A nurse led education and direct access service for the management of urinary tract infections in children: prospective controlled trial

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Abstract

Objectives To determine whether a nurse led education and direct access service improves the care of children with urinary tract infections.
Design Prospective cluster randomised trial.
Setting General practitioners in the catchment area of a UK paediatric nephrology department.
Participants 88 general practices (346 general practitioners, 107 000 children).
Main outcome measures Rate and quality of diagnosis of urinary tract infection, use of prophylactic antibiotics, convenience for families, and the number of infants with vesicoureteric reflux in whom renal scarring may have been prevented.
Results The study practices diagnosed twice as many urinary tract infections as the control practices (6.42 *v* 3.45/1000 children/year; ratio 1.86, 95% confidence interval 1.42 to 2.44); nearly four times more in infants (age <1 year) and six times more in children without specific symptoms. Diagnoses were made more robustly by study practices than by control practices; 99% *v* 89% of referred patients had their urine cultured and 79% *v* 60% had bacteriologically proved urinary tract infections ($P<0.001$ for both). Overall, 294 of 312 (94%) children aged under 4 years were prescribed antibiotic prophylaxis by study doctors compared with 61 of 147 (41%) by control doctors ($P<0.001$). Study families visited hospital half as much as the control families. Twice as many renal scars were identified in patients attending the study practices. Twelve study infants but no control infants had reflux without scarring.
Conclusion A nurse led intervention improved the management of urinary tract infections in children, was valued by doctors and parents, and may have prevented some renal scarring.

Introduction

Urinary tract infections in children may cause focal renal parenchymal scarring, sometimes leading to hypertension and renal failure.[1 2] Evidence that urinary tract infections can cause renal scars rapidly in animals with vesicoureteric reflux and intrarenal reflux may also be relevant in children aged less than 4 years.[3 4] General practitioners in the United Kingdom manage urinary tract infections in children variably, and evidence suggests that their practice does little to prevent scars.[5–7] Yet rigorous hospital based primary care in Sweden has reduced scarring and rates for end stage renal failure in children.[8] We aimed to determine whether the management of urinary tract infections in children in the United Kingdom could be improved with a different healthcare model.

We had already piloted a model with four general practices, allowing them direct access to imaging for children with a bacteriologically proved urinary tract infection. This made practices the focus for management, improved diagnostic standards, reduced delays in treatment, and minimised hospital visits. In the present study we offered this protocol to further general practices, coordinated by a nurse practitioner.

Methods

We invited all general practices (except the pilot practices) in our catchment area to participate. Allocation of participating practices to the study or control limbs was by randomisation within one of 12 strata according to health district (three levels), whether the practice had a trainee doctor, and whether the practice population of children exceeded 1000. Patients referred by control practices were identified from referral letters and requests for imaging, and collection of these data was started as soon as the paired study practice had been enrolled.

Control practices

Control practices were not asked to change their management. The paediatricians followed their standard practice, assessing cases and explaining the imaging investigations when indicated, assisted by information sheets. All children with a probable or certain urinary tract infection underwent ultrasonography and scanning with dimercaptosuccinic acid; infants (age <1 year) also underwent cystography.[9] Infants without renal scars or vesicoureteric reflux were considered at negligible risk of future scarring, as were unscarred children aged over 4 years, whereas children aged 1-4 years were considered still at risk of scarring with future urinary tract infections.[10] Parents and doctors were informed of normal results by letter and contacted individually about abnormal scans.

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Three extra tables appear on bmj.com

Summary of management guidelines for study practices

Clinical awareness
Consider urinary tract infection in every child with unexplained illness
Check urine samples from all febrile infants and babies

Collection of urine sample
Refer all children whose urine culture tests positive
Give parents clear instructions and necessary equipment for collection of urine:
- Infants (age < 1 year)—provide urine pads[11]
- Toddlers (1-4 years)—provide urine pads or advise parents on use of a cleaned potty[12]
- Children (> 4 years)—advise parents to obtain clean catches

Urine cultures
Even if the results of near patient stick testing are negative, assess for:
- Blood and protein—tests may be normal in infections and abnormal in other conditions
- White cells—may be negative with an infection or positive without, so often unhelpful
- Nitrite—a positive test result confirms an infection, but the test is falsely negative in 50% of cases

Phase contrast microscopy
Willing practices will be provided with a microscope and instruction into its use

Storing urine samples
Use plain sample bottles and refrigerate if culturing is delayed, or inoculate onto a culture dip slide using a sterile swab.[13] Avoid boric acid, which may produce a false negative culture

Antibiotic treatment
Start trimethoprim or cephalexin on clinical suspicion or if an infection is confirmed by a positive result with a nitrite stick or by phase contrast microscopy. Seek culture results promptly, and stop antibiotics if these are negative
For infections, confirm the correct choice of antibiotic, submit a referral form to the nurse practitioner, and prescribe night time prophylaxis for children aged under 4 years until investigations are complete

