Bacteriuria and bacteraemia in patients with long-term indwelling catheters—a domiciliary study

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Summary. Men with indwelling catheters and men and women with suprapubic catheters were studied in their homes. Urine and blood were cultured and body temperature recorded after every catheter change. Nearly all patients had infected urine after 4 weeks of catheterisation, and all had bacteriuria after longer periods, usually with a mixture of organisms. Culture on selective media revealed a wider range of organisms than was detected on routine C.L.E.D. and blood agar with antibiotic sensitivity disks, but routine culture gave adequate information for clinical purposes. Bacteraemia was demonstrated after 20 of 197 changes of urethral catheter and after one of 19 changes of suprapubic catheter; but no patient had pyrexia or other symptoms. However, two had rigors on other occasions. When assessing “risk factors” for blood-stream infection in catheterised patients, it is important to record the total incidence of bacteraemia, asymptomatic as well as symptomatic.

Introduction

Operations on the lower urinary tract that require the use of catheters or other urethral instruments are amongst the commonest causes of bacteraemia (Svanbom, 1979; Roberts, 1980). Most reports have been of studies in hospital, especially after operations in patients with infected urine. Bacteraemia may occur immediately after operation, or it may be provoked by the removal or change of catheter some days later (Slade, 1958; Talbot, 1962; Cafferkey *et al.*, 1980, 1982). Patients with long-term indwelling catheters are usually nursed in geriatric, orthopaedic and medical wards, often have bacteriuria, and sometimes suffer from bacteraemia (Jepsen *et al.*, 1982; Bjork *et al.*, 1984).

Most studies of catheter-associated bacteraemia have been in patients with symptoms such as pyrexia or rigor. We have occasionally observed such bacteraemic symptoms after manipulation or change of catheter in patients with long-term bladder drainage. One such incident, which led to severe septicaemia, prompted us to undertake the present investigation.

Bacteraemia, usually transient and symptomless, can often be demonstrated during prostatectomy in patients with infected urine (Sullivan *et al.*, 1973; Murphy *et al.*, 1984). It seems likely that symptom-

less, transient bacteraemia may also occur after manipulation of long-term indwelling catheters. The incidence of bacteraemia might be influenced by the nature of the bacteria in the urine, the underlying urethral abnormality and the type of catheter used. To assess the importance of these and other “risk factors”, we undertook an investigation to estimate the total incidence of bacteraemia, whether symptomatic or not. This was the principal aim of our study. We also studied the bacteriology of the urine in relation to the duration of catheterisation, and we assessed the value of using selective culture media in addition to those used for routine examination of urine.

Patients and methods

Study population

A total of 115 patients was studied in their homes in the Bristol area between 12 September 1984 and 17 December 1986; 102 were men with indwelling urethral catheters and 13 patients (8 men, 5 women) had suprapubic catheters. In most cases indwelling catheterisation was necessary because of lesions of the bladder, urethra or prostate, often in patients who were unfit for prostatectomy. In others, the reason was urinary retention or incontinence resulting from cerebro-vascular accidents or other neuropathic disorders (e.g., multiple sclerosis).

The urethral catheters were of the Foley type, with diameters of 14–20 Charrière gauge, retained in position

by balloons of 5–30 ml capacity. The wider catheters with larger balloons were used in patients with patulous urethras. Catheters were changed at intervals that varied from 2 weeks to 3 months. The same nurse (AL) changed all the catheters, and collected a blood culture immediately after each catheter change. Urine for culture was taken on each occasion. The oral body temperature was recorded with an electronic thermometer immediately before catheter change, 1 h afterwards, again, usually, on the same evening, and next morning. The evening temperature was taken by the patient or a relative, and read by the nurse next morning. Details of antibiotic and other treatment were recorded at the first visit, and symptoms, if any, after the catheter change were recorded on the day after the change. Any later symptoms were recorded at the next visit.

