Study of urinary tract infection in children in one health district

Linda Pead, Rosalind Maskell

Abstract

Objectives—To determine the number of children who had urine specimens sent for culture, who had infections or sterile pyuria, and who were investigated further. To relate the laboratory findings to the results of imaging.

Design—One year survey of urine specimens submitted to a laboratory; review of previous and subsequent laboratory reports; review of the findings of imaging of the urinary tract.

Setting—Portsmouth and South East Hampshire health district.

Subjects—An estimated population of 89 086 children aged 12 years or under.

Main outcome measures—Urine bacterial count and results of imaging.

Results—12 551 urine specimens were submitted from 7450 children, 3138 boys and 4312 girls. 2238 children had infection or sterile pyuria at least once during the study (13.9/1000 boys, 37/1000 girls). 996 (45%) of the children with infection or sterile pyuria underwent some form of imaging. 128 children who had infection or sterile pyuria were already known to have urinary tract abnormalities and 114 children had newly identified abnormalities (1.0/1000 boys, 1.5/1000 girls). 50 (44%) of the children with newly detected abnormalities had no pyuria and 48 (42%) had bacterial counts below 10^4 /l. Eight children who had sterile pyuria on presentation were found to have abnormalities on imaging.

Conclusions—Urinary tract infection is much commoner in children than is widely believed. Low bacterial counts, the absence of pyuria, or a finding of sterile pyuria should not be disregarded.

Introduction

The importance of identifying children at risk from renal damage due to urinary tract infection in childhood has been emphasised repeatedly. A recent consensus conference of the Royal College of Physicians stated that any child who has a urinary tract infection should have some form of imaging and appropriate long term management.¹ If such a policy is to be implemented the size of the problem must be known, but such information was conspicuously lacking from the document. One large study of urinary tract infection in children in the community has recently been published.² Previously, information has been confined to that obtained from screening studies of schoolgirls.^{3,5}

Doctors in the Portsmouth and South East Hampshire health district are highly aware of the importance of urinary tract infection in children, and our laboratory receives many thousands of urine specimens from them each year. Our experience suggests that the condition is much commoner than is generally believed, that there are important age and sex differences in incidence, and that some widely accepted views about

bacterial counts and the presence or absence of pyuria should be questioned. To quantify these impressions and consider their implications we did a survey of all urine specimens from children received in the laboratory during one year.

Methods

We set an upper age limit of 12 years in order to exclude urinary infections related to sexual activity. We obtained mid-year population estimates in one year age groups for children aged 0-12 years in our health district for 1991 and 1992 from the Office of Population Censuses and Surveys. We estimated the population in the middle of the study period by averaging the 1991 and 1992 figures.

To ensure that the survey was complete and accurate we scrutinised every urine culture request form received in the laboratory from 1 July 1991 to 30 June 1992. A copy of the computer generated report was also examined, and we checked the accuracy of the personal details (names, age, and sex), if necessary, by a telephone call to the general practitioner's surgery or hospital department.

All specimens from general practice were stated to have been collected by the midstream or clean catch methods. Hospital specimens were collected by these two methods or suprapubic aspiration. Specimens were taken at micturating cystourethrography by catheter. A few specimens from inpatients were collected by bag, but during the study this method was being phased out and replaced by suprapubic aspiration or clean catch. All hospital specimens were refrigerated immediately and transported to the laboratory within a few hours. Similar advice is given to general practitioners about storage and transport of specimens.

We examined the specimens by the inverted microscope method.⁶ Pyuria was defined as the presence of ≥ 20 white blood cells/ml. For suprapubic aspirates, however, in which extraneous contamination is extremely unlikely, the presence of any white cells was recorded as pyuria.

Specimens were cultured by inoculation on to cystine lactose electrolyte deficient agar and incubated in an atmosphere containing 5% carbon dioxide. Cultures were classified according to the criteria in standard use in the laboratory:

Positive (infection)—Any count of a Gram negative pathogen or of two such organisms in mixed growth; a count of $\geq 10^4$ /l of a Gram positive pathogen in pure growth.

Doubtful (possibly contaminated)—Mixed growths, in any count, of more than two organisms including a Gram negative pathogen; pure growths of $< 10^4$ /l of a Gram positive pathogen.

