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Original Article

Aging Does Not Affect the Outcome of Percutaneous Nephrolithotomy

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SUMMARY

Backround: To assess the safety and effectiveness of percutaneous nephrolithotomy (PCNL) in aging patients.
Methods: The records of patients who underwent PCNL were retrospectively evaluated from our database. The patients were divided into three age groups, ≤ 49 years (Group 1), 50–69 years (Group 2), and ≥ 70 years (Group 3). Baseline characteristics, outcomes, and complications were then compared between the groups. The modified Clavien classification was used for reporting complications. Achieving stone-free status or a residual stone size ≤ 4 mm were regarded as representing surgical success.
Results: Four hundred forty-three PCNL operations were performed between January 2015 and January 2020. Mean stone sizes were similar in the three groups, 508.7 ± 320.7 mm^2 in Group 1, 494.7 ± 314.1 mm^2 in Group 2, and 526.9 ± 328.4 mm^2 in Group 3 ($p = 0.61$). Comorbidities were observed in 6.1% of the patients in Group 1, 39.2% of those in Group 2, and 87.2% of those in Group 3. The level of accompanying comorbidities in Group 1 was significantly lower than in the other two groups ($p < 0.001$). The overall stone clearance rate was 81.5%, and the complication rate requiring invasive procedures was 16.5%. Mean operative time, access number, postoperative hemoglobin drop, nephrostomy removal time, length of hospital stay, and complication and success rates were similar between all three groups ($p > 0.05$).
Conclusion: These results indicate that PCNL is a safe and effective method in aging patients.

1. Introduction

The incidence of nephrolithiasis in countries with high living standards exceeds 10%, and the lifetime prevalence of a history of kidney stones among adults has been reported to have increased significantly, by 37%, in some regions as life expectancy has risen over the last 20 years.[1,2] Nephrolithiasis is associated with risk of chronic kidney disease and a high risk of urinary tract infection. The condition must therefore be treated.[3] Available therapeutic options for nephrolithiasis include shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), and retrograde intrarenal surgery (RIRS). PCNL should primarily be employed in the treatment of stones larger than 20 mm because SWL frequently requires multiple treatments, and is also linked to an increased risk of ureteral obstruction (colic or 'steinstrasse') and a consequent need for adjunctive procedures. RIRS is not recommended as a first-line option for calculi larger than 20 mm in uncomplicated cases, due to decreased stone-free rates and a need for staged procedures.[4]

Successful PCNL procedures depend on factors specific to the patient, the surgeon, and the stone itself.[5] Aging may also be regarded as an additional challenging factor for PCNL, due to the possibility of comorbid chronic diseases in elderly patients, resulting in marked changes in body physiology and cardiorespiratory reserve, and compromised immune system efficiency.[6–8] In addition, total lung capacity diminishes due to abdominal pressure associated with muscle relaxation resulting from the prone position, and the functional residual capacity of the lung decreases. At the same time, pressure on the vena cava inferior reduces blood oxygenation by potentially lowering venous circulation, thus preparing the ground for thromboembolic events.[9] In addition, there is an increased risk of thromboembolic events in patients aged 75 or over.[10] For all these reasons, elderly patients are less tolerant of factors such as postoperative bleeding, pain, septicemia, and other complications. Lowered body reserves and comorbidities are inevitably causes for concern when applying invasive therapeutic modalities, such as PCNL, in elderly patients.[11] This therefore impacts the surgeon's decision concerning PCNL.

Few studies have investigated the efficacy and safety of PCNL in aging patients. Results of PCNL in the elderly may differ from those in middle-aged patients because of an involuntary desire on the part of the surgeon to keep the operative time short due to concerns over anesthetic and surgical complications. PCNL complications may also increase due to aging-related autonomous and physiological changes. The purpose of this retrospective, single-center study was to investigate the effects of aging on PCNL outcomes and complications.

2. Patients and methods

2.1. Study design

Following receipt of approval from the Health Sciences Univer-

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sity, Samsun Training and Research Hospital ethical committee (No. GOKA/2020/4/19), data for patients undergoing PCNL between January 2015 and January 2020 were subjected to retrospective analysis. The clinical findings of patients who had given preoperative informed consent to surgery were recorded. Non-contrast computed tomography (CT) was routinely performed on all patients to assess stone location and size. Stone size was determined by multiplying the maximum length by the maximum width, the result being expressed in mm^2. The modified Clavien classification was employed to assess complications.

