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CORRELATION OF UNILATERAL UROLITHIASIS WITH SLEEP POSTURE

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ABSTRACT

Purpose: Recurrent stone formers commonly present with calculi on the same side and the etiology of recurrent unilateral urolithiasis is unclear. Despite comprehensive metabolic evaluations, many patients will not be readily categorized into a treatable group. Data from the literature support that sleep posture may result in alterations of renal hemodynamics. We investigate the correlation of sleep posture with unilateral urinary stone formation.

Materials and Methods: A prospective study of 110 patients with recurrent unilateral nephrolithiasis was conducted. A questionnaire was used to evaluate patient sleep posture. Right or left side down and rotisserie-like sleep postures were defined. The side of stone formation was correlated with sleep posture using chi-square test.

Results: Of the patients 93 slept consistently with 1 side in a dependent position and the side of stone was identical to the dependent sleep side in 76% ($p = 0.008$). The positive predictive values of right and left side down sleep posture for formation of ipsilateral calculi were 82% and 70%, respectively.

Conclusions: Although the exact pathophysiology of the association between sleep posture and recurrent unilateral stone disease remains to be elucidated, sleep posture may alter renal hemodynamics during sleep and promote stone formation. This observation needs further investigation and should be factored into the evaluation and prevention of unilateral urinary stone disease.

KEY WORDS: urinary calculi, sleep, posture, kidney calculi, calculi

Nephrolithiasis is a heterogeneous disorder and, although the exact cause of urinary stone disease is unknown, many theories have been proposed.[1,2] However, the mechanism of stone formation in many patients remains unclear.[3,4] Most of the theories on the etiology of urolithiasis have concentrated on physical and chemical characteristics of urinary constituents in stone forming patients.[2] Although it is presumed that both kidneys excrete similar urinary constituents, it is a general observation that the majority of patients present with unilateral stone disease. Recurrent stone formers usually present with calculi on the same side.

It has been postulated that stone formation may occur at night when the urine is maximally saturated with various crystals but this would not explain why stones form unilaterally. Thus, the question is raised whether unilateral stone formers have specific changes with regard to the involved kidney at night. One factor may be a change in blood circulation of the kidneys secondary to a specific sleep posture. A similar change in pulmonary blood flow has been reported with change in body posture.[5] We investigate the correlation of sleep posture with unilateral stone disease in a cohort of patients with unilateral nephrolithiasis.

MATERIALS AND METHODS

We prospectively evaluated the sleep posture of 110 consecutive patients with unilateral urinary stones who presented to the Stone Center at the University of California, San Francisco during a 2-year period. All patients with symptomatic unilateral renal (36%) or ureteral (66%) stone disease without evidence of concurrent medical conditions known to be a contributory factor to sleep habits were included in the study. A plain abdominal radiograph and renal ultrasonography confirmed the presence of stone. There were 68 men and 42 women, with a mean age of 46 years (range 24 to 75). Many ureteral stones passed spontaneously and others required ureteroscopic extraction. Renal calculi less than 1.5 cm. were treated with lithotripsy and larger stones were retrieved percutaneously. Complete stone composition was not available.

Sleep habits were obtained by a questionnaire. The investigator was not routinely blinded from the location of the stone. Patients were asked about sleep posture preference, specifically if they sleep preferentially with the right or left side down, supine or prone and/or frequently turn back and forth (rotisserie-like). This information was collected by pretending that the examination bed was their bed.

Patients were asked about the side of the bed they and their spouse or partner routinely slept on, the side of the bed their alarm clock was on and whether they face the clock before going to bed or upon awakening. Spouses or partners were contacted to confirm these data. Chi-square test was used for correlations between stone site and sleep posture. Statistical analysis was performed using a computer software program.

RESULTS

Part *A* of the figure demonstrates an example of a patient with a left stone whose sleep posture was exclusively left side down, which was reflected by the post-percutaneous nephrolithotomy sleep posture. A striking facial asymmetry secondary to sleep posture was also noted (part *B* of figure).

The results of our survey are summarized in the table. Of the 110 patients 93 admitted to sleeping consistently with a distinct side in a dependent fashion (left or right side down), and 48 (43.6%) and 62 (56.3%) had stones on the right or left

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A, sleep posture after left percutaneous nephrolithotomy. *B*, face with clear asymmetry and roughened left side indicating greater than 20 years left side down sleep posture.

Correlation of sleep posture with side of stone formation

Perceived Posture	No. Lt. Stone (%)	No. Rt. Stone (%)	Total No. (%)
Lt. side down	40 (82)	9 (18)	49 (100)
Rt. side down	13 (30)	31 (70)	44 (100)
Rotisserie-like	9 (53)	8 (47)	17 (100)

Correlation of the side of stone with dependent sleep posture $p = 0.008$.

side, respectively. Among the 93 patients with a distinct side specific sleep pattern, overall stone side was identical to the dependent sleep side in 76% ($p = 0.008$). The stone was on the right side in 31 of 40 (78%) patients who slept on the right side and on the left side in 40 of 53 (76%) who slept on the left side. Conversely, 23% (9 of 40) of patients with right stones slept on the left side and 25% (13 of 53) with left stones slept on the right side. The positive predictive value of a left or right side down posture for a stone on the left or right side was 82% and 70%, respectively. The 17 patients with a rotisserie-like sleep posture demonstrated similar stone distribution with 53% (9 of 17) on the right and 47% (8 of 17) on the left side.