Negative—No growth or counts of $< 10^4$ /l of two or more Gram positive organisms.

Sterile pyuria— ≥ 20 white cells/ml with no growth.

Public Health Laboratory,
St Mary's Hospital,
Portsmouth PO3 6AQ
Linda Pead, research
assistant
Rosalind Maskell, associate
specialist

Correspondence to:
Dr Maskell.

BMJ 1994;309:631-4

Haematuria—Any red cells in absence of white cells or infection.

We analysed all the reports at the end of the study. Between six and nine months after the end of the study we checked the records of all children who had had infection or sterile pyuria on the hospital computer, in which all pathology and imaging results are filed. We noted details of previous or subsequent infections or pyuria, and of any urinary tract imaging. Imaging records were also checked in three neighbouring hospitals to which the children might have been referred. We had no information about the reasons for referral by general practitioners.

Results

SOURCE OF SPECIMENS AND CULTURE FINDINGS

A total of 545 specimens were collected by suprapubic aspiration. The findings in these specimens have been published (46 specimens from 44 children yielded positive cultures)⁷ but are also included in the total number reported here.

TABLE I—Source of 12 551 urine specimens from children

Source	Specimens from boys	Specimens from girls	Total
General practitioner	2782	5696	8478
Hospital outpatients	447	995	1442
Hospital inpatients	1453	1178	2631
Total	4682	7869	12 551

The estimated population of children under the age of 13 on 31 December 1991 served by our laboratory was 89 086. During the study year we received 12 551 urine specimens from 7450 children; 4682 from 3138 boys and 7869 from 4312 girls. Thus at least one specimen was obtained from 8.4% (95% confidence interval 8.2% to 8.6%) of the population. The corresponding percentages for boys and girls are 6.9% (6.6% to 7.1%) and 9.9% (9.7% to 10.2%) respectively. Table I shows the source of the specimens and table II shows the findings.

Table III shows the rates per 1000 (and numbers) of children from whom specimens were received and

TABLE II—Findings in 12 551 urine specimens in children

Finding	No (%) of specimens from boys (n=4682)	No (%) of specimens from girls (n=7869)
Negative	3125 (67)	4219 (54)
Doubtful	589 (13)	1176 (15)
Positive	785 (17)	1911 (24)
Sterile pyuria	114 (2)	449 (6)
Haematuria	69 (1)	114 (1)

TABLE III—Rates per 1000 children (numbers of children) for infection or sterile pyuria, infection only, and abnormalities on imaging

Age (years)	Estimated population	Rate/1000 (No) with ≥ 1 specimen	Rate/1000 (No) with infections or sterile pyuria	Rate/1000 (No) with infections	Rate/1000 (No) with newly detected abnormalities
Boys:					
0-1	7 221	130.6 (943)	41.1 (297)	33.7 (243)	5.0 (36)
2-5	14 873	62.0 (922)	12.7 (189)	11.5 (171)	0.4 (6)
6-12	23 633	53.9 (1273)	6.3 (149)	5.9 (139)	0.3 (6)
Total	45 727	68.6 (3138)	13.9 (635)	12.1 (553)	1.0 (48)
Girls:					
0-1	6959	112.8 (785)	34.9 (243)	27.7 (193)	2.4 (17)
2-5	14 223	102.7 (1461)	42.0 (598)	36.1 (513)	2.0 (29)
6-12	22 177	93.2 (2066)	34.4 (762)	28.2 (626)	0.9 (20)
Total	43 359	99.4 (4312)	37.0 (1603)	30.7 (1332)	1.5 (66)

TABLE IV—Number (percentage) of specimens with pyuria according to bacterial count

Bacterial count	Total No of specimens (n=2696)	No (%) with pyuria
Boys:		
< 10 ³ /l	250	45 (18)
10 ³ -10 ⁴ /l	287	32 (11)
> 10 ⁴ /l	248	94 (38)
Girls:		
< 10 ³ /l	527	148 (28)
10 ³ -10 ⁴ /l	488	137 (28)
> 10 ⁴ /l	896	421 (47)

those with infection or sterile pyuria, infection only, and abnormalities on imaging. In all, 635 boys and 1603 girls had infection or sterile pyuria at least once during the study. There were 785 positive specimens from 553 boys and 1911 from 1332 girls. Table IV shows the bacterial counts in the 2696 positive specimens and the percentage that were accompanied by pyuria. Even in specimens with high bacterial counts, no pyuria was found in over half. A total of 704 (90%) of the positive specimens from boys and 1665 (87%) of those from girls yielded coliforms or *Proteus* spp.

