Epidemiology of Nephrolithiasis in Personnel Returning From Operation Iraqi Freedom

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OBJECTIVES To examine the epidemiology of urolithiasis in personnel returning from deployment to Southwest Asia.

METHODS A survey-based study of personnel returning from deployment to Southwest Asia was performed. The demographics were compared between the personnel reporting a history of urolithiasis during or within the first 90 days of returning from deployment and the personnel without a history of reported urolithiasis.

RESULTS A total of 10,180 personnel were demobilized and 6153 surveys were received during a 9-month period, for a survey response rate of 60%. Of the personnel returning survey, 1% reported urolithiasis during their deployment. The personnel who reported urolithiasis were slightly older than those who did not (32.6 vs 29 years old, $P < .00038$). The odds of reporting urolithiasis during deployment were 30.9 times greater for personnel with a history of stone disease and 2.4 times greater for those with a family history of stone disease. No difference was found in the rates of urolithiasis with regard to sex or race. Also, no strong evidence for an association between the rates of reported urolithiasis and seasonal variations in temperature in Southwest Asia was found.

CONCLUSIONS The rate of reported urolithiasis among deployed personnel was lower than that in the general population. The personnel who reported urolithiasis during deployment were slightly older. A personal history or family history of stone disease was significant predictors of urolithiasis in this deployed population. UROLOGY 74: 56–61, 2009. Published by Elsevier Inc.

A personal and family history of urolithiasis and factors such as heat and dehydration are recognized risks of stone disease in the general population[1-6]; however, the effect of these factors in a young and healthy population is unknown. Soldiers deploying to Southwest Asia are presumed to be at an increased risk of developing urolithiasis, but, in truth, little is known about the risk of stone disease in military personnel. In addition, neither the prevalence nor the incidence of stone disease during deployment has been published. Our experience treating urolithiasis at a combat support hospital during the first 6 months of Operation Iraqi Freedom suggested that the rate of symptomatic urolithiasis in deployed personnel was high; however, the incidence and prevalence of stone disease could not be established because of the movement of large numbers of troops in and out of the country during the study period.[7]

The greatest rates of urolithiasis in the world have been reported in the hot, arid environment of Southwest Asia.[8,9] The deployment of large numbers of military personnel to Southwest Asia created a natural cohort of young, healthy people exposed to significant environmental risk factors for stone disease. We conducted a survey-based study to investigate the incidence and correlate the risk factors for urolithiasis in an equal access, closed healthcare system of military personnel returning from deployment to Southwest Asia.

MATERIAL AND METHODS

The institutional review board approved this survey-based, cross-sectional study of urolithiasis in military personnel returning from deployment. For the purposes of the present study, the personnel who reported for treatment of stone disease during deployment or who were diagnosed with symptomatic stone disease within 90 days of returning from deployment were defined as the affected population (ie, a case of urolithiasis during deployment).

All personnel returning from deployment to Southwest Asia through the Soldier Readiness Point at Fort Lewis, Washington from February 2005 to October 2005 were asked to participate in the study by completing the urolithiasis survey. The survey queried the subject's age, sex, race, occupation, military unit, deployment location, length of deployment, history of urolithiasis during deployment, history of urolithiasis before deployment, family history of urolithiasis in first- and second-degree relatives, treatment received for urolithiasis during deployment, period separated from one's unit because of urolithiasis, and the

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need for air evacuation for the treatment of urolithiasis during deployment. For the questions regarding the history of urolithiasis during deployment and previous and family history of urolithiasis, the respondents were instructed to check the appropriate box corresponding to the answers "Yes," "No," and "I don't know." For race, respondents were offered a check list and an area for free text. The remaining questions were answered with free text. A cover letter accompanied each survey and explained the study's purpose and stated that the survey was voluntary and anonymous and that demobilization was not contingent on completing the survey. To ensure anonymity, the surveys were collected before the Soldier Readiness Point medical screening station and were not reviewed by the medical screening personnel. The medical screening personnel were instructed to immediately refer all personnel with signs or symptoms of stone disease or who reported treatment of urolithiasis during deployment to the urology clinic. To ensure that all potential subjects were identified, the surveys were also collected from the military personnel referred or presenting to the urology clinic for symptomatic urolithiasis within 90 days of returning from deployment. All individuals with urolithiasis or a history thereof were evaluated and treated in accordance with the standard of care.