The patients were divided into three age groups, ≤ 49 (Group 1), 50–69 (Group 2), and ≥ 70 years (Group 3). Patients aged under 18 or undergoing bilateral PCNL in the same session or tubeless PCNL were excluded.

2.2. Data collection

Demographic and clinical data, including age, sex, body mass index (BMI), hypertension, diabetes mellitus (DM), coronary artery disease, respiratory disorders, and cerebrovascular disease, American Society of Anesthesia (ASA) score, stone size and location, preoperative blood count parameters, serum creatinine values, hemoglobin drop, operative time, stone-free status, complication rates, and length of hospital stay were analyzed among the study groups.

2.3. Surgical methods

PCNL was performed under general anesthesia by experienced surgeons. An open-ended 6-Fr ureteric catheter was installed transurethrally in the lithotomy position, after which the patients were placed in the prone position (Figure 1). The collecting system was identified by means of a contrast agent. Percutaneous access into the selected calyx was established with an 18-gauge access needle (Cook Inc., Bloomington, IN, USA) under C-arm fluoroscopic guidance using the "eye of the needle" technique. Once a guidewire had been inserted, the tract was dilated for placement of the access sheath using serial fascial dilators between 26 and 30 Fr with amplatz (Boston Scientific Corporation, Miami, FL, USA) dilators. Stones were fragmented with a 24 or 26 Fr nephroscope (Karl Storz, Tuttlington, Germany) and a pneumatic lithotriptor (Karl Storz), and were extracted using stone forceps (Figure 2). Nephrostomy catheter was placed routinely at the end of the procedure. Operative time was defined as the time elapsing between the insertion of the open-ended ureteral catheter and the insertion of nephrostomy tube. The final stone-free rate was evaluated using CT on postoperative day 15.

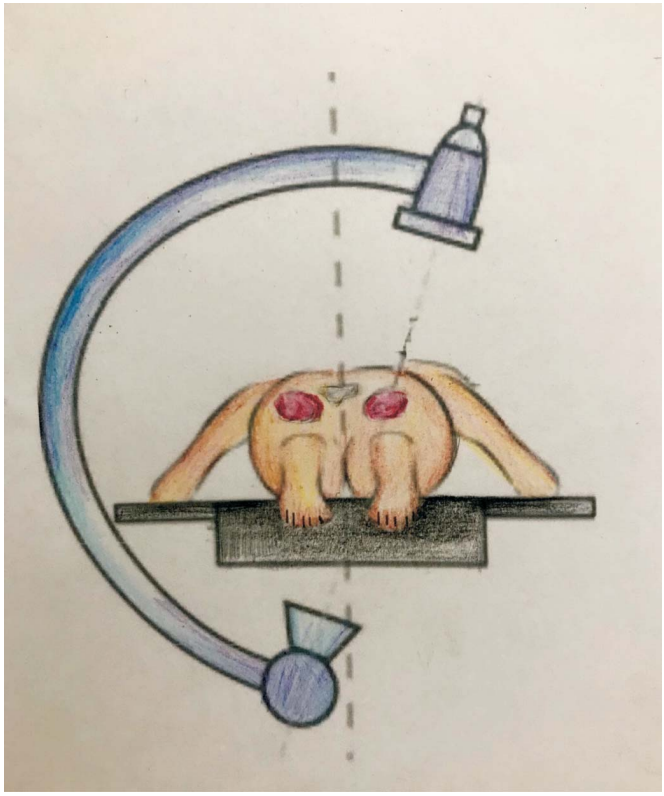

Figure 1. Position employed in percutaneous nephrolithotomy.

2.4. Data analysis and statistics

Data analysis was performed on SPSS 25 (Statistical Package for Social Sciences – IBM Corp., Armonk, NY, USA) software. A p values < 0.05 were regarded as statistically significant. The chi-square test was applied to evaluate differences in categorical variables. ANOVA and the Kruskal-Wallis test were used to assess statistically significant intergroup differences with Bonferroni correction ($\alpha = 0.05/3 = 0.017$).

