noted that it was commoner in girls and in the younger child and that there were often no symptoms related to the urinary tract. This was well recognized by Thompson (1910) and has been emphasized repeatedly over the years (Williams, 1955; Smellie *et al.*, 1964; MacGregor, 1965; Smallpeice, 1968). Nevertheless, the errors in the diagnosis of urinary infection in adults which caused concern to the Editor in 1926 still occur in children in 1985. It is not uncommon for scarred kidneys to be discovered on investigating a toddler eventually found to have urinary infection and first referred to the paediatrician after months of 'grizzling' or low grade fever or colic and without the urine ever having been examined or cultured.

Major advances in our knowledge of childhood urinary infection have followed the development of sophisticated imaging techniques and effective antibacterial agents. A greater understanding of its pathogenesis and natural history has emerged from

formal epidemiological studies, extended follow-up of affected children and from the study of animal models. Yet one of the commonest causes of end-stage renal failure requiring dialysis or renal transplant in this country remains 'pyelonephritis'. These 'salvage' techniques improve the quality and extend the expectation of life in those with terminal renal failure but clearly much more emphasis must be placed upon using our existing knowledge and implementing the less dramatic methods already available to reduce the need for such treatment. As we wrote in 1968: 'At a time when medical resources are being increasingly concentrated on the management of chronic renal failure it is perhaps relevant to consider the potential for its prevention. It is the concern of those caring for children with urinary infection to determine those in whom this risk is present and how it may be minimised or eliminated. This makes the early recognition of urinary infection and the introduction of effective treatment essential' (Smellie & Normand, 1968).

Historical survey

Investigation and imaging techniques

The first major advance in the investigation of childhood urinary tract infection, the introduction of the intravenous urogram (IVU) made possible the *in vivo* diagnosis of chronic atrophic pyelonephritis (Hodson, 1965) which renal biopsy and histology were unable to do because of the irregular distribution of renal scarring. The development of micturating cystourethrography (MCU) allowed VUR to be recognized even when this was unsuspected on the IVU. Although Sampson (1903) and Bumpus (1924) had described VUR many years earlier, it was the association of radiological chronic pyelonephritis with VUR reported by Hodson & Edwards (1960) that led to a major revival of interest in the condition. Intrarenal reflux (IRR) or calycotubular backflow was occasionally noted during cystography, particularly in infants and in areas of the kidney where renal scarring was later seen (Rolleston *et al.*, 1974). Ransley & Risdon (1975)

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demonstrated that this depends upon the morphology of the renal papillae. Simple conical papillae do not permit intrarenal reflux whereas compound papillae, which are present in at least 75% of human kidneys (Tamminen & Kaprio, 1977) and particularly in the polar regions, have a concave central area with circular papillary duct orifices which allow IRR to occur.

Hodson *et al.* (1962) also noted that the renal length was a function of the child's height and that renal growth obtained from serial measurements of length and also of parenchymal thickness provided one of the most sensitive indicators of normal renal development. Vertebral measurements taken from the intravenous urogram could also be used as a reference measurement for renal length if the child's height was not available (Eklof & Ringertz, 1976; Claesson *et al.*, 1981).

Cystoscopy became largely superseded in the primary investigation of children with urinary infection but increasing recognition of the importance of bladder/sphincter dysfunction in children with recurrent urinary tract infection has stimulated interest and greater refinement in urodynamic studies (Koff, 1982; Van Gool *et al.*, 1984).

Microbiology

Enumeration of urinary bacteria and serotyping of coliform organisms have led to more exact diagnosis, to the recognition of the faecal reservoir as the main source of urinary pathogens and to the elucidation of the pathogenesis of urinary infection (Kass, 1956; O'Grady & Brumfitt, 1968). More recent studies have been directed towards the search for virulence factors and in particular the role of bacterial fimbriae in uroepithelial attachment. (Svanborg-Eden *et al.*, 1976; Svenson *et al.*, 1984; Winberg, 1984; Guze *et al.*, 1983). Antibody responses to coliform urinary infection have indicated a correlation between raised antibody titres to O or K antigen and renal involvement but no evidence of lasting protection against further infection.