The data from the surveys were entered into a secure database as the surveys were received. The demographic information was used to prevent duplicate entries. The data from incomplete surveys were included when appropriate.

Statistical Analysis

Protected health information was expunged from the database before the statistical analysis. Those who had marked "I don't know" to the survey question "Were you treated for kidney stones while deployed?" were eliminated from additional analysis. Those who marked "I don't know" to subsequent questions were eliminated from the analysis of only that question. The responses of the affected population (ie, urolithiasis during deployment) were compared with those of the unaffected population. Statistical analysis was performed using the R software environment for statistical computing and graphics (available from: http://www.r-project.org/).

RESULTS

A total of 10,180 active duty personnel, activated reservists, National Guardsmen, and deployed civilians were demobilized through the Soldier Readiness Point during the 9-month period. Of these personnel, 6153 surveys were received, for a survey response rate of 60%. Of the 6153 returning a survey, 60 (1%) responded "Yes," 6047 responded "No," and 46 responded "I don't know" to the question "Were you treated for kidney stones while deployed?" Of the 60 subjects who reported urolithiasis during deployment on the anonymous survey, only 6 (10%) were identified at the medical screening station and subsequently referred to the urology clinic. No subjects were referred from the Soldier Readiness Point site for stone disease who had not reported a history of urolithiasis on the survey. One subject was referred to the urology clinic by his primary care provider for symptomatic nephrolithiasis within 90 days of returning from deployment.

Table 1. Demographics of survey respondents

Variable	Urolithiasis During Deployment: No	Yes
Age (y)		
Mean	29	32*
Range	17-61	18-57
Sex		
Male	5707 (94.4)†	57 (95)
Female	341 (5.6)†	3 (5)
Race		
White	4258 (71)	49 (83)‡
Black	544 (9)	2 (3)‡
Hispanic	618 (10)	5 (9)‡
Other§	594 (10)	4 (5)‡

* $P < .00038$, *t* test.
† $P = .8364$, χ^2.
‡ $P = .1974$, χ^2.
§ Included Asian, Pacific Islander, Native American, and subjects who marked >1 category.

Table 1 summarizes the demographic information of the respondents. The mean age of the subjects reporting urolithiasis during deployment was 32.6 years, and the mean age of those who denied urolithiasis was 29.0 years. Although the age range between the 2 groups overlapped, the increased mean age of the subjects with urolithiasis was statistically significant ($P < .00038$, *t* test). Men constituted 95% of the respondents; 1% of men and 0.9% of women reported urolithiasis during deployment. No statistically significant difference was found in the sex ratio between those who reported urolithiasis during deployment and those who did not ($P = .8364$, χ^2). Of those returning a survey, 6084 provided data regarding race. Only 3 categories, white, black, and Hispanic, had sufficient data to merit a formal test of rate equality. Although white respondents were more likely to report urolithiasis during deployment, the small sample sizes rendered the χ^2 test for equality of rates insignificant ($P = .1974$).

The statistical analysis revealed a significant relationship between a history of urolithiasis during deployment and a history of urolithiasis before deployment. Of the 60 personnel who reported urolithiasis during deployment, 24 (42%) reported a previous history of urolithiasis. In contrast, only 1.9% of subjects who denied urolithiasis during deployment reported a history before deployment. The rate of urolithiasis for subjects reporting a previous history was 0.182 and the rate for those without a previous history was 0.006. This difference was statistically significant ($P < .00001$, χ^2). Logistic regression analysis revealed the fitted odds of reporting urolithiasis during deployment to Southwest Asia were 30.9 times greater for personnel with a history of urolithiasis compared to personnel without a history of stone disease.

