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ORIGINAL PAPER

# The effect of work location on urolithiasis in health care professionals

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**Abstract** The objective of this study is to compare the prevalence and risks factors for urolithiasis among health care professionals who work in the operating room (OR) versus other locations. Electronic surveys, focusing on a history of urolithiasis, were sent to 3,921 randomly selected employees at our institution, 34 % (1,340) of which worked in an OR. Additional information regarding potential risk factors such as quantity of daily fluid intake, stress level, activity level, body mass index, relevant medical conditions and family history of urolithiasis were obtained and analyzed. Of those surveyed, 46 % (1,802/3,921) responded. The prevalence of urolithiasis for all responders was 10.9 % (196/1,802). Those individuals working in an OR had a higher prevalence of stone disease compared to those who work elsewhere [14.6 % (64/439) versus 9.7 % (132/1,363); $p = 0.004$]. Specifically, physicians that work in an OR had the highest prevalence of urolithiasis [17.4 % (20/115) versus 9.7 % (132/1,363); $p = 0.009$). Additionally, physicians that work in an OR reported significantly less fluid intake ($p = 0.04$) and higher stress levels ($p < 0.0001$) compared to employees not working in an OR. On multivariate analysis, working in an OR remained associated with a significantly increased risk stone formation (HR 1.43; $p = 0.04$). Our survey found that health care professionals working in an OR setting, and physicians in particular, are at higher risk of urolithiasis.

**Keywords** Epidemiology · Physicians · Risk factors · Urolithiasis

**Abbreviations**
OR Operating room
BMI Body mass index

## Introduction

The prevalence of urolithiasis in the general population in the United States has been reported between 8.8 and 12 % [1–3]. Multiple risks factors for stone formation have been identified, including being in the fourth or fifth decade of life [4], limited fluid intake [4], medical co-morbidities [5], as well as environmental causes such as stress levels [6, 7], or even geographic location [8, 9]. Typically, these risk factors are related in that stone formation is secondary to fluid balance and/or calcium metabolism.

Based on known risk factors of stone formation, previous studies have focused on occupations that may predispose individuals to stone formation [10–12]. Certain professions share an increased risk for urolithiasis secondary to dehydration from exposure to high temperatures and perspiration. For instance, one report found elevated rates of urolithiasis in glass plant workers with chronic exposure to high temperatures, when compared to their peers without this exposure [10]. There have been similar findings in cooks and engineering room personnel in the Royal Navy [11], as well as with steel workers [12].

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The operating room (OR) presents a unique work environment. Due to limited access to fluids and a high stress environment, the potential for urolithiasis formation may be elevated. Thus, we sought to compare the prevalence and risks factors for urolithiasis among health care professionals who work in the OR versus other locations.

## Materials and methods

Following institutional review board approval, electronic surveys (sent via e-mail), focusing on a history of urolithiasis, were sent to 3,921 employees at our institution (Mayo Clinic, Rochester, Minnesota) in 2012. The potential responders were selected randomly by a third party after generating a list of employees that work in an OR and those that do not. Given the smaller number of employees that work in OR compared to those that do not, 34 % (1,340) of those selected to be surveyed were OR workers. The questionnaires were voluntarily completed over an 8-week timeframe and reported anonymously. Additional information regarding potential risk factors such as quantity of daily fluid intake, stress level (reported using a 1–10 likert scale), activity level via modified Godin Leisure-Time Exercise Questionnaire [13], body mass index (BMI), relevant medical conditions (diabetes mellitus, neurogenic bladder, and/or prior bowel resection) and family history of urolithiasis were obtained (Appendix 1). The overall response rate was 46 % (1,802). Given the anonymous nature of the survey, no verification of responses with patient medical records was performed.

Comparisons were performed between employees that work in an OR and those that do not. Further subgroup analyses evaluating the responses of physicians that work in an OR and non-physician OR employees compared to non-OR workers were also performed. A power assessment was conducted to determine the number of answered questionnaires that would allow detection of an odds ratio of 1.5 between OR and non-OR employees with urolithiasis. Comparisons between categorical variables were performed using Pearson's Chi square or Fisher's exact test, as appropriate. Statistical analysis included Chi square test for categorical variables, and the Cochran-Mantel–Haenszel test for ordinal variables. All tests were two-sided, with a $p$ value $<0.05$ considered significant. Statistical analyses were performed with the SAS, version 9.1.3, software package (SAS Institute, Cary, NC, USA).