Bacteriological methods

Urine culture. All specimens were cultured and isolates identified in the routine laboratory, by a quantitative standard loop method, on C.L.E.D. medium (Cysteine Lactose Electrolyte-deficient medium; Mast Laboratories Ltd, Bootle, Merseyside) and on D.S.T. agar (Oxoid) containing 5% lysed defibrinated horse blood with antibiotic disks for direct sensitivity tests (Stokes and Ridgway, 1980). The lysed blood was supplied by Lab M, Topley House, PO Box 19, Bury, Lancs. The disks (Oxoid) contained ampicillin 25 µg, trimethoprim 1.25 µg, nitrofurantoin 50 µg, gentamicin 10 µg, nalidixic acid 30 µg, cephadrine 30 µg. In addition, to investigate more precisely the incidence of mixed infections, urine specimens obtained between November 1984 and April 1986 were plated on the following selective media: Mannitol Salt Agar (BBL Microbiology Systems, Becton Dickinson UK Ltd, York House, Empire Way, Wembley, Middlesex); MacConkey Agar (Oxoid); a medium selective for *Proteus* and *Providencia* spp. (Clayton *et al.*, 1982), containing colistin 100 mg/L and inositol 10 g/L in Nutrient Agar Base (BBL); *Pseudomonas* Agar F (Difco) containing cetrimide 0.01%; neomycin blood agar containing neomycin 70 mg/L in Blood Agar Base (Lab M).

The minimum viable count for diagnosis of bacteriuria was 10^4 cfu/ml. All urinary isolates were identified to genus level, with the exception of lactose-fermenting gram-negative rods which were recorded initially as "coliform bacilli", in line with the routine practice of clinical reporting in this laboratory.

During the last 6 months of the study, all gram-negative bacilli isolated from urine were identified to species level by means of the API system. This enabled our results to be compared with other published reports. Throughout the whole survey, all organisms isolated from the urine of patients with positive blood cultures were fully identified.

Blood culture. Approximately 10 ml of blood was taken for culture, half into 45 ml of Brain Heart Infusion Broth; (Gibco Ltd, Trident House, PO Box 35, Renfrew Road, Paisley PA3 4EF) containing sucrose 10% and polyanethol-sulphonic acid (Liquoid: Roche Products, Diagnostic Dept, PO Box 8, Welwyn Garden City, Herts

AL7 3AY) 0.5% for aerobic cultures and half into 90 ml of anaerobic broth—Brain Heart Infusion Broth (Gibco) containing sodium mercaptoacetate 0.1%, glucose 0.1%, methylene blue 0.00075%, and Oxoid agar no. 3 0.02%. The blood cultures were examined daily during incubation at 37°C for 7 days. Subcultures were made when there was evidence of bacterial growth and routinely after 2 and 7 days; subcultures were on Blood Agar Base (Lab M) containing defibrinated horse blood (Lab M) 5% incubated in air and CO₂ 10% at 37°C and on blood agar containing yeast extract (Oxoid) 0.3% and L-cysteine hydrochloride 0.05% incubated anaerobically for 48 h at 37°C. Isolates were identified by means of the API system. Antibiotic sensitivities were performed by the Stokes comparative disk method (Stokes and Ridgway, 1980). Coagulase-negative staphylococci were considered significant only when detected in both blood-culture bottles after incubation for 2 days and when similar organisms with the same antibiotic sensitivity patterns were present in the urine.

Results

Nearly all the patients had infected urine. After 8 weeks of indwelling catheterisation, all were infected except two patients who were receiving antibiotics. In the great majority, the bacteriuria was polymicrobial. This was especially evident when the urine was cultured on selective media (figure and table I). Generally, the longer the duration of catheterisation, the greater were the variety and number of bacterial species present in the urine (table II).

The use of selective media revealed the complexity of the bacteriology of the urine of catheterised patients, in agreement with the findings of Clayton *et al.* (1982). It did not alter the accuracy of diagnosis of infection nor of antibiotic sensitivity testing.

Among the wide variety of organisms isolated from urine (tables I and III), *Escherichia coli*

Figure. Comparison of results of urine culture on "routine" media (▨) only and "routine" with selective media (■).