In all 102 boys had sterile pyuria at least once during the study; 42 had it detected in a suprapubic aspirate. Thirty one (30%) of them also had at least one infection

TABLE V—Newly diagnosed urinary tract abnormalities in 114 children

	Boys	Girls
Major abnormality (n=74)	35	39
Vesicoureteric reflux	21	25
Renal scarring	2	7
Vesicoureteric reflux plus scarring	2	4
Vesicoureteric reflux plus stone	1	0
Absent kidney	2	1
Absent kidney plus vesicoureteric reflux	1	1
Hydronephrosis	1	0
Hydronephrosis plus stone	2	0
Pelviureteric junction obstruction	1	1
Posterior urethral valves plus obstruction	2	0
Minor abnormality (n=40)	13	27
Developmental anomalies of kidneys (duplex, etc)	2	7
Dilated collecting system or ureter	3	2
Unequal function of kidneys	1	2
Unequal size of kidneys (> 1.5 cm difference)	1	7
Bilateral large kidneys (glomerulonephritis)	0	1
Trabeculated bladder	2	1
Bladder residue	4	7

before, during, or after the study. Sterile pyuria was detected in 402 girls at least once during the study; 18 had it detected in a suprapubic aspirate. Of these girls, 227 (56%) also had infection on at least one occasion.

The infection diagnosed during the study was the first proved urinary tract infection in 422 (76%) of the 553 boys and 1079 (81%) of the 1332 girls with infection. Of these children, 101 boys and 476 girls had a recurrence of infection during the study period or within nine months after it.

URINARY TRACT IMAGING

Of the 635 boys and 1603 girls with infection or sterile pyuria during the study, 58 boys and 239 girls had previously had some form of imaging of the urinary tract. Abnormalities had been detected in 28 of the boys and 100 of the girls. As a result of finding infection or sterile pyuria during the study, imaging was done during or within nine months after the study on 230 boys and 569 girls. Twenty two of these boys and 78 of these girls had had imaging previously. Ultrasonography only was performed on 83 boys and 254 girls. The other 147 boys and 315 girls had either one alternative imaging technique or two or more techniques.

After all the children known to have abnormalities before the study period were excluded abnormalities of some kind were detected in 48 boys (21% of those investigated) and 66 girls (12% of those investigated). The highest rate of detection was in boys aged 0-1 years (table III). The abnormalities are detailed in table V. For the purpose of assessing the significance of bacterial counts and pyuria the abnormalities were classed as major (of serious clinical importance) and minor (of less serious or doubtful clinical importance). Table VI shows the bacterial counts and presence of pyuria and sterile pyuria in children who had new abnormalities detected. Although only 358 (35%) of the children with a bacterial count below 10⁴/l had further investigations, they comprised 41% of those with major abnormalities and 45% of those with minor abnormalities. Pyuria was absent in 30 (41%) of the children with major abnormalities and 20 (50%) of

TABLE VI—Numbers of children having imaging investigations and new abnormalities detected according to the bacterial count or presence of sterile pyuria. The number of children with abnormalities who also had pyuria is shown in parentheses

Bacterial count	No of children	No of children having imaging	No with new abnormalities (plus pyuria)		
			Major	Minor	Total
10 ³ /l	546	160	13 (5)	12 (5)	25 (10)
10 ⁴ /l	479	198	17 (6)	6 (1)	23 (7)
10 ⁵ /l	819	348	38 (27)	20 (12)	58 (39)
Sterile pyuria	394	93	6	2	8
Total	2238	799	74 (38)	40 (18)	114 (56)

those with minor abnormalities. Table VII shows the ages of the children at the time of diagnosis of the abnormalities. Six boys and 20 girls were older than 5 years; four of these boys and seven of the girls had major abnormalities.