## Results

The prevalence of urolithiasis for all responders was 10.9 % (196/1,802), with individuals working in an OR having a higher prevalence of stone disease compared to those who work elsewhere [14.6 % (64/439) versus 9.7 % (132/1,363); $p = 0.004$]. Additionally, those that work in an OR had a higher mean number of stone events 1.8 versus 1.3 ($p = 0.03$). With regard to risk factors, healthcare professionals working in an OR were more likely to report having less than 1.8 L of daily fluid intake on average ($p < 0.0001$), with a lower average daily fluid intake ($p = 0.006$), and higher self reported stress levels ($p < 0.0001$) compared to employees who do not work in an OR. Additionally, OR workers had a significantly lower calculated BMI ($p = 0.0001$). No difference in pertinent medical co-morbidities, level of exercise or family history of urolithiasis was noted between the cohorts (Table 1).

Given the potential risk factors identified, we performed two subgroup analyses, of physicians and other employees that work in an OR. Physicians that work in the OR were also found to have a significantly increased prevalence of urolithiasis compared to employees that work outside of an OR [17.4 % (20/115) versus 9.7 % (132/1,363); $p = 0.009$]. Additionally, the rate of having their first stone event while working as a health care provider was significantly increased among physicians that work in an OR compared to non-OR employees [13.6 % (15/110) versus 6.2 % (82/1,313); $p = 0.003$]. Similar to OR workers in general, physicians reported significantly less fluid intake ($p = 0.04$), higher stress levels ($p < 0.0001$) and lower BMI ($p = 0.0002$) (Table 2).

Likewise, when evaluating the rate of urolithiasis among non-physician OR workers, a significantly increased prevalence of urolithiasis was found compared to employees that do not work in an OR (13.5 versus 9.7 %; $p = 0.04$). Again, the rate for having a first stone event while working as a healthcare provider was also significantly increased among non-physician OR workers (12.7 versus 6.2 %; $p = 0.0001$). Among non-physician OR employees, there was also significantly increased levels of stress ($p = 0.0001$), and significantly lower level of fluid intake ($p < 0.0001$). Furthermore, no difference in pertinent medical co-morbidities, level of exercise or family history was noted between the cohorts.

We next assessed the independent association of working in an OR with stone formation, controlling for urolithiasis risk factors (Table 3). We found that working in an OR remained associated with significantly increased risk of urolithiasis (HR 1.43; $p = 0.04$). Likewise, having a higher BMI, a personal history of bowel resection or diabetes, or a family history of kidney stones were also associated with increased risks of urolithiasis. Meanwhile, stress level and a daily fluid intake of less than 1.8 L were not independently associated with urolithiasis.

**Table 1** Survey answers for employees working in operating room versus staff not working in operating room

| | Non-OR worker ($N = 1,363$) | OR worker ($N = 439$) | $p$ value |
|---|---|---|---|
| History of urolithiasis | 132 (9.7 %) | 64 (14.6 %) | 0.004 |
| Mean no. kidney stones (SD) | 1.3 (1.3) | 1.8 (1.9) | 0.03 |
| Daily intake <1.8 L | 651 (48 %) | 277 (63.1 %) | <0.0001 |
| Mean fluid intake (L) (SD) | 1.7 (1.02) | 1.6 (0.88) | 0.006 |
| Stress level | | | <0.0001 |
| 0 or 1—Not at all stressful | 37 (2.7 %) | 5 (1.1 %) | |
| 2 | 64 (4.7 %) | 10 (2.3 %) | |
| 3 | 112 (8.3 %) | 29 (6.6 %) | |
| 4 | 146 (10.8 %) | 20 (4.6 %) | |
| 5 | 240 (17.7 %) | 60 (13.7 %) | |
| 6 | 242 (17.9 %) | 78 (17.8 %) | |
| 7 | 263 (19.4 %) | 114 (26 %) | |
| 8 | 175 (12.9 %) | 70 (16 %) | |
| 9 | 44 (3.3 %) | 24 (5.5 %) | |
| 10–Extremely stressful | 30 (2.2 %) | 28 (6.4 %) | |
| Amount of exercise | | | 0.64 |
| None | 97 (7.1 %) | 22 (5 %) | |
| 1 | 132 (9.7 %) | 36 (8.2 %) | |
| 2 | 184 (13.5 %) | 66 (15.1 %) | |
| 3 | 287 (21.1 %) | 108 (24.7 %) | |
| 4 | 224 (16.5 %) | 68 (15.5 %) | |
| 5 | 237 (17.4 %) | 68 (15.5 %) | |
| 6 | 74 (5.4 %) | 29 (6.6 %) | |
| 7 | 75 (5.5 %) | 22 (5 %) | |
| 8 or more | 51 (3.7 %) | 19 (4.3 %) | |
| Median BMI (IQR) | 26.5 (23, 31) | 25 (23, 29) | 0.0001 |
| Prior bowel resection | 18 (1.3 %) | 9 (2.1 %) | 0.28 |
| Neurogenic bladder | 2 (0.1 %) | 1 (0.2 %) | 0.72 |
| Diabetes mellitus | 56 (4.1 %) | 15 (3.4 %) | 0.51 |
| Family history of kidney stones | 172 (12.7 %) | 62 (14.2 %) | 0.40 |