3. Results

3.1. Demographic features and stone characterization

Four hundred forty-three patients (173 female, 270 male) with a

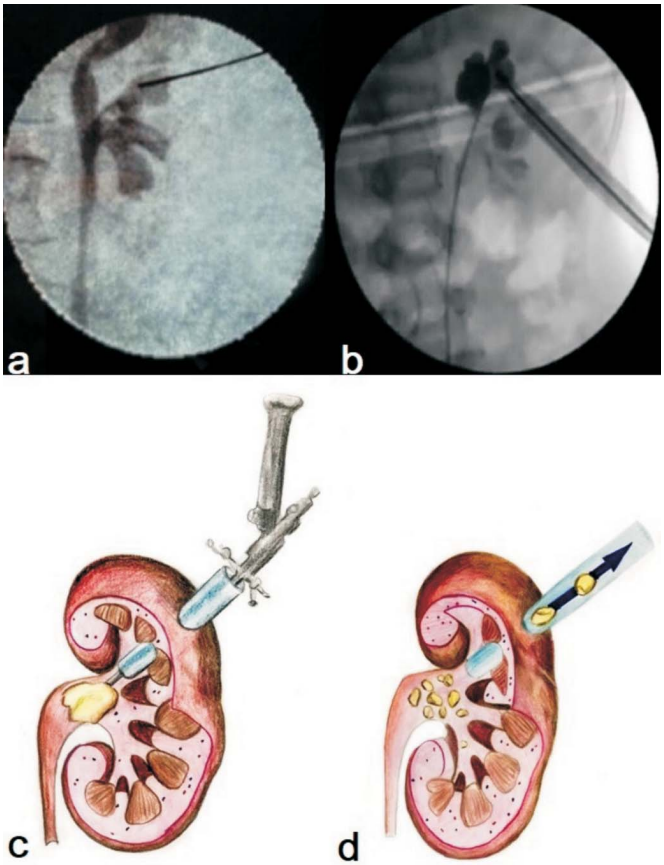

Figure 2. Technique employed in percutaneous nephrolithotomy (a: The kidney collecting system is accessed using a needle via a contrast agent; b: Dilatation of tract and placement of the access sheath; c: The stone is located using a nephroscope and is fragmented with a lithotriptor; d: Stone fragments are removed using a grasper and a nephroscope).

mean age of 47.7 ± 14.3 years were included in the study. Mean ages were 36.1 ± 7.9 in Group 1, 57 ± 5.1 in Group 2, and 73.4 ± 3.6 in Group 3. Mean ASA values were 1.21 ± 0.46 in Group 1, 1.93 ± 0.49 in Group 2, and 2.74 ± 0.49 in Group 3 (p < 0.001). Comorbidities were observed in 6.1% of Group 1, 39.2% of Group 2, and 87.2% of Group 3. The level of accompanying comorbidities was significantly lower in Group 1 than in the other two groups (p < 0.001).

Stones were on the right side in 226 (51%) patients, the most common location being the pelvic region, in 124 (28%) cases. Mean stone size was 508.7 ± 320.7 mm^2 in Group 1, 494.7 ± 314.1 mm^2 in Group 2, and 526.9 ± 328.4 mm^2 in Group 3 (p = 0.06). Demographic features, stone characteristics, and preoperative laboratory data in each group are listed in Table 1.

3.2. Intraoperative and postoperative outcomes

The mean duration of surgery was 73.2 ± 26.6 min in Group 1, 75.9 ± 28.3 min in Group 2, and 79.7 ± 32 min in Group 3 (p = 0.42). No significant difference was observed in terms mean numbers of percutaneous access among the three groups (p = 0.47). The mean hemoglobin drop was 1.92 ± 1.1 g/dL in Group 1, 1.82 ± 0.95 g/dL in Group 2, and 1.98 ± 0.99 g/dL in Group 3, and the differences between the groups were not significant (p = 0.49). Mean hospital stay was longer in Group 3, although the difference was insignificant (p = 0.052). The duration of nephrostomy was also comparable among the three groups (p = 0.27). Stone-free rates were 82.8% in Group 1, 80.1% in Group 2, and 79.5% in group 3, and no significant difference was detected among the groups (p = 0.73). Patients' operative data and outcomes are shown in Table 1.