A significant association was also found between reporting a family history of urolithiasis and reporting urolithiasis during deployment. Of the 60 personnel who reported urolithiasis during deployment, 22 (47%) re-

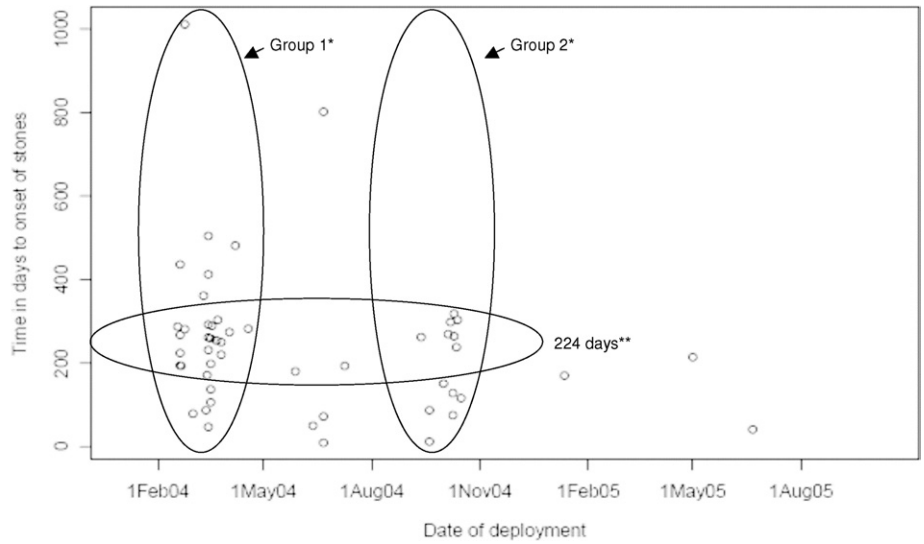

Figure 1. Interval to onset and rates of urolithiasis among groups of deployed personnel. Rate of reporting urolithiasis was 0.012 for group 1 and 0.006 for group 2 (p=0.02, Chi-squared). Median time to onset for both groups 224 days (individual medians not significantly different).

ported a family history of stone disease. In contrast, only 19% of subjects who denied urolithiasis reported a family history of stone disease. The calculated rate of urolithiasis for subjects reporting a family history was significantly greater than that for subjects without a family history (0.025 vs 0.007, respectively; $P < .00001$, χ^2). The fitted odds of reporting urolithiasis during deployment to Southwest Asia were 2.4 times greater for subjects with a family history of urolithiasis than for those without a family history of stone disease.

No evidence was found that occupation affected the rate of urolithiasis during deployment. Infantrymen comprised the dominant occupation; however, 280 different occupational categories were reported. Although 14 categories had ≥100 individuals, the number of individuals per category was not large enough for a meaningful analysis.

The median length of deployment to Southwest Asia was 355 days. A review of the data revealed two 2-month periods during which approximately 80% of respondents departed for Southwest Asia. Group 1 departed in February and March of 2004 (n = 2477) and group 2 departed approximately 6 months later in September and October of 2004 (n = 2453). The median interval to the onset of urolithiasis was 250 days for group 1 and 238 days for group 2. The difference between these times was not statistically significant ($P = .49$, Wilcoxon rank-sum test). The median interval to the onset of urolithiasis for both groups was 224 days (Fig. 1). The rate of reporting urolithiasis during deployment was 0.012 (1.2%) for group 1 and 0.006 (0.6%) for group 2. Although the difference in rates was statistically significant ($P = .02$, χ^2), frequency testing did not support the existence of a "stone season" ($P = .7$, χ^2).

COMMENT

This is the only published study to determine the rate of urolithiasis among deployed military personnel and to quantify the significant effect of a previous and family history of stone disease. A surprisingly low number of personnel (1%) reported urolithiasis during deployment, and a discouragingly low number of them sought medical evaluation (10%) on return from deployment. We chose an anonymous survey to maximize the participation in our study, and this decision was validated by the low percentage of personnel who reported urolithiasis to the medical personnel during medical screening. The personnel could have a variety of reasons to decide not to report a medical condition at their demobilization, not least of which is a strong desire to complete demobilization and return home. The failure to report medical conditions could have serious consequences for deploying personnel and a negative effect on the health of the fighting force.