**Table 2** Survey answers for physicians working in operating room versus staff not working in operating room

| | Non-OR worker ($N = 1,363$) | Physician OR worker ($N = 115$) | $p$ value |
|---|---|---|---|
| History of urolithiasis | 132 (9.7 %) | 20 (17.4 %) | 0.009 |
| Mean no. kidney stones (SD) | 1.3 (1.3) | 1.8 (1.8) | 0.19 |
| Daily intake <1.8 L | 651 (48 %) | 67 (58.3 %) | 0.04 |
| Mean fluid intake (L) (SD) | 1.72 (1.02) | 1.56 (0.77) | 0.16 |
| Stress level | | | <0.0001 |
| 0 or 1—Not at all stressful | 37 (2.7 %) | 5 (1.1 %) | |
| 2 | 64 (4.7 %) | 1 (0.9 %) | |
| 3 | 112 (8.3 %) | 5 (4.3 %) | |
| 4 | 146 (10.8 %) | 2 (1.7 %) | |
| 5 | 240 (17.7 %) | 8 (7.0 %) | |
| 6 | 242 (17.9 %) | 18 (15.7 %) | |
| 7 | 263 (19.4 %) | 29 (25.2 %) | |
| 8 | 175 (12.9 %) | 27 (23.5 %) | |
| 9 | 44 (3.3 %) | 10 (8.7 %) | |
| 10—Extremely stressful | 30 (2.2 %) | 13 (11.3 %) | |
| Amount of exercise | | | 0.55 |
| None | 97 (7.1 %) | 6 (5.2 %) | |
| 1 | 132 (9.7 %) | 15 (13.0 %) | |
| 2 | 184 (13.5 %) | 24 (20.9 %) | |
| 3 | 287 (21.1 %) | 21 (18.3 %) | |
| 4 | 224 (16.5 %) | 10 (8.7 %) | |
| 5 | 237 (17.4 %) | 16 (13.9 %) | |
| 6 | 74 (5.4 %) | 12 (10.4 %) | |
| 7 | 75 (5.5 %) | 5 (4.3 %) | |
| 8 or more | 51 (3.7 %) | 6 (5.2 %) | |
| Median BMI (IQR) | 26.5 (23, 31) | 25 (23, 27) | 0.0002 |
| Prior bowel resection | 18 (1.3 %) | 2 (1.8 %) | 0.71 |
| Neurogenic bladder | 2 (0.1 %) | 0 (0 %) | 0.68 |
| Diabetes mellitus | 56 (4.1 %) | 6 (5.2 %) | 0.58 |
| Family history of kidney stones | 172 (12.7 %) | 17 (14.8 %) | 0.52 |

## Discussion

Our study demonstrates that health care workers at our institution who work in an OR have a significantly higher prevalence of urolithiasis compared to those that do not. This finding remained significant after controlling for self reported employee-related variables (i.e. stress level, fluid intake, medical co-morbidities and family history) suggesting that working in an OR is independently associated with a risk of urolithiasis. A subgroup analysis showed that physicians who work in an OR are specifically at risk. While there are previous reports regarding the prevalence of urolithiasis in other professions [10–12], from our review of the literature this is the first study to report such a finding in healthcare professionals.

Previous reviews have shown a variety of occupations with an increased risk of urolithiasis from dehydration

**Table 3** Multivariate analysis of factors associated with urolithiasis

| Variable | Stone formation | | |
|---|---|---|---|
| | HR | 95 % CI | *p* value |
| Working in an OR | 1.43 | 1.01, 2.04 | 0.04 |
| Stress level | 1.07 | 0.99, 1.16 | 0.08 |
| <1.8 L of daily fluid intake | 1.15 | 0.83, 1.58 | 0.40 |
| Body mass index | 1.02 | 1.00, 1.05 | 0.05 |
| Prior bowel resection | 3.05 | 1.28, 7.30 | 0.01 |
| Diabetes mellitus | 2.08 | 1.09, 3.98 | 0.03 |
| Family history of urolithiasis | 2.59 | 1.79, 3.76 | <0.0001 |

secondary to chronic exposure to high temperatures and perspiration [10–12]. Similarly, dehydration may be present in the cohort of employees that work in an OR due to decreased fluid intake. We found that significantly more employees that work in the OR, including physicians, drink less fluid per day on average than those that do not work in an OR. This may be related to behavioral changes centered on the length of cases or a busy operative schedule.