TABLE VII—Ages of children with newly detected major and minor abnormalities

Age (years)	Boys		Girls		Total	
	Major	Minor	Major	Minor	Major	Minor
0-1	28	8	14	3	42	11
2-5	3	3	18	11	21	14
6-12	4	2	7	13	11	15

Ultrasound scans were reported as normal in 20 boys and 19 girls who were found to have major abnormalities on other imaging techniques. Twenty seven (69%) of these children were under 1 year. Nineteen of the boys and 18 of the girls had vesicoureteric reflux. A boy of 11 months had vesicoureteric reflux and renal scarring, and a girl of 10 years had renal scarring. The initial diagnosis of urinary tract infection in the 114 children found to have abnormalities was made by the general practitioner in 21 (44%) of the boys and 50 (76%) of the girls.

Discussion

Urine specimens were received from 8.4% of children aged 12 years and under during one year. Most specimens (68%) were sent by general practitioners. The laboratory findings were negative in 67% of the specimens from boys and 54% of those from girls. In view of the difficulties of collecting specimens from babies and young children, and the inevitable delays in transport, the possible contamination rate (doubtful cultures) of 13% in boys and 15% in girls is low.

CRITERIA FOR BACTERIURIA

Our criteria for diagnosis of infection—that is, indicative of likely bladder bacteriuria—have been used in this laboratory for several years. Kass's criterion of significance ($10^5/l$) is widely used elsewhere, but we believe that this criterion could miss many cases. Kass found that symptom free women with bladder bacteriuria usually had a count of $\geq 10^6$ organisms/l in an early morning midstream urine specimen. He also found, however, that a minority of women had lower counts.^{8,9} Several authors have since shown that lower counts may be indicative of bladder bacteriuria in women with symptoms.¹⁰⁻¹² Low bacterial counts have been reported in specimens collected by suprapubic aspiration from children,¹³ and 18 (41%) of the 44 children with positive suprapubic aspirates in our study⁷ had counts below $10^5/l$.

Our recognition of the possible importance of low counts has been vindicated by the findings of this study. Forty two per cent of the children in whom major urinary tract abnormalities were detected for the first time had bacterial counts below $10^5/l$. Important infections will be missed if laboratories adhere to Kass's criterion, fail to report low counts, or use techniques that are not sufficiently sensitive to detect them.

The importance of pyuria has also been debated. Many infections (about two thirds of the total and half of those associated with urinary tract abnormalities) were not accompanied by pyuria. On the other hand, sterile pyuria is an important finding for which an explanation should be sought. Eight children with sterile pyuria on presentation were found to have urinary tract abnormalities and many others had a urinary infection before or after the episode of sterile

pyuria. Our findings in suprapubic aspirates showed that pyuria cannot be dismissed as a non-specific finding in febrile children.⁷

We do not conclude, however, that every child with a low bacterial count or sterile pyuria must be presumed to have infection. Other factors such as method of collecting the specimen, antibiotic treatment, and clinical circumstances must be taken into account. Instead, laboratories should always ask for a repeat specimen to be submitted for confirmation.

DEMAND ON SERVICE

Many children with infection or sterile pyuria (635 boys and 1603 girls) were identified during one year, a rate of 13.8/1000 boys and 36.9/1000 girls. This figure is still likely to be an underestimate of the true incidence because, as confirmed by Jadresic *et al*, general practitioners do not always send urine specimens for confirmation of the diagnosis.² The infection diagnosed during the study was the first to be diagnosed in 422 (76%) of the boys and 1079 (81%) of the girls. These numbers far exceed those previously reported in screening studies^{3,5} and indicate that urinary tract infection is much commoner in childhood than is widely believed. This raises important questions about the extent to which such children should be subjected to imaging and the scale of the provision needed for appropriate clinical and laboratory follow up.