A particularly important change has been the almost total disappearance of tuberculous renal disease in children and the infrequency of stone formation as prolonged bed rest for disorders such as poliomyelitis, osteomyelitis and tuberculous disease of the spine is no longer needed.

Advances in treatment

In 1926, the therapeutic armamentarium was limited to surgical relief of obstruction and to symptomatic treatment of bacterial infection. Neonatal and paediatric surgery and anaesthesia have advanced to the point that the prognosis in infants with urinary

infection and outflow obstruction depends on the speed of diagnosis and surgery and on the amount of renal parenchyma present at birth.

Advances in chemotherapy with mandelic acid, sulphonamides, penicillins and a succession of further antibacterial agents has transformed the management of the acute infection. The tendency for urinary infection to recur is indicated by reinfection rates of 50% in one year and 75% within two years of the initial infection (Kunin *et al.*, 1964; Bergström *et al.*, 1968; Smellie *et al.*, 1978). For this reason low dose prophylactic chemotherapy to reduce the risk of reinfection of the susceptible urinary tract was introduced and has proved highly effective (Smallpeice, 1968; Normand & Smellie, 1965; Normand, 1970).

Epidemiology, follow-up and experimental studies

The first comprehensive screening of children for bacteriuria was carried out in Charlottesville, Virginia by Kunin *et al.* (1964) and established a prevalence in girls on school entry of 1.2% and of 0.03% in boys. Repeated screening of cohorts of the same population of girls between 6 and 12 years showed an annual increment with a cumulative incidence during school age of 5%. Further screening of schoolgirls for bacteriuria was carried out in Britain, notably in Dundee, Oxford and Cardiff, Newcastle and Birmingham (Savage *et al.*, 1969; Asscher *et al.*, 1973; Newcastle Asymptomatic Bacteriuria Research Group, 1975; Edwards *et al.*, 1975). The prevalence and other findings were broadly similar to that of Kunin. Many girls had minor symptoms for which no medical advice had been sought so the term asymptomatic bacteriuria was replaced by covert bacteriuria. A past history of known symptomatic urinary infection which had not been investigated or followed-up was also a feature. The proportion of girls with vesico-ureteric reflux alone or with scarred kidneys was very similar to that found in symptomatic girls. This suggested that most infective renal damage had already occurred and that screening for bacteriuria at school entry to prevent scarring was unlikely to be worth while. Screening for bacteriuria in the pre-school child has been undertaken and has demonstrated that the proportion of bacteriuric children with scarred kidneys under the age of four decreases with diminishing age. In contrast, pre-school screening in the context of general practice suggests that the prevalence of girls in this age group may be as high as 4% (Mond *et al.*, 1970; Randolph *et al.*, 1975). However, the problems of satisfactory urine collection from a total, non-captive, pre-school population and the need for repeated screening if bacteriuria is to be used to identify all children at risk of scarring means that this cannot be introduced as a routine procedure.

Lindberg *et al.* (1975) report similar findings on

screening schoolgirls in Göteborg and found among them a slightly lower prevalence of bacteriuria with reflux in 21% and 10% with renal scarring, all but one of whom had reflux. Interestingly, Helin & Winberg (1980) report no reflux nephropathy in Swedish children with chronic renal failure. Whether this important difference is one of nomenclature or reflects differences in early management requires further study.

In examining the outcome of childhood urinary infection over a period of time, a change can clearly be discerned from a high mortality, mainly in association with obstructive lesions in young children (Steele *et al.*, 1963) through a period of continuing but substantially lower mortality from non-obstructive renal disease (Lindblad & Ekengren, 1969) to much more encouraging findings after the advent of effective chemotherapy in carefully supervised groups of children with symptomatic infections (Winberg *et al.*, 1974; MacGregor & Freeman, 1975; Smellie & Normand, 1968, 1981). The natural history of the covert bacteriuria identified amongst the schoolgirl cohorts, many of the girls now being in their reproductive years, of the Charlottesville (Kunin, 1970; Gillenwater *et al.*, 1979), Cardiff/Oxford (1978) and Newcastle studies (Davison *et al.*, 1984) is currently being examined.