Parent information
Explain the rationale, practicalities, and interpretation of the imaging investigations, and provide information sheets

Results
Normal results—these will be reported to you and the parents by standard age dependent letters, which advise that families requiring further clarification should contact you
Equivocal imaging results—these will be discussed by the paediatric nephrology team, which will provide you with a summary opinion
Abnormal results—the nurse practitioner will telephone you and the parents to outline the problem and to arrange for the patient to see a paediatric nephrologist

Study practices

A nurse practitioner and a part time clerk based in a paediatric nephrology department facilitated the study service. Study doctors were educated about the study at a seminar held at their practice. Further teaching was organised when necessary. New management guidelines were established (box). The doctors ordered imaging investigations for children with bacteriologically proved urinary tract infections through the nurse practitioner. She sought clarification about equivocal referrals; organised imaging; reviewed results with a paediatric nephrologist, radiologist, and medical physicist as necessary; and informed the doctor and family of normal test results. Only children with abnormal test results saw a paediatric nephrologist. Direct access was refused if study practices could not provide clinical details or failed to collect a urine sample. Practices were offered a phase contrast microscope and training in its use.

When our study began, a community paediatrician independently introduced a form of direct access for four control practices (19 general practitioners, 4218 children), arranging imaging for children that doctors suspected of having a urinary tract infection. This involved no training element or any specific quality requirement for referrals. We analysed these four practices both with the control practices and separately.

Statistical methods

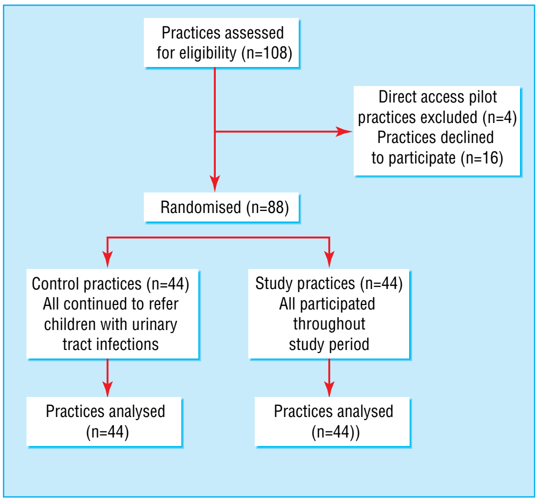
For each practice we calculated the annual referral rate per 1000 children. These rates were compared between the study and control practices by using a randomisation test that took into account the stratification of the allocation. Stata (version 7) was used to compute the ratio of the rates between the study and control practices and the associated bias corrected bootstrap confidence interval. We analysed separately the proportions of referred patients in a practice who had particular attributes, such as treatment without delay. Conditional logistic regression was used for comparisons within practices—for example, between patients with urethral and systemic symptoms. Geometric means were computed for waiting times for imaging for each practice. Study and control practices were compared by using a randomisation test and bootstrap confidence interval.

Results

Our catchment area comprised 104 general practices; 16 declined to participate (figure). The remaining 88 (85%) were randomised equally into study and control practices (table 1). The nurse practitioner enrolled practices for four months. Subsequent contact included frequent telephone guidance and 36 seminars. Referrals were monitored for a mean of 20 months, totalling 180 000 children years. Seven practices analysed urine by microscopy.

Referral patterns

The quality of diagnosis was poor for 22 patients (2%) seen by deputising or casualty doctors; only six patients



Flow of practices through trial

Table 1 Details of study and control practices

Practice characteristics	Study practices (n=44)	Control practices (n=44)
Location:		
Newcastle	14	16
Northumberland	22	20
North Tyneside	8	8
No with a trainee doctor	20	18
No with <1000 children	20	21
No of doctors	185	161
No of children	55 800	51 300

(27%) had a bacteriologically proved urinary tract infection compared with 635 of 884 (72%) seen by general practices. The general practitioners referred 884 children overall (5.1/1000 annually), but compared with the control practices the study practices referred twice as many children, nearly four times as many infants, and six times more patients without urethral symptoms, and they did so consistently (tables 2 and 3). Children without urethral symptoms were predominantly younger; 48 of 84 (57%) were infants but only 28 of 404 (7%) were aged over 4 years (odds ratio 12.4, 95% confidence interval 5.8 to 26.2; $P<0.001$). Referral rates were unrelated to practice size or trainee status of the doctors. The groups had identical age and sex profiles. Male and female infants were referred equally, but among children aged over 1 year females outnumbered males fourfold.