DISCUSSION

Advances in endourological techniques and the introduction of new technologies have revolutionized surgical management of urinary stone disease. Although significant knowledge has been gained regarding the pathophysiology of stone disease, this has not translated into a similar dramatic change in medical management and prevention. A reason for this discrepancy may be the fact that the etiology of recurrent calcium stones in many patients remains unclear and/or is multifactorial.

Theories on the pathogenesis of urolithiasis are incomplete.[1–4] The nucleation theory postulates that urinary stones originate from immersion of crystals or foreign bodies in supersaturated urine.[2] However, stones do not form in all patients who are relatively dehydrated or hypersecretors of crystals. Moreover, 24-hour urinalysis in many stone forming patients demonstrates normal concentration of stone forming ions.[6] In contrast, the crystal inhibitory theory suggests that absence or low concentration of natural stone inhibitors favors stone formation but this is not true for all patients, as some individuals who lack these inhibitors may never form a stone. Conversely, many patients with an abundance of urinary inhibitors may form stones.[7]

It is striking that many patients with urolithiasis form stones exclusively on 1 side. If the concentration or supersaturation of urine with various constituents were the major etiological factor in these patients, logically one would expect most to present with bilateral stone disease. In our study sleep posture correlated with the side of stone formation. Stones formed significantly more often in the dependent kidney. Overall, 76% of the patients with a distinct sleep dependent side formed recurrent stones on the same side. One may question the reliability of a history of sleep posture. However, sleep study data have confirmed the correlation between subjective sleep parameters including posture and objective laboratory findings.[8,9]

Although the exact mechanism for this observation is not apparent, an attractive hypothesis is that a change in renal blood flow with sleep posture may promote stone formation. It has been shown that varied pulmonary perfusion in dependent and nondependent fields will change ventilation and oxygenation.[5] Uninterrupted stationary positions like sleep on right or left side down will likely have the same impact on renal as on lung circulation.[10] Sleep posture may alter the renal blood flow and perfusion in the dependent kidney. Temporary renal ischemia has been found to alter metabolic and functional activity of the renal parenchyma,[11] which may alter renal clearance of various substances as the time increases.

Early experimental studies in animal models have demonstrated that renal ischemia favors stone formation.[12,13] Gray studied the effect of incomplete unilateral ligation of the renal artery in a rabbit model.[12] In this study only the ischemic kidneys developed stones in 15% of the cases. Furthermore, the dietary addition of calcium and vitamin D resulted in an increase in stone formation rate in the ischemic kidney to 45%. Further experimental studies in the rat have confirmed previous results that acute unilateral renal ischemia enhances nephrolithiasis.[11] This observation may explain why the peak incidence of urinary stone disease occurs in the third and fourth decades. This period is when most individuals sleep throughout the night without awakening to void as is frequently the case in the elderly population. It is curious that the incidence of urinary stone disease does not increase with increased age.

Our study suggests that simple methods to alter sleep habits may help prevent recurrent nephrolithiasis. Patients with unilateral stone disease should be carefully questioned about sleep posture. If a consistent picture is clear then intervention may be appropriate. Similar to sleep apnea, placing a tennis ball on the affected side of nighttime garments will help prevent patients from returning to this position while they are asleep.

CONCLUSIONS

Our data clearly demonstrate an association between sleep posture and ipsilateral urinary stone disease. Although the mechanism by which sleep posture impacts on unilateral stone formation remains to be elucidated, this observation should be factored into the evaluation and prevention of unilateral nephrolithiasis.

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EDITORIAL COMMENT

The authors report their unique observation on the location of stones relating to sleep patterns. They found a significant correlation with the side down position in the formation of ipsilateral calculi. In fact, when they studied patients with nondominant sleep patterns, the so-called rotisserie sleep pattern, they found a nonlateralizing distribution of stone disease. Therefore, they concluded that laterality of stone disease correlates with sleep posture.

Although not well documented in the literature, urolithiasis generally tends to be prevalent on 1 side. I do not believe there has been another study attempting to correlate this with sleep posture. As described by the authors, the pathogenesis of urolithiasis is multifactorial and still not completely understood. They postulate that there might be relative ischemia of the kidney on the side recumbent position, thus resulting in low urine output and supersaturation of crystals leading to stone disease. They quote literature citing relative decrease in pulmonary blood flow in the lateral recumbent position.

However, there are several mechanisms unique to the kidney that maintain its blood flow despite significant changes in systemic pressure referred to as "auto-regulation." These mechanisms reside within the kidney and are sensitive to any systemic changes. On the other hand, renal handling of sodium is also crucial in the ultimate urine volume, and can be affected and maintained by glumerotubular balance, tubular capillary Starling forces, redistribution of renal blood flow in the kidney, effects of aldosterone and perhaps existence of hormones such as atrial natriuretic hormones and prostaglandins. It is also conceivable that there may be diuresis in the contralateral kidney which in essence is preventing crystal supersaturation and stone formation in a patient who is at risk for stone disease. It seems that without performing sleep recumbent renal blood flow and tubular excretion studies, it will be almost impossible to suggest that relative renal ischemia might be the etiological factor.

Despite lack of scientific explanation, the observation is important. I believe this finding does have clinical implications and may be useful in clinical practice. Sleep posture may also impact on residual stone fragments following shock wave lithotripsy and other forms of intrarenal endoscopic procedures. By manipulating sleep habits, stone recurrence may decrease and perhaps clearance of stone fragments following shock wave lithotripsy may be enhanced.

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