The results of animal studies have been of value in understanding the pathogenesis of renal scarring but the direct extrapolation to the human requires some caution. The piglet model has proved to be the most promising in recent years, particularly in view of the similarity in renal morphology to the human, with multiple papillae many of which are of the compound type allowing intrarenal reflux to occur (Hodson 1975; Ransley & Risdon, 1978).

Aspects of current interest

Diagnosis and treatment of the presenting infection

Rapid recognition of urinary infection in infancy and childhood is fundamental but remains a major problem, first because the diagnosis is not thought of, second because of difficulties in urine collection in young children, and third because there are no simple, rapid and completely reliable methods which provide an immediate diagnosis of significant bacteriuria.

The clinical presentation varies from any of the common symptoms of infancy and childhood such as fever, vomiting, abdominal pain and failure to thrive to the more characteristic symptoms of loin pain, frequency and dysuria. Because they are so varied, the clinical examination of the sick child cannot be considered to be complete without bacterial examination of the urine. If the child is too young to cooperate, a satisfactory specimen can usually be obtained from a

collecting bag if it is used correctly. When urgent treatment is needed in a sick infant, bladder urine can be collected directly by suprapubic aspiration or by catheterization if the bladder is impalpable. The nitrite test (N-Multistix, Ames) correlates with formal cultures in nearly 80% but does not detect coccal infections. Direct microscopy is reliable but now seldom performed as a 'side-room' test. The overgrowth of contaminants which so often vitiates the results of mid-stream specimens can be prevented by the immediate inoculation of dip slides or refrigeration of the specimen if there is to be any delay in laboratory examination (Meers, 1978).

In the sick child, treatment should be started as soon as a satisfactory urine sample has been obtained if the nitrite test or microscopy is positive or the history very suggestive. Even if another diagnosis is in question there is no need to delay antibacterial treatment after lumbar puncture and blood culture have been carried out. Delay in treatment will only increase the chance of renal damage in those at risk.

A week's full dosage antibacterial treatment is usually recommended, although infection should be eradicated within 48 hours. A low dose of a suitable drug should then be continued until the cause of the infection has been discovered.

A single dose or 48 hours' antibacterial treatment may be sufficient in children with uncomplicated infection. This approach is not recommended in the young child or when VUR, obstruction or renal lesions might be suspected. If infection has not been eliminated after one week of treatment with an antibiotic to which the organism is sensitive, the possibility of obstruction should be considered and imaging carried out straight away. Further antibacterial treatment will only generate resistant organisms.

Investigation and imaging

Every child with a proved symptomatic UTI deserves investigation after the first attack to know why it happened, if there is a structural abnormality needing surgery and whether renal scarring is present or there is a risk that it may develop. Nearly half will be found to have a structural abnormality. (Smellie & Normand 1982).

Gross abnormalities may be identified by clinical examination, but in general, the clinical history gives little indication of the condition of the urinary tract and early investigation must be undertaken.

The understandable reluctance to subject children to invasive techniques often results in the postponement of investigation and unfortunately appropriate treatment is thereby delayed. New, less invasive imaging methods have been introduced. These have given promising results in the investigation of the young child but require further validation against established

methods and wider experience in their performance and interpretation.

Our current policy is to carry out an IVU in every child with a proved urinary tract infection. All the necessary information is available on a small number of planned films (unless tomography is needed in a baby). This will define the size, shape and function of the kidneys, renal pelves and ureters, indicate the bladder size, shape and residue and identify spinal defects, stones and faecal overloading. In addition, a visual image is helpful in explaining the disorder to the parents and child and thus obtaining their cooperation in a treatment regimen. Measurement of the renal length and the parenchymal thickness are useful if the kidney is enlarged by an acute inflammatory response and measurements will also provide a baseline for the assessment of renal growth.