A paucity of published data is available describing stone disease in military populations, and no previous publications have determined the incidence of urolithiasis in deployed military personnel. Pierce and Bloom[10] described 61 cases of urolithiasis occurring in an undisclosed number of American troops stationed in a "desert area" during the First World War but did not provide the prevalence or incidence. An increase in urine calcium was reported in a small group of British naval personnel deployed to the Gulf Region during the summer; however, the investigators did not correlate this finding with clinical or radiographic evidence of stone disease.[11] The experience of one of us (K.B.) treating 182 cases of urolithiasis at the 47th combat support hospital during the first 6 months of Operation Iraqi Freedom has been published, but the large movement of troops in and out of the theater precluded any meaningful analysis of the incidence or prevalence of stone disease.[7] Furthermore, 20% of the patients with urolithiasis who were known to have been evacuated out of the theater from the 47th combat support hospital were missing from the air evacuation database.[7] This data lapse precluded epidemiologic analysis of the air evacuation database and was one of the factors motivating the initiation of the present study.

The rate of reporting urolithiasis in deployed personnel (1%) was lower than the 2%-3% rate reported for the general population.[12] Presumably, the military's emphasis on forced hydration as a method to prevent heat injury contributed to the decreased rate of stone disease in this cohort; however, a causal relationship between forced hydration and decreased stone disease could not be established through the present survey-based study. The relatively younger age of the military population vs the general population could also have contributed to the lower rate of urolithiasis among deployed personnel, because the rate of urolithiasis increases with advancing age.[13] The lower rate among our study cohort could also have been a result of underreporting—a potential confounder for survey-based studies.

A history of stone disease was a significant risk factor for urolithiasis in the present study. According to the National Center for Health Statistics (1999, 2001), the rate of recurrent urolithiasis can exceed 50% within 10 years, with a lifetime risk of recurrence estimated to be as great as 60%-80%.[14] Our analysis determined that subjects with a history of urolithiasis before deployment were 30.9 times more likely to report urolithiasis during deployment than those without. This increase is compelling evidence and supports the practice of screening military personnel with a history of urolithiasis for active stone disease so that treatment and/or additional preventive measures can be instituted before deployment.

Although <2% of patients with renal stone formation can be categorized as having a heritable stone disorder, ≤40% of patients with urolithiasis have a first-degree relative with a history of the disease.[15] Similarly, 47% of those personnel who reported urolithiasis during deployment also reported a family history, and subjects with a family history were 2.5 times as likely to report urolithiasis during deployment. Inheritable and environment factors have both been proposed for the prevalence of urolithiasis in families.[16] A study of twins determined that urine characteristics, such as urinary calcium, oxalate, citrate, and uric acid, were highly heritable.[15] The relative risk of stone formation in men with a family history of stone disease was 2.57 (95% confidence interval 2.19-3.02) in a longitudinal study of 37 999 men.[1] Given the risk of urolithiasis, screening for active stone disease and instituting preventive measures would be prudent in deploying personnel with a significant family history of urolithiasis.

Although the difference in years was small, the subjects who reported urolithiasis in our study were significantly older statistically at 32.6 years than those who denied it (mean age 29 years). Our study found no statistically significant difference in the rates of reporting urolithiasis between the sexes, among racial groups, or among occupations. In the general population, men are 3 times more likely to experience urolithiasis than women.[13] The effect of ethnicity on urolithiasis is less well defined. Evidence has suggested that whites, particularly white men, are more likely to develop urolithiasis.[13,17,18] A retrospective review of 193 consecutive patients with stone disease by Mason et al.,[19] however, concluded that urolithiasis is not rare in blacks and that the prevalence of urinary calculi in their study population mirrored the racial demography of the underlying population.[19] Studies of additional ethnic groups have revealed rates of urolithiasis to rival those reported for whites.[17,20] If one accepts that heat and dehydration are risk factors for stone disease, one could postulate that the rates of urolithiasis between the sexes and among racial groups were equivalent in our study population because the deployed personnel were subjected to the same environmental exposures. The rates could also be influenced by factors such as the equal access to healthcare in the military system, shared dietary exposures (deployed personnel are restricted to approved food sources such as dining facilities), and hydration status.

