Changing Composition of Renal Calculi in Patients With Neurogenic Bladder

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Purpose: Renal calculi are a significant source of morbidity for patients with neurogenic bladder. Calculi from patients with NB have traditionally been composed primarily of struvite and carbonate apatite secondary to chronic urea-splitting bacteriuria. In the current era there have been great improvements in the urological rehabilitation of patients with NB. We defined the composition of renal calculi in a contemporary cohort of patients with NB due to spinal cord injury or myelomeningocele who underwent percutaneous nephrolithotomy.

Materials and Methods: We performed a retrospective evaluation of all patients with NB due to SCI or MM who underwent PNL between January 2002 and January 2005.

Results: A total of 32 patients with NB (14 with SCI, 18 with MM) underwent PNL in this period. Stones were infectious in etiology in 37.5% (12 struvite/carbonate apatite) and metabolic in 62.5% (1 uric acid, 2 calcium oxalate monohydrate, 2 brushite, 6 hydroxyapatite, 9 mixed hydroxyapatite/calcium oxalate). All patients with struvite calculi were infected with urea-splitting bacteria on preoperative urine culture.

Conclusions: Patients with neurogenic bladder are traditionally thought to harbor infection related calculi. These data demonstrate that many contemporary patients will be found to have calculi of a metabolic etiology. Although patients with NB still have renal calculi, advances in urological treatment may have affected the composition of their calculi, as metabolic stones are becoming more commonly identified. When metabolic components are identified, stone activity may be attenuated with appropriate metabolic evaluation, pharmacological therapies and dietary modifications.

Key Words: kidney calculi; bladder, neurogenic

Renal calculi are a significant source of morbidity and mortality for patients with voiding dysfunction due to NB. It is estimated that 7% of patients with SCI will develop a kidney stone within 10 years of injury.[1] The incidence of renal calculi in patients with MM may be even greater.[2] Kidney calculi in patients with spinal cord injury have previously been reported to be composed predominantly of struvite and carbonate apatite, likely a result of chronic bacteriuria with urea-splitting organisms.[3,4] However, the reports detailing stone composition data in patients with SCI or MM are more than 2 decades old, and in the time since their publication significant advances have been made in the urological rehabilitation of patients with NB due to spinal cord lesion.[5] We performed a study to define the composition of renal calculi in a contemporary cohort of patients with NB due to either SCI or MM who underwent PNL.

MATERIALS AND METHODS

We performed a retrospective evaluation of an Institutional Review Board approved database composed of all patients who underwent PNL at our institution. Between January 2002 and January 2005, 498 patients underwent PNL. A cohort of all patients with NB due to either SCI or MM was selected for further analysis.

All patients underwent urine culture testing, and were placed on 2 weeks of tailored antibiotic therapy before undergoing PNL. All PNL procedures were performed as a single stage, with the urologist obtaining access in the operating room. Our technique for obtaining access uses retrograde instillation of contrast in the renal collecting system to delineate the targeted calix of entry. In most cases this may be accomplished by the retrograde placement of an externalized ureteral catheter. However, in select patients such as those who have previously undergone surgical urinary diversion, this may not be possible. For these patients a 3-way catheter may be placed in the urinary diversion and contrast instilled under gravity pressure so that the contrast refluxes into the intrarenal collecting system.

Percutaneous access is obtained using a triangulation technique, which we have previously described.[6] In all cases

Submitted for publication June 14, 2005.

* Financial interest and/or other relationship with Lumenis, Boston Scientific and Karl Storz.

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‡ Financial interest and/or other relationship with Lumenis, Boston Scientific, Olympus, Midstate Mobile Lithotripsy LP, Midwest Mobile Lithotripsy LP, Progressive Thermotherapy LP and Storz Medical.

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DOI:10.1016/S0022-5347(05)01015-3

Bladder management techniques

	No. Pts
Myelomeningocele:	
CIC	7
Bladder augmentation + continent catheterizable channel	4
Ileal conduit	6
Diaper drainage	4
Spinal cord injury:	
CIC	4
Ileal conduit	1
Diaper drainage	1
Indwelling suprapubic tube or Foley catheter	9

a 30Fr working sheath is placed. Stone fragmentation is accomplished primarily using the ultrasonic lithotriptor, with a pneumatic lithotriptor or Ho:YAG laser used only if necessary. In all cases rigid and flexible nephroscopes are used to completely inspect the intrarenal collecting system. A 10Fr cope loop nephrostomy tube is routinely placed at the conclusion of the procedure. On the morning of postoperative day 1 a noncontrast CT is performed. If a stone-free status is confirmed, the patient undergoes a nephrostogram to confirm antegrade drainage, and the nephrostomy tube is removed. If residual stones are identified, the patient undergoes a second look nephroscopy under intravenous sedation on the second day following the initial procedure.