In a child under the age of five, a radiographic MCU is recommended 2 to 4 weeks after treatment of a proved infection and while the child remains on prophylaxis, to identify VUR and its severity, and over the age of five if there is a duplex or scarred kidney or a dilated ureter on IVU or a family history of reflux. It is also useful after repeated infections to obtain information about the bladder capacity, residual urine, and function, and to identify diverticula. The progression of reflux can be followed by radionuclide cystography (Conway, 1984) which will reduce the radiation exposure. There is, however, less than 75% correlation between indirect isotope cystography and the radiological method and direct cystography still involves catheterization.

Ultrasound is valuable in the young infant to detect urinary tract dilatation due to obstruction or gross reflux. The renal findings tend to be subjective, and measurements are not yet sufficiently accurate for serial use in renal growth assessment. Isotope renography provides a measurement of differential renal function. The diethylene triamine penta acetic acid (DTPA) scan is useful in the further investigation of obstruction. The dimercaptosuccinic acid (DMSA) scan can provide early evidence of renal parenchymal involvement (Merrick *et al.*, 1980).

It is easy to postpone investigation of the baby with a urinary tract infection 'till the next time'. The 'next time' may already be too late as permanent renal damage may have been initiated and there will inevitably be a 'next time' in at least 75% of infected infants and children.

Recurrent urinary tract infection

Pathogenesis The primary source of organisms infecting the urinary tract is the faecal reservoir of bowel commensals (Grüneberg *et al.*, 1968) but organisms invading the bladder will only multiply there if the conditions are favourable (O'Grady & Cattell, 1966),

such as when residual urine collects or the bladder is emptied incompletely or infrequently as with any degree of functional or structural outflow obstruction. Incomplete voiding when a loaded colon interferes with bladder emptying or voiding is hurried in the busy toddler, infrequent voiding on holiday or when school toilets are distasteful, or the return of refluxed urine to the bladder will thus all favour reinfection.

Important considerations in the clinical history are therefore drinking, voiding and bowel habits and the family history. The question of sexual abuse may have to be considered.

Prevention In principle, prevention of recurrent urinary infection is achieved by ensuring good urine flow and bladder emptying, and protection from reinfection by low-dose prophylaxis.

(a) *Improvement of host defences.* The child should be encouraged to drink plenty, to empty the bladder regularly, frequently and completely, and open the bowels daily. If the outflow of urine is mechanically obstructed this must be corrected surgically: continued antibacterial therapy will be ineffective and low dose prophylaxis is contra-indicated because resistant organisms would inevitably be generated. The child with a functional problem in bladder emptying may be helped by training or treatment with drugs acting upon the autonomic nervous control or intermittent catheterization and may then benefit from prophylaxis.

(b) *Low-dose prophylaxis.* The purpose of using antibacterial prophylaxis is to prevent reinfection of the susceptible urinary tract until the underlying cause has resolved or been corrected. Indications for its use include children with VUR whose kidneys may be at risk of infective damage, children with recurrent symptomatic infections and in infancy, when the symptoms are not specific and the diagnosis of recurrence is most difficult. In a child without VUR, neither persistent symptomless bacteriuria (Cardiff/Oxford, 1978) nor recurrent symptomatic infection (Figure 1) appears to affect the kidneys.

Suitable prophylactic drugs, which include nitrofurantoin, co-trimoxazole and trimethoprim, should be effective against urinary pathogens, well tolerated with good compliance, excreted in high urinary concentration and produce minimal bowel flora resistance. Nitrofurantoin has little effect on the bowel flora resistance pattern and is used in a prophylactic dose of approximately 1–2 mg/kg/day. Co-trimoxazole and trimethoprim tend to eliminate aerobic coliforms from the bowel flora (Grüneberg *et al.*, 1976). There has been remarkably little increase in trimethoprim resistance over the decade of its use (Grüneberg, 1984) and these agents remain at the present time effective prophylactic drugs used in children in doses of 10 mg sulphamethoxazole and 2 mg of trimethoprim/kg/day, or 2 mg trimethoprim/

