Acta Medica et Biologica
Vol. 40, No. 3, 123-127, 1992

Studies on Bacteria Isolated from Catheter Edges and Urine in Short and Long-Term Urethral Catheterization

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Received June 1, 1992

Summary. **Intravesical urine samples and the edges of catheters were examined for the presence of bacteria when the catheter was removed from 113 patients with indwelling urethral catheters. In 89 cases with catheterization for less than 10 days, the bacterial culture was positive for both the urine sample and the catheter edge in 13 cases (15%). In 41 cases (46%), only the catheter edges showed a positive culture, and both urine and catheter in 35 cases (39%). Negative urine culture was obtained in 76 cases (85%) of this group. This suggests that sterile control can be achieved if the catheter is exchanged within 10 days. In cases where the indwelling catheter was retained between 11 days and one month, bacteria were positive both in the urine and on the catheter in 7 of 13 cases (54%) and were negative in the urine but positive on the catheter in 5 (38%). As for the urine alone, bacteria were negative in 6 of 13 cases (46%). In 11 cases with indwelling catheterization for more than one month, bacteria were seen both in the urine and on the catheter in 10 cases (91%), and on the catheter only in the remaining one (9%). When the indwelling catheter was retained for more than one year, many strains of bacteria were isolated both in the urine and on the catheter.**

INTRODUCTION

It is possible to maintain normal urinary flow and to alleviate renal dysfunction by the use of an indwelling urethral catheter. However, the indwelling catheter may easily cause urinary tract infections for which antibacterial chemotherapy is not always effective.[1)] For this reason, intermittent self-catheterization[2)] or withdrawal of the catheter as early as possible, along with the use of drugs or Crede's maneuvers, is required. However, many problems actually remain in the management and treatment of patients suffering from tetraplegia or physical weakness.

It is known that the incidence of bacteriuria increases[3)] as the indwelling period is prolonged, and that bacterial infection can be prevented if the indwelling catheter is employed only for a short period. However, there is no precise study concerning the relationship between the incidence of bacterial infection and the duration of catheterization. In the present study, urine and the catheter edge were examined for the presence of bacteria when the catheter was removed, and were evaluated with respect to the duration of catheter indwelling.

PATIENTS AND METHODS

We studied 113 cases treated with indwelling urethral catheters at the Department of Urology, Nagaoka Red Cross Hospital, between December 1988 and June 1989. Of these, 102 cases were indwelt with the catheter for one month or less, and 11 cases retained the catheter for over one month. Silicon or teflon coated latex catheters were used for short-term treatment, and an all-silicon catheter was employed for the long-term cases. In all cases, a closed sterile bag was used. The site of catheterization was sterilized daily with benzal chloride, and covered by sterile gauze coated with gentamicin ointment. In cases of long-term indwelling, the catheter was usually changed once every two weeks. However, it was replaced once every 4 weeks in patients with severe spinal cord injury and those who had difficulty in visiting the hospital frequently. The catheter edge was cut off, and intravesical urine samples were collected by

urination after the catheter was removed. Bacteria were cultured using Heart Infusion Agar (HIA) and Heart Infusion Broth (HIB), and regarded as positive if more than a single colony was present. Each bacterial isolate was identified according to standard bacteriological examination.

RESULTS

The underlying diseases of the 102 patients with short-term catheters were as follows; benign prostatic hypertrophy in 33 cases, urinary bladder tumor in 21, ureterolithiasis in 7, renal cell carcinoma in 5, renalpelvic and ureteral tumor in 5, testicular tumor in 4, urethral rupture in 4, renal trauma in 3, with other diseases in the remaining 20 cases. The catheters were inserted just before or immediately after surgery for these diseases. In 11 cases with indwelling catheters for more than one month, 9 cases were patients with neurogenic bladder due to spinal cord injury or apoplexy, for whom urination by Crede's maneuvers or intermittent self-catheterization was difficult to achieve. The longest indwelling period was 34 years.

When the catheter was removed, bacteriological examination was done for the catheter tip and the urine sample. In 102 cases of short-term catheterization, evaluation was made for each catheterization. When we examined these cases according to the duration of catheter indwelling, for 7 days or less, 10 days or less, or 14 days or less, the appearance rate of bacteria on the catheter and in the urine was almost the same in the former two groups. The rate of positive culture was apparently higher in the third group. We therefore divided these 102 short-term cases into two groups (1 to 10 days, and 11 to 30 days). The catheter was indwelt for 10 days or less in 89 cases (Table 1). Among these cases, positive culture for both urine and the catheter was observed in 13 cases (15%), 41 cases (46%) showing positive results only for the catheter. The remaining 35 cases (39%)

Table 1. Incidence of positive or negative cultures in samples obtained from short-term catheterization

Bacteria	1-10 Days	11-30 Days	Total
Urine (+) Catheter (+)	13(15%)	7(54%)	20(20%)
Urine (−) Catheter (+)	41(46%)	5(38%)	46(45%)
Urine (−) Catheter (−)	35(39%)	1(8%)	36(35%)
Total	89	13	102