Complications requiring Grade 2 or higher invasive procedures according to the modified Clavien classification system developed in 73 (16.5%) patients. Complication rates were 14.1% in Group 1, 19.3% in Group 2, and 17.9% in Group 3 (p = 0.36). JJ stents were installed in 11 (2.5%) patients in the postoperative period due to persistent urinary leakage resulting from clotting following withdrawal of the nephrostomy tube. Ureterorenoscopy was performed on 10 (2.3%) patients developing ureteral stone-related colic pain or persistent urinary leakage. The most severe complication was sepsis in three patients. No patients developed nephrectomy or died from any complications. Detailed complication data are provided in Table 2.

4. Discussion

Autonomous and physiological changes that occur with aging also result in various differences and difficulties during and after surgery in the elderly compared to the middle-aged.[7,12] Thus, the ma-

Table 1
Demographic features, stone characterization, and clinic outcomes in the study groups.

Variables	Overall	Group 1	Group 2	Group 3	p
N, %	443 (100%)	228 (51.5%)	176 (39.7%)	39 (8.8%)	
Age (years), mean ± SD (min–max)	47.76 ± 14.3 (18–82)	36.18 ± 7.9 (18–49)	57.06 ± 5.1 (50–69)	73.41 ± 3.6 (70–82)	< .001
Body mass index (kg/m²), mean ± SD	28.85 ± 4.5	27.9 ± 4.6	29.9 ± 4.2	29.6 ± 3.5	< .001
Sex, N (%)					.005
Female	173 (39.1%)	78 (34.2%)	71 (40.3%)	24 (61.5%)	
Male	270 (60.9%)	150 (65.8%)	105 (59.7%)	15 (38.5%)	
Comorbidities, N (%)	117 (26.4%)	14 (6.1%)	69 (39.2%)	34 (87.2%)	< .001
Diabetes mellitus	62 (14%)	7 (3.1%)	37 (21%)	18 (46.1%)	< .001
Hypertension	26 (5.8%)	4 (1.7%)	15 (8.5%)	7 (17.9%)	< .001
Coronary artery disease	19 (4.3%)	2 (0.9%)	11 (6.1%)	6 (15.4%)	< .001
Respiratory disorders	7 (1.6%)	1 (0.4%)	4 (2.3%)	2 (5.2%)	.06
Cerebrovascular disease	3 (0.7%)	0	2 (1.1%)	1 (2.6%)	
Preoperative laboratories, mean ± SD					
Blood white blood cell, (K/uL)	7.23 ± 1.28	7.26 ± 1.29	7.22 ± 1.26	7.13 ± 1.29	.77
Blood platelet, (K/uL)	250.3 ± 63.2	251.7 ± 63.9	247.6 ± 64.7	254.6 ± 52.1	.48
Blood hemoglobin, (g/dL)	13.7 ± 1.36	13.9 ± 1.4	13.6 ± 1.3	13.3 ± 1.27	.01
Serum Creatinine, (mg/dL)	0.87 ± 0.34	0.81 ± 0.2	0.87 ± 0.39	1.23 ± 0.5	< .001
Positive urine culture	73 (16.5%)	39 (17.1%)	23 (13%)	11 (28.2%)	.06
Side, N (%)					.59
Right	226 (51%)	111 (48.7%)	94 (53.4%)	21 (53.9%)	
Left	217 (49%)	117 (51.3%)	82 (46.6%)	18 (46.1%)	
Stone Location, N (%)					.57
Pelvis	124 (28%)	63 (27.6%)	51 (28.9%)	10 (25.6%)	
Isolated calyx	113 (25.5%)	61 (26.8%)	44 (25%)	8 (20.5%)	
Pelvis + calyx	106 (23.9%)	50 (21.9%)	44 (25%)	12 (30.8%)	
Staghorn	100 (22.6%)	54 (23.7%)	37 (21.1%)	9 (23.1%)	
Stone size (mm^2), mean ± SD	504.8 ± 318.2	508.7 ± 320.7	494.7 ± 314.1	526.9 ± 328.4	.61
ASA score					
Mean	1.63 ± 0.68	1.21 ± 0.46	1.93 ± 0.49	2.74 ± 0.49	< .001
ASA I	213 (48.1%)	184 (80.7%)	28 (15.9%)	1 (2.5%)	
ASA II	179 (40.4%)	39 (17.1%)	132 (75%)	8 (20.5%)	
ASA III	51 (11.5%)	5 (2.2%)	16 (9.1%)	30 (77%)	
Access number, N (%)	1.27 ± 0.51	1.29 ± 0.51	1.26 ± 0.52	1.23 ± 0.48	.47
Hemoglobin drop (g/dL), mean ± SD	1.89 ± 1.01	1.92 ± 1.1	1.82 ± 0.95	1.98 ± 0.99	.49
Operative time (minutes), mean ± SD	74.8 ± 27.8	73.2 ± 26.6	75.9 ± 28.3	79.7 ± 32	.42
Hospital stay (days), mean ± SD	3.32 ± 1.25	3.18 ± 1.12	3.39 ± 1.21	3.76 ± 1.85	.052
Nephrostomy duration (days), mean ± SD	2.49 ± 1.54	2.49 ± 1	2.46 ± 1.16	2.64 ± 1.59	.27
Stone-free status, N (%)	361 (81.5%)	189 (82.8%)	141 (80.1%)	31 (79.5%)	.73