Figure 1 Normal renal growth without scarring in a girl with recurrent symptomatic urinary infection and no VUR. (F & N = nitrofurantoin (Furadantin), G = sulphafurazole, A = ampicillin). There was no recurrence of infection during 2½ years of prophylaxis, or during the following 3 years. (O—O) normal; (O) right; (●) left.

kg/day respectively, taken once daily at bedtime (Smellie *et al.*, 1982). Recurrence of infection during prophylaxis is rare; if the organism is sensitive to the drug the child's compliance should be checked, if resistant it suggests too high a dose or incomplete voiding and a possible unstable bladder (Allen & Bright, 1979). Recurrence of infection after completion of therapy indicates that the urinary tract is still susceptible to infection and re-investigation may be necessary.

Vesico-ureteric reflux and urinary tract infection

Vesico-ureteric reflux is the most common abnormal finding when the infant's or child's urinary tract is investigated radiologically following a urinary infection and it is seen in 30 to 40% of them. It is usually due either to delay in the development of the vesico-ureteric junction or it may be associated with lateral displacement of the vesico-ureteric orifice and with other malformations such as an ectopic ureter, a duplex system or a paraureteric diverticulum. There is no convincing evidence that it is caused by infection though it can undoubtedly occur only intermittently. Vesico-ureteric reflux may be familial and appears to have a multifactorial inheritance with a 10 to 12% chance of being present in first degree relatives (Leading Article, 1975; de Vargas *et al.*, 1978; Bailey *et al.*, 1984). This could make the early diagnosis of VUR possible in some infants.

The dynamic interrelationships of urine secretion, ureteric peristalsis, the bladder voiding mechanisms and the pressures generated are complex and incompletely unravelled. In the child with urinary infection, however, the importance of vesico-ureteric reflux is to afford vesical pathogens an easy route of access to the kidney, to encourage reinfection by forming a residue when refluxed urine returns to the bladder and to allow the bladder voiding pressure to impinge directly upon the renal papilla which may result in intrarenal reflux (IRR). At least 30% of children with urinary infection and reflux have renal scarring and over 90% of children with renal scarring have VUR and a history of urinary infection. The severity of reflux varies but even in the more severe grades, reflux tends to stop spontaneously with time (Smellie 1967; Smellie & Normand, 1968; Reischauer *et al.*, 1969; King *et al.*, 1974). During continuous long-term prophylaxis it disappeared in 80% of undilated and over 40% of dilated ureters (Edwards *et al.*, 1977). The dilatation and lateral displacement of the ureteric orifices may however persist into adult life and Vermillion & Heale (1973) were able to demonstrate VUR in less than 50% of adults with chronic pyelonephritic scarring although a high proportion had abnormal ureteric orifices on cystoscopy. This natural resolution of reflux is related to the lengthening of the intramural segment as the ureter passes more obliquely through the bladder wall (King *et al.*, 1974).

Controversy has surrounded the management of

children with urinary infection and reflux though opposing views are now less polarized.

In experienced hands, ureteric reimplantation is successful in stopping reflux in over 90% of children (Carpentier *et al.*, 1982) though there may be later complications (Filly *et al.*, 1974). Medical management has been variously interpreted as observation only or short courses of treatment for any recurrent infections or a genuine effort to *prevent infection* of the urinary tract. The last approach is clearly the appropriate conservative line in infants and children without obstruction whose kidneys are at risk of permanent damage if exposed to infection.

Low-dose antibacterial prophylaxis, combined with double micturition and other measures already discussed is successful in preventing recurrent infection in children with VUR and there is seldom difficulty in gaining complete compliance in the regimen once the problem is discussed with the interested parent and the child, and the purpose explained. We have followed, for up to 20 years, 200 children with all grades of reflux managed in this way. Three-quarters of the children remained completely free from infection and renal growth proceeded normally in all of these, including those whose kidneys were already scarred. No new scars developed (see Figure 2). During this same period 88 refluxing kidneys were exposed to a single infection and amongst these, two new scars developed and renal growth was slower than expected in 16, ten of them already small and scarred and with severe

reflux (Smellie & Normand, 1981). In the present state of knowledge, the objective should clearly be complete prevention of infection.