Table 2. Incidence of positive or negative cultures in samples obtained from long-term catheterization

Bacteria	1-12 Months	1 Year-	Total
Urine (+) Catheter (+)	3(75%)	7(100%)	10(91%)
Urine (−) Catheter (+)	1(25%)	0	1(9%)
Urine (−) Catheter (−)	0	0	0
Total	4	7	11

Table 3. Bacterial isolates from urine and catheters in short-term catheterization

Species	No. (%) of isolates		
	Urine	Catheter	Total
Staphylococcus epidermidis	5(23)	30(39)	35(36)
Enterococcus faecalis	2(9)	13(17)	15(15)
Candida albicans	4(18)	9(12)	13(13)
Pseudomonas aeruginosa	3(14)	4(5)	7(7)
β-hemolytic streptococci	1(5)	3(4)	4(4)
Enterococcus faecium	—	3(4)	3(3)
Staphylococcus aureus	—	3(4)	3(3)
Enterobacter cloacae	1(5)	2(3)	3(3)
Escherichia coli	—	1(1)	1(1)
Acinetobacter anitratus	—	1(1)	1(1)
Others	6(27)	7(9)	13(13)
Total	22	76	98

Table 4. Bacterial isolates from urine and catheters in long-term catheterization

Species	No. (%) of isolates		
	Urine	Catheter	Total
Enterococcus faecalis	5(24)	5(22)	10(23)
Pseudomonas aeruginosa	4(19)	4(17)	8(18)
Proteus vulgaris	3(14)	3(13)	6(14)
Providencia stuartii	2(10)	2(9)	4(9)
Staphylococcus epidermidis	1(5)	3(13)	4(9)
Candida albicans	2(10)	2(9)	4(9)
Morganella morganii	1(5)	1(4)	2(5)
Staphylococcus aureus	1(5)	1(4)	2(5)
Streptococcus mitis	1(5)	1(4)	2(5)
Proteus mirabilis	—	1(4)	1(2)
Gram positive rod	1(5)	—	1(2)
Total	21	23	44

Table 5. WBC counts in the urine of patients with indwelling catheters

Catheterization	Bacteria in Urine	WBC in Urine (/HPF) 0-20	>20	Total
Short-term	(+)	16	4	20
	(−)	71	11	82
Long-term	(+)	1	9	10
	(−)	−	1	1
Total		88	25	113

were sterile, and 76 cases (85%) gave negative results in urine culture. In cases of indwelling for 11 days or more, bacteria were negative on the catheter only in 1 (8%) of 13 cases. The remaining 12 cases showed positive cultures in the catheter or in both the catheter and urine. To summarize results of these 102 cases, bacteria were positive in the urine in 20 cases (20%), and on the catheter in 66 cases (65%).

In 11 cases of catheterization for over 1 month, including 4 cases with indwelling periods between 1 and 12 months and 7 cases of more than one year, bacteria were found in all (Table 2). In most of the cases, bacteria were detected both in the urine and on the catheter.

Next, the strains isolated from the urine and the catheter were analysed. In 102 cases with short-term indwelling, 22 strains were isolated from the urine, and 76 strains from the catheter (Table 3). Gram-positive cocci (GPC) including *Staphylococcus epidermidis, Enterococcus faecalis* were found in 36% of 22 isolates from the urine, while these accounted for 68% of 76 strains from the catheter. All the three isolates of *Staphylococcus aureus* were methicillin-sensitive *S. aureus* (MSSA). On the other hand, gram-negative rods (GNR) including *Pseudomonas aeruginosa, Enterobacter cloacae,* were found in 18% and 11% of the isolates from the urine and catheters, respectively. *Candida albicans* was often isolated in both the urine and the catheter.

In 11 cases with long-term indwelling, 21 strains were isolated from the urine, and 23 from the catheter (Table 4). Gram-positive cocci (GPC) including *E. faecalis* and *S. epidermidis* were found in 38% of 21 isolates from the urine and in 43% of 23 strains from the catheter. One isolate of *S. aureus* was methicillin-resistant *S. aureus* (MRSA). Gram-negative rods (GNR) including *P. aeruginosa*, *Proteus vulgaris* or *Providencia stuartii*, were isolated more frequently than GPC; 10 strains (48%) in the urine, and 11 strains (48%) from the catheter.

The white blood cell (WBC) count in the urine of short-term indwelling cases was 20 or less in the visual field (×400) in 87 (85%) out of the 102 cases, and 21 or more in 15 (15%) cases (Table 5). However, there was little relationship between WBC count and detection of bacteria. In contrast, the WBC count was 21 or more in most of the cases with long-term indwelling, and more than 100 WBC were seen in 8 (73%) cases.