Table I. Organisms isolated from 122 urine specimens by use of (a) C.L.E.D. plates and blood agar with direct sensitivity disks, and (b) selective media

Bacteria isolated	Number of isolates	
	(a)	(b)
"Coliform bacilli" (lactose-fermenting)	80	99
<i>Proteus</i> spp.	52	73
<i>Pseudomonas</i> spp.	58	65
<i>Providencia</i> spp.	3	12
<i>Morganella</i> spp.	0	1
<i>Acinetobacter</i> spp.	2	2
Other gram-negative rods	23	4
<i>Streptococcus</i> spp.	47	68
<i>Staphylococcus aureus</i>	3	12
<i>Staphylococcus</i> , coagulase-negative	28	39
<i>Corynebacterium</i> spp.	2	3
<i>Candida</i> spp.	2	2

was comparatively uncommon and accounted for <15% of the gram-negative bacilli. This finding was similar to that of Kunin *et al.* (1987), but differed from that of a multicentre survey, in which *E. coli* was the commonest gram-negative bacillus (Jepsen *et al.*, 1982).

Some of the urinary organisms were resistant to one or more antibiotics, often to several (table III). Most patients had been in hospital previously and many probably had received antibiotics, but only 32 patients were receiving antibiotics when the urine specimens were taken. This figure included ten patients who were taking antibiotics for reasons other than urinary-tract infection. The chemother-

apy rarely cleared the bacteriuria, and then only temporarily (table II).

There were 20 episodes of bacteraemia after 197 changes of urethral catheter (an incidence of 10.2%). The organisms isolated from the blood cultures are shown in table IV. Four blood cultures yielded two different organisms, and one yielded three. One of the 19 changes of suprapubic catheter was followed by bacteraemia with *Providencia stuartii*.

No episode of bacteraemia was accompanied by any relevant symptoms, although two patients had rigors on other occasions. Body temperatures did not differ appreciably before and after catheter change, and none rose above 37.5°C. The temperature records of bacteraemic patients were indistinguishable from those with negative blood cultures.

Predisposing factors for bacteraemia

Bacteraemia was commoner in patients with lesions of the prostate, urethra or bladder (17 out of 137 changes) than in those with neuropathic disorders (3 out of 60 changes). However, the difference was not statistically significant ($\chi^2 = 1.764$; $p = 0.092$). There was no evidence that any particular urinary organism was more likely than others to enter the blood stream. There was no evidence that the incidence of bacteraemia was related to any one of the wide variety of Foley-type catheters that were used, nor to the size of the catheter-retaining balloons. It must be remembered, however, that wider catheters with larger balloons were used in patients with patulous, hence wider, urethras.

Table II. Numbers of microbial species isolated from urine cultured on routine medium, in relation to duration of catheterisation and antibiotic administration

Duration of catheterisation	Patients receiving antibiotics	Number of urine specimens	Number of positive cultures	Number of species per urine specimen	
				range	median
Less than 1 month	No	9	9	1-3	2
	Yes	3	1	0-1	
1-6 months	No	45	43	0-5	2
	Yes	13	11	0-4	2
6-12 months	No	37	37	1-4	3
	Yes	7	7	1-4	1
1-5 years	No	57	57	2-5	3
	Yes	6	6	1-3	2
More than 5 years	No	17	17	2-4	3
	Yes	3	3	1-3	2
Total		197	191		

Table III. Identity and antibiotic sensitivity of gram-negative bacilli isolated from urine (June–December, 1986)

Species	Resistant to one or more antibiotics to which normally sensitive	Antibiotic sensitive	Total
<i>Escherichia coli</i>	8	12	20
<i>Citrobacter freundii</i>	3	8	11
<i>Citrobacter diversus</i>	–	1	1
<i>Klebsiella aerogenes</i>	5	10	15
<i>Klebsiella oxytoca</i>	4	18	22
<i>Klebsiella rhinoscleromatis</i>	1	0	1
<i>Enterobacter cloacae</i>	3	0	3
<i>Enterobacter amnigenus</i>	0	3	3
<i>Enterobacter agglomerans</i>	0	1	1
<i>Enterobacter aerogenes</i>	1	0	1
<i>Pseudomonas aeruginosa</i>	0	17	17
<i>Proteus mirabilis</i>	3	29	32
<i>Proteus vulgaris</i>	0	1	1
<i>Morganella morganii</i>	1	7	8
<i>Providencia stuartii</i>	0	6	6
<i>Providencia rettgeri</i>	0	2	2
<i>Serratia marcescens</i>	1	3	4
<i>Acinetobacter calcoaceticus</i> var. <i>anitratus</i>	0	2	2
Total	30	120	150