Controlled trials of medical and surgical treatment of children with moderate to severe reflux and of infants with severe VUR have not yet demonstrated any advantage of one form of treatment over the other in terms of recurrence of infection, development of new scars, or renal function (Birmingham Reflux Study, 1983; International Reflux Study, 1981; Great Ormond Street Study, see Ransley 1981). New renal scars have tended to appear in the early part of the studies suggesting they were initiated at the time of presentation and that either medical or surgical management was introduced too late for their prevention.

The authors' medical management consists in outline of the rigorous prevention of recurrent infection by uninterrupted low-dose antibacterial prophylaxis starting immediately after treatment of the acute infection and continuing until reflux is known to have stopped or the child is fully grown. Double micturition at bedtime to ensure the bladder is emptied completely at least once each day and regular bowel habits are also encouraged. This is monitored by urine culture every three months or, if a fever or other symptoms develop, by renal growth assessment on one film intravenous urography every two to three years.

Surgical correction is indicated if there is associated structural obstruction, or if gross VUR is accompanied by urological malformation, large diverticula, and

Figure 2 Normal renal growth without scarring over 10 years in a girl with persistent VUR and no recurrence of U.T.I. during continuous prophylaxis. (O--O) normal; (O) left; (●) right.

ectopic ureter, or if recurrent symptomatic infection cannot be prevented by prophylaxis. The latter is often due to social reasons in children with unsatisfactory family or home circumstances. It is now recognized that surgery is unnecessary in children with less severe reflux (which will resolve spontaneously) and that in the grossly dilated atonic ureter with a trabeculated thick walled bladder it may be unsuccessful.

In children with recurrent infection and severe VUR the choice must still be an individual one. Parental and

patient inclination and compliance, the child's age, the severity of reflux and the availability of medical supervision or of a paediatric urologist will all influence the decision. Good medical and good surgical care of children with urinary tract infection and vesico-ureteric reflux should both produce good results. What is important is to identify the children with VUR and recognize that their kidneys are potentially at risk if exposed to infection.

Figure 3 Scars developing in the initially normal left kidney of a girl, following infection of a refluxing urinary tract, aged 3½ years. (a,b) Aged 3 years 4 months. IVU and tracing of normal kidneys. (c) Aged 6. MCU showing left reflux. (d,e) Aged 8. IVU and tracings showing established scars accentuated by hypertrophy of surrounding tissue.

Renal scarring and its prevention

Vesico-ureteric reflux and renal scarring have stimulated wide interest and a considerable literature has accumulated. Some of the recent literature is reviewed in the proceedings of two workshops (Hodson & Kincaid-Smith 1979; Hodson *et al.*, 1984) and by Govan (1984) and Bellinger (1985).

The segmental renal scarring of chronic atrophic pyelonephritis or reflux nephropathy is a major and potentially preventable cause of renal insufficiency and hypertension. It is found in 12 to 25% of children with urinary tract infection, the higher proportion being in those with a history of previous infection (Smellie *et al.*, 1964) and it is seen in 30 to 60% of children with urinary tract infection and vesico-ureteric reflux (Scott & Stansfeld, 1968). Renal scarring is characterized radiologically by a reduction in overall renal size and by irregularly dispersed scarred areas, mainly polar in distribution. At the site of scarring, the surface is indented and the calyx deformed or clubbed by the contraction of scarred tissue (Hodson, 1965). In the young, growing child these appearances are accentuated by the hypertrophy of any surrounding normal parenchyma. Renal scarring is symptomless and in children is almost always associated with vesico-ureteric reflux. It is usually discovered on investigation of either a child with urinary infection or of patients with hypertension or impaired renal function.