The treatment employed for prevention of the infection with short-term catheter indwelling was drip infusion, mainly of cephem antibiotics, such as Cefmetazole (CMZ), Cefotiam (CTM), Ceftizoxime (CZX), or Latamoxef (LMOX). Following the drip, a new quinolone, such as Norfloxacin (NFLX), or Ofloxacin (OFLX) was administered orally. However, the incidence of positive culture did not differ according to the type of antibiotic used. In general, no antibiotic treatment was given to the patients with long-term catheter indwelling. However, in cases of heavily clouded urine or in the presence of severe symptoms, urinary bladder washing was done using physiological saline, polymyxin B, etc., and the treatment by cephem or new quinolone drugs was performed.

DISCUSSION

In cases of complicated urinary tract infection (UTI), particularly with an indwelling catheter, the effect of drugs is less marked than in cases with simple infections. The bacteria themselves acquire drug-resistance-like MRSA or a particular strain of *Escherichia coli*,[4] and superinfection occurs with *Serratia marcescens*[5] or *P. aeruginosa* and others. With respect to infections due to an indwelling catheter, Nishiura[6] reported the following; 1) closed catheterization could prevent infection, at least for a short period (1 to 2 weeks); 2) prevention and control of infection were impossible when the catheter was indwelt for a long period, and therefore intermittent catheterization should be employed as early as possible; 3) how the catheter was managed was closely related to the incidence of infection, and therefore instructions to patients were very important; and 4) antibacterial treatment during the indwelling period should be minimized. While these conclusions were very informative and reasonable, many problems remained in the practical management and treatment of patients, especially in the cases of tetraplegia and those who had difficulty in visiting the hospital frequently.

A double-J catheter is a kind of artificial ureter

characterized by the absence of contact with the skin. In our previous study, bacteria were found in all 18 cases on the bilateral edges (renal pelvis and urinary bladder) of the double-J catheter[7] at the time of removal. On the other hand, microbes were isolated from cultured urine samples only in 4 (20%) of 20 cases. Three of these were a yeast-like fungi, and the remaining isolate was a coccus. This suggested that microbes, even though not found in the urine, may be present on the catheter and cause urinary tract infection at any time.

In the cases of a urethral catheter indwelt for 10 days or less, bacteria were positive in 54 (61%) of 89 cases on the catheter, and in 13 cases (15%) in the urine. On the other hand, in those cases with an indwelling catheter for more than one month, similar bacteria were found both in the urine and on the catheter in 10 (89%) of 11 cases. This was clearly different from the cases with short-term catheter indwelling, and it may suggest that UTI can be reduced if the catheter is replaced within 10 days. This must be considered in a future study. Noberg et al.[8] described the catheter life, but made no definite suggestion on the replacement period. In general, the catheter is replaced after 1 to 2 weeks, but we think that 2 weeks is too long for catheter exchange. However, the replacement period should be reconsidered according to the patient's condition and urine excretion.

Prophylactic antibiotic treatment may be effective for a few days as noted by Bulter et al.[9] and Warren et al.[10] Mountokalakis et al.[11] studied the relationship between antibiotic chemotherapy and the incidence of bacteriuria using three groups of cases; the group injected three times with intramuscular ampicillin before and after the insertion of the catheter (Group 1), the group with intramuscular injection of ampicillin every 8 h (Group 2), and the group with no antimicrobial prophylaxis (Group 3). The detection ratio of bacteria was 12.5, 42.8 and 45.1% in Groups 1, 2 and 3, respectively. Significant difference was noted between Group 1 and Groups 2 and 3. Especially in Group 3, the mean number of bacteria in the urine and the drug-resistant bacteria were much less. It appears that good results may not be obtained with aimless or careless administration of antibacterial drugs. In our department, we usually use a single antibiotic drug for 1 to 3 weeks for short-term catheter indwelling cases, and do not use it for long-term catheter indwelling cases.

Kunin and Steele[12] studied 398 cases with indwelling catheters and reported that the attachment of bacteria to the catheter surface was found in 16.8% of male patients and 67.0% of females. The isolated bacteria were mostly GPC, such as *S. epidermidis*, and *S. faecalis*. The ratio of GNR increased with longer indwelling periods, as in our report.

In cases of long-term catheter indwelling, it is reported that a biofilm developed on the catheter surface, enveloping the bacteria.[13-15] The bacteria are covered with exopolysaccharide glycocalyx produced by the bacteria themselves, which adhere to the surface of the silicon-coated latex catheter. As a result, the biofilm provides a protective shield against anti-bacterial agents and makes it difficult to eliminate the bacteria from an indwelling catheter. Nishitani[16] reported that the growth and regrowth time of this biofilm were more rapid in *P. aeruginosa* than in *E. coli* and *E. faecalis*. Similarly in this report, *P. aeruginosa* showed the second highest frequency of isolation in long-term catheterization. In our previous study, three strains of *E. coli* isolated from patients with chronic prostatitis, chronic pyelonephritis and urosepsis developed a mucoid-form colony on HIA.[4] A scanning electron microscopic observation of these colonies showed a biofilm-like image similar to that observed in bacteria adhering to the catheter surface. Biofilm formation may not be limited to cases of an indwelling catheter.

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