Table IV. Bacteriuria and bacteraemia in men with indwelling urethral catheters; urine and blood samples were taken immediately after catheter changes

Duration of catheterisation	Total number of urine specimens	Number of infected urine specimens	Positive * blood cultures
<1 month	12	10	2
1–6 months	58	54	6
6–12 months	44	44	7
1–5 years	63	63	3
>5 years	20	20	2
All	197	191	20

* The organisms were: *Proteus mirabilis* 5 isolates, *Proteus* sp. 1, *Ps. aeruginosa* 4, *Streptococcus faecalis* 4, *S. agalactiae* 1, *Citrobacter freundii* 2, *C. diversus* 1, *K. aerogenes* 2, *Prov. stuartii* 1, *Prov. rettgeri* 1, *Staphylococcus* (coagulase-negative) 2, *Ent. cloacae* 1, *M. morganii* 1. Four blood cultures yielded two species and one yielded three.

Discussion

In the management of catheterised patients, much emphasis, rightly, is placed on the importance of aseptic precautions, including the maintenance of closed drainage. With correct catheter care, bacteriuria usually can be avoided during short periods of indwelling catheterisation; but when the catheter remains *in situ* for more than a few weeks,

bacteriuria is almost inevitable (Slade and Gillespie, 1985; Kunin, 1987). The longer the period of catheterisation, the greater was the incidence of mixed infection by organisms many of which were resistant to several antibiotics. These facts underline the limitations of antibiotics in the management of catheter-associated urinary infection (Bjork *et al.*, 1984; Gillespie, 1986; Kinder, 1987). It was gratifying to find that relatively few patients in our series were receiving antibiotics although many may have received them previously, in hospital or at home. By using special selective media, an even greater range of organisms could be demonstrated in the urine, confirming the findings of Clayton *et al.* (1982), but urine culture on selective media is unnecessary for routine diagnosis of infection and antibiotic management in catheterised patients. Our results show that adequate information is obtained by culture on C.L.E.D. agar, combined with direct antibiotic-sensitivity tests.

Bacteraemia, with symptoms such as pyrexia and rigors, sometimes fatal, is a well-recognised complication of catheterisation and urethral instrumentation (Jepsen *et al.*, 1982; Slade and Gillespie, 1985; Kunin, 1987). The risk of bacteraemia is especially great in patients with infected urine. It is well known that catheter-associated bacteraemia may be symptomless, but the magnitude of the difference between the incidence of symptomatic and asymptomatic cases may not be widely recog-

nised. Our findings suggest that the number of bacteraemic patients with symptoms may be a very small proportion of the total. Catheter-associated bacteraemia, even when asymptomatic, may lead to bacterial endocarditis in susceptible patients (Bayliss *et al.*, 1984). It is clear, therefore, that an assessment of the risk factors for bacteraemia in catheterised patients requires systematic study of total incidence of bacteraemia, and should not be limited to patients with symptoms. There were several factors that we could not study for practical and ethical reasons—e.g. the use of different types and sizes of catheter chosen at random, and the skill and experience of the catheter operator. In our study, bacteraemia was commoner in patients with lesions of the prostate, urethra or bladder than in those with normal urethras who were catheterised because of neurological disorders. The incidence of

bacteraemia was not affected by the nature of the organisms in infected urine. The absence of *E. coli* from the blood cultures, at first sight surprising, was consistent with its comparative infrequency in the patients' urine. In this respect, patients with long-term catheters tend to differ from those whose catheters are removed a few days after prostatectomy (Slade and Gillespie, 1985).

Our study shows that the microbiological findings in catheter-associated urinary infection in domiciliary patients are similar to those encountered in hospital (Clayton *et al.*, 1982; Kunin, *et al.*, 1987).

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