Amongst 83 children with renal scarring whom we have followed for at least fifteen years, renal function was impaired in five, three of whom required dialysis or transplant, two others died; hypertension was present or developed in a quarter of them (Smellie & Normand, 1979). Hypertension had developed in 12% of a group of 166 children with scarred kidneys who were followed up ten or more years after reflux stopping surgery and in 18% of those with bilateral renal scarring (Wallace *et al.*, 1978).

Dysplasia or other renal abnormalities may be present from birth but it appears from the few detailed reports of acquired renal scars that most fresh scarring takes place after symptomatic infection of refluxing urinary tracts often in areas where intrarenal reflux had previously been visualized. This usually occurs in infancy or early childhood though new scars can appear following infection throughout childhood (Smellie *et al.*, 1975, 1985; Winberg *et al.*, 1982; Figure 3). Delayed recognition or treatment and recurrence of symptomatic infection between the last unscarred IVU and the first with a new scar have been common features of studies of acquired scars (Winter *et al.*, 1983, Smellie *et al.*, 1985), and at least one fifth of these children had social problems which interfered with their management.

These clinical observations and their interpretation

are compatible with recent experimental studies in piglets. Hodson *et al.* (1975) and Ransley & Risdon (1978) were able to produce segmental renal scarring after infection of the refluxing piglet model. Ransley & Risdon (1975) suggested that maximum renal damage might follow the first severe infection of a refluxing urinary tract, the distribution of the permanent scarring depending on the sites of compound papillae (Figure 4a). In the piglet model they then (Ransley & Risdon, 1981) showed that this scarring could be prevented or modified when antibacterial treatment was given within a week of infection (Figure 4 (b)). The question arises whether, once permanent scarring has developed, there is any indication for either medical or surgical treatment. There is evidence that further new scars may develop at a later date (Smellie *et al.*, 1985) and that among children with VUR established scarring is found in a higher proportion of those with a history of recurrent infection than in those with less than two recurrences (Smellie *et al.*, 1981).

Figure 4 (a) Diagrammatic representation of the development of a new renal scar. After infection of a refluxing urinary tract, inflammation is followed by scarring localized to a segment with a compound papilla. (From Ransley, P.G., 1982, with permission from the editors and publishers). (b) Diagrammatic representation of the development of a new renal scar following infection of a refluxing 'renal unit' – in a piglet. Introduction of antibacterial treatment within 6 days modified or prevented scar formation. (After Ransley & Risdon, 1981).

Reflux is not always reported, however, in children acquiring new scars (Winberg *et al.*, 1982; Winter *et al.*, 1983) and conversely, Winberg (1982) describes a child with VUR, intrarenal reflux and urinary infection subsequently found to have normal kidneys. A possible explanation for the former would be postponement of the initial micturating cystogram for some time so that reflux had already resolved and for the latter, rapid effective treatment of the presenting infection.

The first essential in preventing renal scarring is to identify the children with VUR and urinary infection. Since there is no method of screening for VUR, infection must remain the marker of children at risk; they will need rapid antibacterial treatment and then prophylaxis until investigation is complete. The DMSA scan may in the future provide some guide to those needing further investigation, continued prophylaxis and careful follow-up and by its increasing use will focus more detailed attention on the morphology and function of the kidney. We still consider an IVU to be essential.

Conclusion

Urinary tract infection in children in 1985 is still common, overlooked and important. It matters in particular if it occurs in association with obstruction

or with reflux, the latter being far more common, and it is in infancy and early childhood that most, but not all, of the damage to the kidneys is done.

What we have learnt over the past 60 years is the importance of early diagnosis and rapid treatment of the infection, of investigation to ascertain why the child should be subject to infection and of the need to prevent further infections from occurring so long as the kidneys remain vulnerable. All of this should be part of standard paediatric practice, but there is still a need for wider awareness of the non-specific but real symptoms of infection in early childhood and perhaps a greater sense of urgency in the treatment and investigation of the child with urinary infection. All the therapeutic measures we need are available but the greater advance in the care of these children over the next 60 years will come from the development of accurate sensitive but simple tests for the diagnosis of urinary tract infection and in inexpensive non-invasive methods of identifying that small proportion of children whose kidneys are particularly at risk.

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