Selection and recall bias were potential confounders of this survey-based study. The possibility exists that the questions were not interpreted as intended, because our questionnaire was not validated. It is also possible that some personnel did not report urolithiasis during deployment to avoid a delay in demobilization.

CONCLUSIONS

The rate of urolithiasis among deployed military personnel appears to be lower than that in the general population. Personnel with a history of stone disease were 30 times more likely to report treatment of stone disease during deployment than were personnel without such a history. A family history of stone disease was also a significant risk factor for urolithiasis in this young, healthy population. As such, military personnel with a personal history or family history of urolithiasis should be considered at high risk of developing urolithiasis during deployment. These individuals should be screened for active stone disease, and preventive measures should be initiated before deployment.

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EDITORIAL COMMENT

Patients, in general, exposed to hot, dry, arid climates have an increased risk of stone formation. These environmental conditions are typical in Southwest Asia, where the factors for stone disease are well established. It is surprising, therefore, in this article, *Epidemiology of Nephrolithiasis in Personnel Returning From Operation Iraqi Freedom*, that some recognized risks for stone disease were not present. Given these environmental factors, it is perplexing that the risk of stones in the service personnel were (a) less than that of the general population, and (b) did not demonstrate sex or racial differences. One factor that might explain these differences is the low survey response rate of 60% in this study. Second, the personnel might have been prepared for the combat terrain and were subsequently encouraged to be well hydrated in the field. Finally, the service personnel in this study might not have been followed up long enough to have developed a symptomatic stone. Only personnel who were symptomatic for urolithiasis after 90 days of deployment were seen in the urology clinic. An unknown number of patients with asymptomatic stones were not included in this survey, and, therefore, the true prevalence of nephrolithiasis might have been underestimated.

In the general population, men are known to have urolithiasis 2-3 times more frequently than women. In addition, whites are 3-4 times more likely to have stones than black patients. The present study demonstrated no apparent differences in sex or racial factors among the personnel. The lack of differences might have been minimized because these personnel might not have had been exposed to the same conditions as the general population. These authors make note of the equal access to healthcare, encouraged hydration, and the similar dietary exposure. These similarities might have minimized the significance differences among the sexes and ethnicities.

Patients with an established personal and family history of nephrolithiasis have an increased risk of recurrent stones. In fact, the risk of stone recurrence could be as great as 50% within 5 years, with a lifetime recurrence risk of ≤80%. This study has demonstrated the risk among service personnel with a known history of stones was 31 times greater than those personnel without a history of stones (42% vs 1.9%, respectively). Similarly, patients with a family history of stone disease were 2.4 times more likely to have stones than servicemen who did not have first-degree family members with stones (47% vs 19%, respectively). Although these factors are important, future investigations could examine the urinary chemistry findings to determine the additional military personnel at risk.

The authors point out the small number of personnel seeking medical evaluation (10%) for their stone disease. Such a failure to report the symptoms of stones could have serious consequences for those individuals and other personnel in combat situations. These authors should be credited for identifying factors that might determine the personnel in combat or after combat who are at risk of stone disease. Such measures will help to recognize these servicemen and minimize their potential risk before or during deployment. The diagnosis of stones among service personnel is paramount, especially for those involved in combat.

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REPLY

Diseases and nonbattle injury account for a significant portion of medical casualties during combat. Defining the prevalence of, and identifying the risk factors and preventive measures for, diseases that have a significant effect on military operations are important aspects of military medicine.

This large, survey-based study addressed symptomatic nephrolithiasis in soldiers returning from deployment in Southwestern Asia, an admittedly unique population. Our study is not exempt from the shortcomings to which survey studies are prone. However, we believe it is noteworthy that in an anonymous survey using a self-reported and generous definition of a history of symptomatic nephrolithiasis, the risk of symptomatic stone disease in military personnel returning from Southwestern Asia was not increased to greater than that of the baseline population. This study is not the final word on the effect of stone disease in the military; however, we found no evidence of an epidemic of stone disease among military personnel returning from deployment. This low rate was not the result we had expected—the original study design included a plan to perform