RESULTS

A cohort of 32 patients (17 male and 15 female) with NB due to either SCI or MM was identified. Mean patient age was 42.4 years (range 11 to 77). A total of 14 patients suffered a previous SCI. The mean length of time from when the patient experienced SCI to when the patient underwent PNL was 13.2 years (range 6 to 20). Myelomeningocele accounted for the neurological lesion in the remaining 18 patients. Bladder management techniques are delineated in the table. Notably, none of the patients in the MM cohort managed their bladder with chronic indwelling drainage tubes.

Ten patients harbored left side calculi only, 11 patients harbored calculi on the right side only and 11 patients harbored bilateral renal calculi. All 11 patients with bilateral renal calculi underwent simultaneous bilateral PNL. There were 12 renal units that harbored calculi less than 2 cm, and the remaining 31 renal units harbored calculi greater than 2 cm (largest a 5 cm staghorn). Mean operative time was 130 minutes (range 90 to 200). Mean length of hospitalization was 3.3 days (range 2 to 10).

On postoperative day 1, 30 renal units were found to harbor residual calculi, and the remaining 13 renal units were stone-free as determined by CT imaging obtained on the morning of postoperative day 1. A total of 29 renal units were stone-free following secondary PNL, and 1 renal unit required a tertiary PNL to achieve a stone-free status.

Complications included fever in 6 patients. One patient required a 10-day hospitalization, due to complications related to a preexisting stage IV pressure sore. One patient underwent only placement of the nephrostomy tube at the initial PNL due to the aspiration of grossly purulent material. Secondary PNL was performed 5 days following the initial procedure, which the patient tolerated without complication, and a stone-free status was confirmed on postoperative CT.

Stone analysis was performed in all cases by Fourier transform infrared microspectroscopy (Beck Analytical Services, Indianapolis, Indiana). There were 12 patients (37.5%) who harbored infection related calculi, defined as pure struvite or as a mixture of struvite and carbonate apatite. All patients with struvite calculi were infected with urea-splitting organisms on preoperative urine culture, including Proteus sp. in 7 patients, Klebsiella sp. in 3 patients and Pseudomonas sp. in 2 patients. A total of 20 patients (62.5%) were found to have metabolically derived calculi, including uric acid in 1, calcium oxalate monohydrate in 2, brushite in 2, hydroxyapatite in 6 and mixed hydroxyapatite/calcium oxalate in 9. There were no patients who had mixed calcium oxalate and struvite stones.

DISCUSSION

Patients with NB due to SCI or MM are at risk for a number of urological complications, including chronic urinary tract infection, vesicoureteral reflux, and urinary calculi. Burr reported that 98% of renal calculi identified in a SCI group were composed of struvite.[3] Only 2% of stones were of metabolic derivation, being composed of calcium oxalate. Nikakhtar et al confirmed these findings, reporting that, in a series of 26 patients with SCI and renal calculi, 25 (96%) of the stones were composed of struvite.[4] Since these findings were first reported more than 2 decades ago, it has become axiomatic that patients with NB due to SCI or MM who are diagnosed with renal calculi will be found to harbor infection related stones composed of struvite or carbonate apatite. However, in our contemporary series of patients, we have noted that many patients with NB due to SCI or MM harboring calculi have been found to have metabolic stones. In fact, in the cohort presented herein, the majority of patients (62.5%) were found to harbor metabolically derived calculi. We hypothesize that significant advances in urological care of the patient with SCI or MM that have been accomplished in the modern era are responsible for this paradigm shift in stone composition. The modern urodynamic evaluation of detrusor and sphincter function allows a rapid assessment of the urinary tract. Increasing understanding of the physiology of urine storage and elimination has substantially altered the manner in which patients with SCI and MM manage their urinary tract.[1,5,7,8] The greater use of CIC and bladder augmentation has allowed many patients formerly at risk for renal deterioration due to increased urinary storage pressures now to be maintained with low pressure urinary drainage systems. DeVivo et al have confirmed that that the frequency of deaths due to renal failure in patients with SCI have decreased in recent years, likely a consequence of advances in urological techniques.[9]

Another consequence of the increasing urological understanding of neurogenic voiding dysfunction is a decreasing incidence in the rate of urinary tract infection in the SCI and MM patient population. Van Gool et al reported that in a series of 61 patients with MM begun on a CIC regimen, the rate of UTI decreased significantly after CIC was initiated.[10] Krishna and Gough similarly reported that bladder augmentation, introduction of a CIC regimen, and antibiotic prophylaxis reduced the rate of UTI in a patient population with MM.[11] We hypothesize that the reduction in the incidence of

UTI in patients with NB due to SCI or MM may have a contributory role in the increased percentage of metabolically derived calculi that we observed.