Urinary tract abnormalities were detected for the first time in 114 children; an additional 128 were already known to have them. This number is large but, again, it is clearly an underestimate. Only a minority of the children with infection or sterile pyuria had imaging. We cannot postulate on the number of abnormalities that would have been detected had all children been investigated because we have no information about the reasons for referral of children. Furthermore, many of the consistently negative results came from children with known abnormalities who were taking long term low dose antibacterial prophylaxis. Lastly, limited imaging—ultrasonography only—was performed on 36% of the boys and 45% of the girls who were investigated. Although such limited imaging has been recommended for some children, in particular those aged over 5 years,¹ it does not detect vesicoureteric reflux or minor degrees of renal scarring. In our study ultrasound scans were reported as normal in 20 boys and 19 girls with major abnormalities, and 11 children with major abnormalities were older than 5 years. We suggest that general practitioners should be advised to arrange urine cultures at three monthly intervals, and whenever illness or symptoms occur, for at least one year after a report of a normal ultrasound

Clinical implications

- Urinary tract infection is much commoner in children than is generally believed
- In this study 1/1000 boys and 1.5/1000 girls had abnormalities of the urinary tract, and many had low bacterial counts in urine
- General practitioners should be aware that urinary tract infection is a pointer to such abnormalities and laboratories should provide an accurate diagnostic service
- A considerable expansion of services will be needed if all children with urinary tract infection are sent for imaging
- Alternatively, selection criteria indicative of likely abnormality must be developed and validated

scan. This would ensure that recurrences of infection indicating the need for further imaging are detected.

Outpatient consultation and imaging services would need to be expanded considerably if all children with a proved urinary tract infection were referred for investigation, and only a minority will be found to have abnormalities. Attempts have been made to define criteria for selecting those children who should be investigated.^{14 15} When general practitioners used the criteria of fever, recurrent infection, infection persisting after treatment, infection with unusual or resistant organisms, or infection with enuresis to determine referral for investigation, abnormalities were found in 38% (58% of those who underwent intravenous urography or radionuclide scanning).¹⁴ Until more refined criteria are available, facilities for accurate diagnosis of infection must be provided and general practitioners encouraged to use them.

We thank Dr Hazel Inskip for statistical advice, our clinical and radiologist colleagues and laboratory scientific and clerical staff for their cooperation in this study, and Veronica Symes for typing the manuscript.

1 Guidelines for the management of acute urinary tract infection in childhood. Report of a working group of the Research Unit, Royal College of Physicians. *J R Coll Physicians Lond* 1991;25:36-42.

- 2 Jadresic L, Cartwright K, Cowie N, Witcombe B, Stevens D. Investigation of urinary tract infection in childhood. *BMJ* 1993;307:761-4.
- 3 Kunin CM, Deutscher R, Paquin A. Urinary tract infection in schoolchildren; an epidemiological, clinical and laboratory study. *Medicine (Baltimore)* 1964;43:91-130.
- 4 Newcastle Asymptomatic Bacteriuria Research Group. Asymptomatic bacteriuria in children in Newcastle-upon-Tyne. *Arch Dis Child* 1975;50:90-102.
- 5 Asscher AW, McLachlan MS, Jones RV, Meller S, Sussman M, Harrison S, et al. Screening for asymptomatic urinary tract infection in schoolgirls. A two-centre feasibility study. *Lancet* 1973;ii:1-4.
- 6 Maskell R. *Urinary tract infection*. London: Edward Arnold, 1982:24.
- 7 Buys H, Pead L, Hallett R, Maskell R. Suprapubic aspiration under ultrasound guidance in children with fever of undiagnosed cause. *BMJ* 1994;308:690-2.
- 8 Kass EH. Asymptomatic infections of the urinary tract. *Trans Assoc Am Physicians* 1956;69:56-63.
- 9 Kass EH. Bacteriuria and the diagnosis of infections of the urinary tract. *Arch Intern Med* 1957;100:709-14.
- 10 Stamm WE, Wagner KF, Amsel R, Alexander ER, Turck M, Counts GW, et al. Causes of the acute urethral syndrome in women. *N Engl J Med* 1980;303:409-15.
- 11 Kunin CM, Van Arsdale White L, Hua Hua T. A reassessment of the importance of 'low-count' bacteriuria in young women with acute urinary symptoms. *Ann Intern Med* 1993;119:454-60.
- 12 Maskell R. A new look at the diagnosis of infection of the urinary tract and its adjacent structures. *J Infect* 1989;19:207-17.
- 13 Chiu N-C, Huang F-Y, Tsai T-S. Urinary tract infections in children. *Acta Paediatr Sin* 1989;30:225-31.
- 14 Maskell R. Urine microscopy and culture in the selection of patients for urinary tract investigation. *Br J Urol* 1989;63:7-10.
- 15 Rickwood AMK, Carty HM, McKendrick T, Williams MPL, Jackson M, Pilling DW, et al. Current imaging of childhood urinary infections: a prospective survey. *BMJ* 1992;304:663-5.