Abbreviation: ASA, American Society of Anesthesia.

Table 2
Complication rates in the study groups by Clavien complication category.

Complication, N (%) (within 30 days)		Overall (N = 443)	Group 1 (N = 228)	Group 2 (N = 176)	Group 3 (N = 39)	p
	Total	73 (16.5%)	32 (14.1%)	34 (19.3%)	7 (17.9%)	.36
Grade	Complication					
2	Blood transfusion	40 (9%)	19 (8.3%)	18 (10.2%)	3 (7.7%)	.89
3a	JJ stent insertion	11 (2.5%)	5 (2.2%)	5 (2.8%)	1 (2.6%)	.12
3a	Hydrotorax	3 (0.7%)	2 (0.9%)	1 (0.6%)	-	
3a	Urinoma	2 (0.4%)	1 (0.4%)	1 (0.6%)	-	
3b	Ureterorenoscopy	10 (2.3%)	4 (1.7%)	5 (2.8%)	1 (2.6%)	.24
3b	Primer repair	2 (0.4%)	-	2 (1.2%)	-	
3b	Embolization	1 (0.2%)	-	1 (0.6%)	-	
4a	Myocardial infarction	1 (0.2%)	-	-	1 (2.6%)	
4b	Sepsis	3 (0.7%)	1 (0.4%)	1 (0.6%)	1 (2.6%)	

jority of surgeons today agree that that the risks, complications and outcomes of surgery in the elderly also differ from those in middle-aged and young patients.[13] On the basis of that hypothesis, the present study investigated the effects of aging on the safety, efficacy, and complication rates of PCNL. No difference was observed between the study groups in terms of stone size, stone location, access numbers, operative time, hemoglobin drop, hospital stay, stone-free rates, nephrostomy duration or complication rates. At the same time, although no age-related differences were found in terms of blood WBC, platelet, or hemoglobin values, serum creatinine values increased with age, this elevation becoming statistically significant after the age of 70 ($p < 0.001$).

Although the World Health Organization's latest classification describes the 66–79 range as middle-aged, several studies investigating the relationship between PCNL and age have considered patients aged 70 or over as elderly.[14–17] This is because reaching the age of 70 is recognized as an independent predictor of cardiac risk; a widely employed perioperative risk assessment focused on cardiac complications employs a cut-off age of 70.[17] Based on that research, patients over 70 were included in the elderly group in the present study. Male patients predominate in previous international geriatric PCNL studies.[14,16,18] However, women predominate in the elderly patient group in studies from Turkey.[19,20] Women also predominated in the elderly patient group in the present study, which from that perspective is consistent with previous research from Turkey.

