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The Bacteriology of the Urine and Renal Calculi

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Summary. The bacteriological status of the pre-operative urine, removed calculus and the pelvic urine was studied in 63 consecutive patients undergoing removal of intrarenal calculi. The overall infection rates in the pre-operative urine, removed calculi and pelvic urine were 29%, 38% and 30% respectively. In patients with staghorn calculi, 58% of patients had an infected pre-operative M.S.S.U., and 82.5% of removed calculi demonstrated significant bacterial growth, with *Proteus mirabilis* being the predominant organism isolated. In patients with single or multiple oxalate calculi, 17% had an infected pre-operative M.S.S.U., and 22% of removed calculi demonstrated a significant bacterial growth. The findings would indicate that the presence of a positive M.S.S.U. in a patient with a renal calculus is an indication for surgical removal.

Key words: Infected urine, Stone culture, Bacteriology of urine and renal calculus, Struvite calculus, Oxalate calculus.

Introduction

The destructive effect upon the kidney by renal calculi may be complicated by a superadded infection, most commonly associated with a gram negative organism. Studies that have assessed the role of infecting organisms within the calculus and their relationship with the urine are rare. Thompson and Stamey [7] have reported a 77% incidence of bacterial growth within removed "infection stones" whilst Dajani and Shehabi [1] report a 14% incidence of bacterial growth in all removed calculi. We report our findings in 63 patients who underwent removal of intrarenal calculi, and examine the relationship between the bacteriological stone culture and the urine.

Patients and Methods

Sixty-three consecutive patients undergoing removal of intrarenal (27) or obstructing pelvicalyceal calculi (36) were studied. In this group of patients there were 36 males and 27 females with an age range of 24–76 years, and a mean (± sem) age of 64.3 (± 2.2) years.

Prior to surgery a mid-stream sample of urine (M.S.S.U.), by the conventional "clean catch" method, was obtained and at operation both a sample of the pelvic urine was aspirated and the removed stone was cultured. Urine samples were assessed for bacterial growth in a manner previously described [3] and the stone was cultured by the method of Nemoy and Stamey [5].

Analysis of stone constituents was performed in the routine manner [6], and struvite calculi (n = 17) were classified by the presence of magnesium ammonium phosphate, the remaining stones were either solitary (n = 39) or multiple (n = 7) oxalate stones.

From previous studies it was noted that routine antibiotic prophylaxis to cover the operative period was of benefit, and patients received either a single dose of Netilmicin (200 mg, n = 25), Piperacillin (2 G, n = 18) or a short course regime of Netilmicin (3 x 100 mg doses, n = 20) [6].

Results

Prior to surgery 18 of the 63 patients (29%) had a positive M.S.S.U. At operation 24 patients (38%) demonstrated positive bacterial culture in the removed calculi, and 19 (30%) had a positive culture from the pelvic urine. Results have been classified into two groups: (I) struvite calculi and (II) oxalate calculi.

I. Struvite Calculi (n = 17; Table 1)

In the 17 patients with struvite calculi 10 (58%) had a positive pre-operative M.S.S.U., 13 (76%) had a significant culture from the aspirated pelvic urine, and 14 of the 17 removed calculi (82.5%) demonstrated significant bacterial culture from the stone. The commonest organism isolated from the M.S.S.U., stone and pelvic urine was *Proteus mirabilis* in 70%, 86%, and 85% of cases respectively. It is

Table 1. Positive bacteriological findings in the preoperative M.S.S.U., removed calculus and aspirated pelvic urine in patients with struvite calculi ($n = 14$)

No.	Patient	Preoperative M.S.S.U.	Calculus	Aspirated pelvic urine
1	F	*E. coli*	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*
2	F	–	*Proteus mirab.*	–
3	F	–	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*
4	F	–	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*
5	F	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*
6	F	*Proteus mirab.*	*Proteus mirab.*	*Proteus mirab.*
7	F	*Pseudomonas*	*E. coli*	*E. coli*
8	F	*E. coli*	*E. coli*	*E. coli*
9	F	*Proteus mirab.*	*Proteus mirab.*	*Proteus mirab.*
10	F	*Proteus mirab.*	*Proteus mirab.*	*Proteus mirab.*
11	F	*Proteus mirab.*	*Proteus mirab.*	*Proteus mirab.*
12	F	–	*Proteus mirab.*	*Proteus mirab.*
13	M	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*	*Proteus mirab.* + *E. coli*
14	M	*Pseudomonas* + *Proteus mirab.*	*Pseudomonas* + *Proteus mirab.*	*Pseudomonas* + *Proteus mirab.*

Table 2. Positive bacteriological findings in the preoperative M.S.S.U., removed calculus and aspirated pelvic urine in patients with oxalate calculi ($n = 13$)