Urine collection

Urine pad (study 75 of 85; 88%, control 19 of 22; 86%) or clean catch was mostly used to collect urine from infants.[11] Only four sterile adhesive collection bags were used. More study parents than control parents used pads for infants aged 1 or 2 years (81% *v* 49%: ratio 1.67, 1.13 to 3.03; $P=0.001$). More study parents than control parents used potties in infants aged 2 or 3 years (26.4% *v* 10.5%: 2.51, 1.08 to 11.03; $P<0.02$), and 95% prepared them appropriately compared with 43% of control parents (2.24, 1.11 to 8.00; $P<0.001$).[12] More study children than control children were given prophylactic antibiotics pending investigations (table 4).

Standards of microbiology

More children referred from study practices than from control practices had bacteriologically proved urinary tract infections (see table A on bmj.com). More were unequivocal, with $>10^5$/ml *Escherichia coli*, *Proteus* spp, or *Klebsiella* spp (study 79%, controls 60%: 1.31, 1.16 to 1.54; $P<0.001$), and only five study children compared with 31 control children had no urine cultured (1% *v* 11%: 0.09, 0.01 to 0.25; $P<0.001$). Fewer study practices than control practices referred children whose colony counts excluded infection (7% *v* 17%: 0.41, 0.21 to 0.72; $P=0.008$). Equivocal cases were referred equally (study 14%, controls 12%: 1.12, 0.69 to 1.80; $P=0.62$).

Treatment delays

Study practices started a smaller proportion of children on antibiotic treatment immediately (48% *v* 68%: 0.70, 0.59 to 0.83. $P<0.001$), waiting instead for the culture result. However, because they diagnosed urinary tract infections in more children, they treated

Table 2 Referral rates of infants and children with suspected urinary tract infections from study and control practices, according to clinical category (excluding 22 first seen by deputising doctor or casualty officer)

Clinical category	No of children referred per 1000 children/year: Study practices	Control practices	Study:control practices (95% CI)	P value
All children	6.42	3.45	1.86 (1.42 to 2.44)	<0.001
Infants aged <1 year	0.92	0.24	3.84 (1.94 to 9.32)	<0.001
Children and infants with non-specific symptoms only and no urethral symptoms*	1.49	0.24	6.10 (3.47 to 11.76)	<0.001

*From 841 children and infants whose presenting symptoms were described with sufficient accuracy.

Table 3 Numbers of children aged under 1 year or over 1 year,* referred with suspected urinary tract infection by study and control practices throughout four successive five month periods of study

Categories of referrals	No of referrals in each 5 month period: Period 1	Period 2	Period 3	Period 4
Aged <1 year:				
Study practices	20	22	19	24
Control practices	6	6	4	6
Aged >1 year:				
Study practices	136	116	123	131
Control practices	59	77	75	60

*These age groups were compared because diagnosing urinary tract infections in infants is particularly difficult compared with diagnosing them in older children.

Table 4 Proportion of study and control children given antibiotic prophylaxis while awaiting imaging investigations for suspected urinary tract infection

Age group	No (%) of children given prophylaxis: Study practices	Control practices	Study:control practices (95% CI)	P value
<1 year	82/85 (97)	12/22 (55)	2.09 (1.37 to 4.29)	<0.001
1-2 years	55/55 (100)	20/34 (59)	2.11 (1.51 to 3.53)	<0.001
2-3 years	84/90 (93)	18/51 (35)	2.37 (1.66 to 3.88)	<0.001
3-4 years	73/82 (89)	11/40 (28)	2.89 (1.81 to 5.82)	<0.001
>4 years	82/278 (29)	13/143 (9)	4.46 (2.45 to 9.17)	<0.001

more without delay (300 *v* 186). Immediate treatment was less common among children without urethral symptoms (without 48%, with 70%: 3.40, 2.21 to 5.23; $P < 0.001$) in both groups (test for interaction $P = 0.26$). Study practices used nitrite sticks less often than control practices (study 18%, control 41%: 0.44, 0.26 to 0.68; $P < 0.001$), but they were more likely to treat immediately when they did (with sticks 69%, without 43%: 3.07, 1.75 to 5.37; $P < 0.001$). Few study practices assessed urine by microscopy (study 4%, controls 3%: 1.36, 0.27 to 11.70; $P = 0.78$).

Renal imaging

Of 644 children with unequivocal, uncomplicated urinary tract infections, 598 underwent ultrasonography and scanning with dimercaptosuccinic acid, 12 underwent scanning with dimercaptosuccinic acid only, and 15 underwent ultrasonography only (see table A on bmj.com); 3% of families in each arm refused all investigations (study 14, controls five). Nine children were not scanned because of previous normal imaging at age over 4 years. Three study children were initially assessed by a paediatric nephrologist (one child with a kidney stone and one with a family history of dominantly inherited polycystic kidney disease were imaged, but one child with balanitis was not imaged). Most children whose urine was not tested or was equivocal were imaged. Sixty per cent of study children and 90% of control children whose bacteriological evidence excluded a urinary tract infection were still imaged (0.67, 0.44 to 0.90; $P < 0.03$).