Several studies have been published investigating the relationship between age and PCNL. Stoller et al. first compared PCNL results in terms of age groups in 1994 (> 65 years and < 65 years).[21] Those authors described PCNL as a safe, and effective method in the elderly patient group. However, blood transfusion requirements were higher among the elderly patients. In a study from 2001, Sahin et al. reported similar PCNL results in young and elderly patients. However, the rate of fever without bacteremia was higher among elderly patients (14% vs. 10%).[19] Anagnostou et al. divided their patients into two age groups, < 70 and ≥ 70, in a study from 2008. Those authors observed no statistically significant differences between the two groups in terms of stone burden, complications, complete stone-free rates, or clinical success rates.[16] Nakamon et al. compared patients aged under 65 and 65 or older and reported no significant differences in terms of operative time, success rates, length of hospital stay, or complications. However, sepsis rates were higher in the elderly patient group.[22] Buldu et al. reported statistically similar mean operative times, postoperative hematocrit drops, and complication and success rates, although length of hospital stay was significantly shorter in younger patients.[20] In a study involving men only, Besiroglu et al. compared patients aged 70 or over with younger individuals and found no differences between the two groups in terms of mean operative time, access number, hemorrhage, nephrostomy removal time, length of hospital stay, stone-free rates, or complications.[17] In the present study, PCNL success and complication rates were similar between patients aged 70 or over and the younger patient group, and our results were compatible with those previous reports.

Chronological analysis of studies investigating the relationship between age and PCNL shows that while stone-free rates were similar between elderly and young-middle aged patients in the earliest publications, complication rates were higher among elderly patients.[19,21] However, while no change occurred in stone-free rates in subsequent years, complication rates decreased progressively, eventually approaching those of young patients.[16–18,20,22] We attribute the decrease in PCNL complication rates in the elderly eventually approaching those in young patients to technological improvements over the years, and to PCNL surgery being better mastered and performed by surgeons.

Single-center studies of geriatric PCNL show similar stone-free and complication rates between elderly and young/middle aged patients.[16–20] However, in contrast to single-center studies, the multicenter Clinical Research Office of the Endourological Society (CROES) study reported significantly higher complication rates in patients over 70.[14] In a multicenter, prospective, observational study, Okeke et al. divided 5803 patients into two groups, aged < 70 and ≥ 70, and compared the two groups' preoperative and postoperative data. While no difference was determined between the groups in terms of success rates, total complication levels were higher in the elderly patient group ($p < 0.001$). However, in the CROES study, blood transfusion levels in the elderly group were similar to those in the younger patient group ($p = 0.09$).[14] The present study is compatible with the CROES study in terms of duration of surgery, stone size, and stone-free and complication rates.

Patients over 70 in this study had higher comorbidity levels ($p < 0.001$), particularly DM and cardiovascular diseases, and a higher ASA classification ($p < 0.001$). This is unremarkable since chronic disease rates increase with age. Similarly to the present research, other studies have also reported higher comorbidity rates and ASA levels in elderly patients.[14,17,18,20,22]

No significant different difference was observed between the study groups when complications were grouped according to Clavien classification system ($p = 0.36$). The blood transfusion rate in the entire patient group in this study was 9%, and the rate of complications requiring major and surgical intervention was 7.5%. However, the blood transfusion rate among patients aged over 70 was 7.7%. Okeke et al. reported a figure of 6%, Besiroglu et al. 13.3%, Sahin et al. 21.4%, and Nakamon a figure of 6.5%.[14,17,19,22] Our blood transfusion rate in the elderly patient group is compatible with the previous literature. The level of major complications requiring surgical treatment in the present study was 7.5%. Besorlu et al. reported a rate of serious complications requiring surgery of 13.4%, Okeke et al. a fig-

ure of 5.1%, and Buldu et al. a figure of 4%.[14,20,23] Our study is again compatible with the literature from that perspective. Major complications requiring medical treatment occurred in four patients in this study. These consisted of sepsis in one patient from each three groups and MI in one patient in Group 3. All patients were discharged following medical treatment.

There are several limitations to the present study. One involves the retrospective and single-center nature of the research. The number of patients in Group 3 was also low. The duration of fluoroscopy and recovery room discharge score were not included in the study due to missing data. In addition, stones were not subjected to biochemical analyses. Further multicenter prospective studies are therefore needed to better understand our findings and identify new risk factors.

5. Conclusion

The results of this study suggest that PCNL is an effective method with high success and low complication rates that can be applied in both young and elderly patients.

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Declaration of any potential financial and non-financial conflicts of interest

None.

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