No.	Patient	Preoperative M.S.S.U.	Calculus	Aspirated pelvic urine
1	F	–	*Proteus mirab.*	–
2	F	*Klebsiella* + *E. coli*	*E. coli*	*E. coli*
3	F	*E. coli*	*E. coli*	*E. coli*
4	F	*E. coli*	*E. coli*	–
5	F	*E. coli*	–	–
6	F	*Klebsiella*	*Klebsiella*	*Klebsiella*
7	M	–	*E. coli*	*E. coli*
8	M	*E. coli*	–	*Strep. faecalis*
9	M	*Enterobacter aer.*	–	–
10	M	–	*Strep faecalis*	–
11	M	–	*E. coli*	*E. coli*
12	F	–	*E. coli*	*E. coli*
13	F	*E. coli*	*E. coli*	*E. coli*

interesting to note that in two patients (Nos. 1 and 7), the urine culture differed to that of both the stone and pelvic urine and possibly represents overgrowth of bladder urine by resistant organisms following repeated attempts to preoperatively sterilize the urinary tract with conventional oral antibiotics (in both cases Co-trimoxazole).

II. Oxalate Calculi ($n = 46$; Table 2)

In the 46 patients in whom oxalate calculi were removed, 8 patients (17%) had a positive preoperative M.S.S.U., 8 patients (17%) had a significant culture from the aspirated pelvic urine and in 10 patients (22%) the removed calculus demonstrated significant bacterial growth. In this group of patients the most common organism isolated from the M.S.S.U., stone and pelvic urine was *E. coli*, isolated in 68%, 70%, and 75% of cases respectively.

As noted in struvite calculi, in two patients the urine culture differed from that of the stone and pelvic urine (in case 2) and from the pelvic urine only (case 8), and again possibly reflects secondary infection of the bladder urine, following conventional antibiotic treatment.

Discussion

In the 63 patients studied, 24 (38%) were found to have infected stones. This figure is lower than that noted by Thompson and Stamey [7], but in the 17 patients with struvite calculi, a positive bacterial culture was obtained in 14 (82.5%) which is closer to the figure observed by Stamey and his co-workers [5, 7]. In the present group of patients with struvite calculi, the commonest infecting organism found in both stone and urine was *Proteus mirabilis*, and is in keeping with the concept of development of struvite calculi in which the urea splitting property of the *Proteus* species is an important aetiological factor in the development of struvite calculi.

Oxalate calculi may be associated with infected urine [6], but the presence of infecting organisms within these calculi is not universally recognized. Ten of 44 patients with oxalate calculi (22%) were found to have a significant bacterial growth within the removed stone, five of whom had an identical isolate in the preoperative urine and seven in the aspirated pelvic urine. In five patients bacteriological isolates were obtained from the cultured calculi, in the absence of a positive preoperative urine. This finding is similar to that of Dajani and Shehabi [1] who have reported a 14% incidence of infected stones in their series in which oxalate stone predominated. The presence of an infecting organism within an oxalate stone may be related to the development of the calculus, as the presence of an infective focus may act as a nidus stone formation around which oxalate crystals are deposited.

An alternative reason for the presence of bacteria within the calculus and pelvic urine is that of a secondary ascending infection from the bladder urine. Penetration of bacteria into the stone will prevent complete eradication by conventional antibiotic therapy and thus allow the development of resistant organisms which will be constantly shed into the urine.

The pelvic urine more accurately reflects the urine environment in which the stone exists and bacterial growth within this urine may reflect bacterial shedding from the stone or the source of bacteria within the stone. In the patients in whom the calculus demonstrated bacterial growth, identical organisms were obtained from the pelvic urine in 83% (20 of 24), compared with a figure of 50% for the preoperative M.S.S.U.

As noted in 4 of our cases, the organisms obtained from the bladder urine differed from that of the removed calculi and most probably reflects the changing environment of the bladder urine following treatment with conventional antibiotics. Overgrowth of resistant organisms may occur within the bladder and thus the M.S.S.U. may not accurately reflect the true urinary environment of the stone. Continuing antibiotic therapy may be of little value. Poor antibiotic penetration into the renal calculus will fail to eradicate the original infecting organisms and, as mentioned above, constant shedding of organisms into the pelvic urine will result in a persistantly infected environment, possibly potentiating growth of the calculus.

In patients with struvite calculi, it is not surprising that a large number of patients will have a significant culture of the preoperative urine, as the development of these calculi is closely linked to bacterial growth. In patients with oxalate calculi it is interesting to note that of the 13 patients with positive bacteriological findings, the presence of a positive preoperative M.S.S.U. in the absence of either a positive stone or pelvic urine culture occurred in only 2 patients, and thus a positive M.S.S.U. in patients with oxalate calculi may be assumed to be an indicator of significant bacteriological contamination of the upper urinary tract.

Under ideal conditions, removal of an intrarenal calculus is performed in the presence of a sterile urine. It is seen that in a proportion of patients bacterial growth occurs within the stone, and bacteria may be constantly shed into the urine. Repeated attempts to obtain a sterile preoperative M.S.S.U. will fail, leading to the development of antibiotic resistant organisms. The presence of an infected M.S.S.U. in association with a renal calculus is an indication for stone removal and postoperative complications may be prevented by the use of a short course perioperative antibiotic regime [3, 4].

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