Several authors have reported an increased incidence of urinary calculus disease within the first several months following SCI, hypothesized to be due to immobilization hypercalciuria.[1,12] Typically, calcium stones predominate in this time period. However, it should be noted that no patient in the SCI cohort in the current series was treated within the first year of injury, and in fact the shortest interval from time of SCI to time of PNL was 6 years. Therefore, we do not believe that this phenomenon was a confounding factor in our patient series.

The population of patients with SCI and MM in our series used a wide spectrum of techniques to manage their urinary tract including diaper, chronic indwelling Foley catheter, suprapubic tube, ileal conduit, and bladder augmentation with continent catheterizable channel. Others have previously reported that the likelihood of developing calculi is not significantly influenced by the type of urinary drainage.[1,13] However, we did note that all patients who developed struvite calculi managed their urinary tract with either a chronic indwelling urethral catheter or a chronic suprapubic tube, a finding also noted by Wan et al.[7]

In evaluating the composition of calculi reported in our current series, we have noted that of the 20 metabolic calculi, 17 (85%) were comprised totally or partially of calcium phosphate. This predominance of phosphate calculi differs from an analysis of 15,624 stones performed by Gault and Chafe, who reported that oxalate stones were much more commonly detected.[14] Parks et al have reported similar findings, noting that in a series of 1,201 patients, calcium oxalate calculi were more commonly detected than calcium phosphate calculi.[15] However, the authors did note that there has been an increasing incidence in calcium phosphate calculi during the previous 3 decades. We can only speculate on the explanation for the unusual preponderance of calcium phosphate calculi in our series, although there may be a relationship with resorptive bone disease that is commonly seen in patients with SCI and MM.[16,17]

The data presented herein documenting an increase in the incidence of metabolic calculi in patients with NB due to SCI or MM emphasize the importance of obtaining a stone analysis for all patients undergoing a stone removal procedure. If a metabolically derived stone is identified, the patient should be offered further metabolic evaluation. Properly selected medical and dietary therapy, when based on data obtained from a metabolic evaluation, can attenuate stone activity.[18,19]

CONCLUSIONS

Patients with NB have been traditionally thought to harbor infection related calculi, a tenet based on literature more than 2 decades old. In the intervening years there have been significant improvements in the urological rehabilitation of patients with NB. Coincident with these advancements there have been reports of decreasing rates of UTI in this patient population. There have also been efforts to avoid the use of chronic indwelling drainage catheters such as Foley catheters or suprapubic tubes in this patient population. We have established that many patients with NB due to SCI or MM undergoing PNL will be found to have calculi that are metabolically derived rather than calculi secondary to chronic infection with urea-splitting organisms. When such metabolic stones are identified, a complete metabolic evaluation should be performed so that future efforts may be directed toward attenuating new stone activity.

Abbreviations and Acronyms

CIC	=	clean intermittent catheterization
CT	=	computerized tomography
MM	=	myelomeningocele
NB	=	neurogenic bladder
PNL	=	percutaneous nephrolithotomy
SCI	=	spinal cord injury
UTI	=	urinary tract infection

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EDITORIAL COMMENT

This contemporary observational study details the stone composition of renal calculi obtained via percutaneous nephrolithotomy in 32 patients with neurogenic bladder due to myelomeningocele or spinal cord injury. It is interesting to note that only 12 patients (37.5%) had infection stones (struvite or carbonate apatite), whereas several references from 20 years ago indicate that stones in similar patients were then almost exclusively struvite.

The authors attribute the apparent reduction in infection stones to improved bladder management techniques. Reading between the lines, clean intermittent catheterization or urinary diversion via ileal conduit appear to carry a better prognosis. Chronic indwelling suprapubic or urethral catheter drainage (used in 60% of patients with spinal cord injury and none of the patients with myelomeningocele) were associated with all cases of struvite calculi. Presumably chronic indwelling catheterization promoting continued reflux of infected urine to the kidneys is the predominant lithogenic process.

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