(Accepted 12 July 1994)

The sight test fee: effect on ophthalmology referrals and rate of glaucoma detection

D A H Laidlaw, P A Bloom, A O Hughes, J M Sparrow, V J Marmion

Abstract

Objective—To assess changes, if any, in the numbers of referrals and outcome of glaucoma referrals to the hospital eye service since the introduction of the sight test fee on 1 April 1989.

Design—Review of referral records and clinical notes.

Setting—Referrals to the Bristol Eye Hospital.

Subjects—51 919 patients referred to the Bristol Eye Hospital between 1984 and 1992. 9438 case notes of patients referred between 1987 and 1991 were examined in detail.

Main outcome measures—Numbers of referrals; rate of adult true positive glaucoma referrals.

Results—Referrals to the Bristol Eye Hospital were between 13.7% and 19.0% fewer than expected after the introduction of the sight test fee. True positive glaucoma referrals were reduced by the same proportion.

Conclusions—The numbers of patients being identified as requiring treatment or follow up for potentially blinding glaucoma have declined by nearly one fifth since the introduction of the sight test fee. An increased prevalence of preventable blindness may result.

Introduction

The sight test is the only existing means of screening adults in Britain for sight threatening but treatable ocular diseases such as glaucoma. Over 80% of glaucoma referrals to ophthalmologists are initiated as a result of screening during routine sight tests.¹ Unconditionally free sight testing was withdrawn in the United Kingdom on 1 April 1989.

Concern was expressed that the introduction of a sight test fee would deter people, particularly elderly people, from having sight tests. It was suggested that

as a consequence the rate of detection of blinding but potentially treatable ocular diseases such as glaucoma would fall.² The effect of the sight test fee on the rate of detection of eye disease has not been investigated. We therefore tested the hypothesis that there had been no change in the number of referrals to, or rate of identification of glaucoma at, the Bristol Eye Hospital since the introduction of the sight test fee.

Subjects and methods

Records of referrals to the Bristol Eye Hospital were examined for the number of referrals received each year during 1984 to 1992. Referral data from before 1984 were not available. The case records of adult referrals received between 1 July and 31 December each year during 1987 to 1991 were targeted for examination. A sample of these records was examined to determine the outcome of referrals for suspected glaucoma. Adult referrals were targeted because sight tests on children are still funded by the NHS.

There is a latency of up to six weeks between the identification of suspected disease by an optometrist and receipt at the hospital of a referral from the patient's general practitioner. To ensure that we were comparing referrals initiated after the sight test fee was introduced with those initiated before we targeted referrals received between 1 July and 31 December of each year during 1987 to 1991. The case records of patients referred with suspected glaucoma were examined to determine whether the referral was a true positive referral. Suspected glaucoma was defined as mention in the referral letter of glaucoma, abnormal intraocular pressure, optic disc changes compatible with glaucoma, family history of glaucoma, or field loss compatible with glaucoma. True positive cases were those in which the patient was noted at the first clinic visit to require follow up for confirmed or suspected

Bristol Eye Hospital,
Bristol BS1 2LX
D A H Laidlaw, registrar
P A Bloom, research registrar
V J Marmion, consultant

Department of
Epidemiology and Public
Health Medicine,
University of Bristol,
Bristol BS8 2PR
A O Hughes, senior lecturer

Department of
Ophthalmology, University
of Bristol, Bristol BS1 2LX
J M Sparrow, senior lecturer

Correspondence to:
Mr Laidlaw.

BMJ 1994;309:634-6