Similar numbers of study and control children were imaged within the target of four months after referral (study 26%, controls 21%: 1.24, 0.72 to 2.35; $P = 0.51$). For the rest, study children were delayed for a geometric mean of 26 days and control children for a geometric mean of 68 days (0.38, 0.31 to 0.49; $P < 0.001$). Study families attended hospital a mean of 1.3 times compared with 2.6 for control families.

Renal scars were identified in 10 study children (five multiple) and five control children (two multiple). Four study children had other parenchymal abnormalities, including a hypoplastic kidney, a multicystic dysplastic kidney, a pelvic calculus, and dominantly inherited polycystic kidney disease, and one control child had nephrocalcinosis. Cystograms showed vesicoureteric reflux in 19 of 86 (22%) study children and 2 of 19 (11%) control children (see table B on bmj.com). Twelve study infants and no control infants had reflux without scarring.

Direct access alone

The four control practices with simple direct access referred 38 children. They had similar standards to the other control practices but poorer standards than the study practices (see table C on bmj.com).

Discussion

A nurse led direct access service improved the management of children with urinary tract infections, was preferred by general practices and families alike, and saved time for paediatric clinics. We developed this model to try to improve the service for children with urinary tract infections by bridging the primary-secondary healthcare interface, increasing the involvement of general practitioners, and reducing hospital attendances. Although we anticipated a slight increase in referrals through greater awareness and a slight decrease in false referrals, the diagnosis rate doubled overall and quadrupled in infants and in children without urethral symptoms. The study children had the same age and sex profiles as the control children and as some previous cohorts.[14 15] These data imply that general practices without this service misdiagnose three quarters of infants with urinary tract infections and half overall. The standards of deputising doctors were lower than established colleagues.

Study practices advocated parent friendly urine collection and had higher standards of bacteriological confirmation. They used pads for many toddlers as well as for infants and advised using "washed-up" potties for children aged 1-4 years, whereas many control parents used unsatisfactory cleaning methods.[5 12]

We encouraged study practices to treat young children on clinical suspicion because prompt treatment may prevent renal scars.[8] Without reliable near patient testing, such as phase contrast microscopy (which most practices consider impractical), antibiotics have to be given "blind" until culture results are confirmed.[16] We discouraged stick testing urine for bacterial nitrite because this misses about half the cases, and we discouraged looking for white cells, which is unhelpful.[9 17] Control practices may have lowered their diagnosis rates by discarding urine samples that were negative by stick testing.[5]

Although the study practices treated more children without delay than the control practices, this represented a smaller proportion of their cases. The reasons are complex. Firstly, not all study practices may have accepted that a patient with a suspected urinary tract infection justified "blind" treatment with antibiotics. Secondly, more study patients than control patients had non-specific symptoms. Thirdly, discouraging the use of nitrite sticks reduced the opportunities for confident instant diagnoses; it may have been better to encourage their use and to ensure that negative samples were cultured.

Because most children do not scar after a urinary tract infection, evaluating interventions is difficult. Long term studies produce robust evidence but are hard to achieve.[8] Alternatively, patients at higher risk could be considered, such as infants with vesicoureteric reflux.[7] If they remain unscarred, this is more likely to reflect effective prevention than the presence of simple papillae only.[18] We saw 12 study infants like this but no control infants.

The success of our model was not through providing the direct access per se because it was ineffective when introduced alone by a community paediatrician. Education was vital. Previous formal teaching of general practitioners was insufficient, but informal, practical teaching during the nurse practitioner's case feedback seemed more effective. The incentive of retaining clinical control through direct access probably contributed to the high quality of management. General practices may have had the importance of making a robust diagnosis reinforced by counselling families about imaging.

Our model has several advantages: general practices retain clinical control, families are managed by their own doctor, fewer hospital visits are needed,

What is already known on this topic

It is often difficult to diagnose urinary tract infections in children, especially infants aged under 1 year

General practices may fail to make a bacteriological diagnosis, miss the diagnosis, or start treatment after a delay

Renal scarring, which can occur rapidly in children aged under 4 years, may be prevented by early treatment

What this study adds

A nurse led education model improves the rate and bacteriological quality of diagnoses of urinary tract infections made by doctors in children

The model combines continuing education, the ordering of imaging investigations by the general practitioner, and their management of patients with normal results

The rate of diagnosis increased fourfold among infants, who are at greatest risk of scarring

and parents need less time off work to attend consultations. This model is now being run as a clinical service.

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Competing interests: None declared.

Ethical approval: Thise study was approved by the Newcastle joint ethics committee and steered by a multidisciplinary group.

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