Fluid intake is a well-established risk factor for stone formation. For instance, a prospective analysis of 45,619 men found an inverse association between fluid intake and the risk of stone formation after 4 and 14 years of follow-up [4, 14]. It has been hypothesized that this decreased rate of stone formation may be secondary to urinary dilution, or decreased intra-tubular transit time thus inhibiting the formation of Randall's plaques [15].

Another potential factor for stone formation that was evaluated was stress levels, which were significantly higher in OR workers in general and physicians in the OR in particular. Previous reports highlight multiple psychological job stressors that physicians experience including a high work load, surgical complications and long working hours [16]. Furthermore, Ruitenberg et al. [17] surveyed surgeons at an academic center and found that significantly many reported their work physically strenuous (41 versus 13 %, $p < 0.000$) compared to other hospital physicians. Stress levels have been linked to stone formation secondary to increased vasoactive intestinal peptide levels. Vasoactive intestinal peptide impacts the membrane of collecting tubules in the kidney by increasing permeability to water, which leads to hypertonic urine and the potential for stone formation [6, 7].

Our results from multivariate analysis demonstrate a significantly increased risk of urolithiasis among employees that work in an OR in general. While not independently associated with urolithiasis in our study, a lower level of fluid consumption and higher stress levels were more common among OR workers and may work in combination to increase the risk of stone formation. Additionally, it should be noted that the magnitude of these risk factors in this population may be underestimated given the significantly lower calculated BMI that was found in both OR workers in general and physicians that work in an OR. A lower BMI has previously been demonstrated to be a protective factor for the formation of kidney stones [5]. Likewise, in our multivariate analysis an increased BMI was associated with an increased risk of urolithiasis.

While this study evaluates potential risk factors for urolithiasis found in employees that work in an OR, it is important to recognize that fluid intake and stress levels are potentially modifiable behaviors. For instance, focusing on increased hydration, both while at work and on personal time, is a possible solution, as increasing hydration has been shown in one prospective randomized trial to decrease the risk of stone recurrences [18]. However, no other prospective randomized trials are available in the urolithiasis literature on this management strategy. Similarly, physicians should be cognizant of their stress burden. Utilizing strategies such as support of family/friends, hobbies, support groups and recreational activities it may be possible to diminish the stress burden faced by those working in an OR [19, 20]. In terms of the physical burden of operating, Dorion and Darveau [21] suggested that micro-pauses for posture changes, for instance, 20 s for every 20 min, may decrease the muscular strain of operating in long cases. The impact of behavioral modification decreasing stress levels on stone formation has not previously been evaluated, but may be an area for further study.

We acknowledge that our study is limited by its survey-based design. As a survey-based study, it is inherently limited by participation, potential for response and recall bias given that participation can be influenced both by employee job type and interest in the study subject. For instance, employees that have a history of urolithiasis may have greater interest in the subject and willingness to participate in the survey. However, after generating a list of employees that work in an OR and those that do not, potential responders were selected randomly by a third party. Thus, while stone-formers may have been more likely to respond, this would be true of both cohorts. Similarly, the overall prevalence of urolithiasis in our cohort (10.9 %) is comparable to those reported for the population of the United States [1–3]. Additionally, survey questions regarding fluid intake and stress levels are not adapted from a validated questionnaire. Furthermore, we recognize that not all known risk factors for stone formation can be evaluated in a brief survey such as ours. For instance, our analysis does not include the role of age, gender, diet, among other risk factors for stone formation. Additionally, a comparison of employees with similar occupations (i.e. physicians that work in an OR compared to physicians that work elsewhere) would be interesting, however, we are limited by the study design and such

information is not available for non-OR workers. Despite these limitations, the risks factors noted in this study can likely be extrapolated to a similar population at other institutions, given the similar occupational demands.

## Conclusion

Healthcare professionals that work in an OR and physicians in particular, are at an increased risk of urolithiasis. The recognition of possible modifiable risk factors for urolithiasis in these populations, including levels of fluid intake and stress, may help to increase awareness and incite future studies.

**Conflict of interest** The authors have no conflicts of interest or disclosures.

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