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Urological Complications in Patients Undergoing Hemodialysis and Peritoneal Dialysis

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ABSTRACT

Urological complications (UCs) remain a significant concern following kidney transplantation (KT), contributing to both morbidity and mortality. **Objectives:** To determine the prevalence of urological complications and associated factors in patients receiving hemodialysis (HD) and peritoneal dialysis (PD). **Methods:** A comparative cross-sectional study was conducted in the Department of Urology at Bacha Khan Medical College and Mardan Medical Complex, Mardan. A tertiary hospital, involving 310 dialysis patients. Data on demographics, comorbidities, and urological complications were collected. Urological complications assessed included urinary tract infections (UTI), bladder dysfunction, nephrolithiasis, hematuria, and urethral stricture. Laboratory tests were used to evaluate renal function parameters. T-tests discover differences between groups, and chi-squares are used for identifying differences in categorical data. If the p-value was less than 0.050, the result regarded as statistically significant. **Results:** The mean age of participants was 58.7 ± 12.3 years, and the majority were male (58.1%). Diabetes and hypertension were prevalent in 45.8% and 71.0% of patients, respectively. The prevalence of urological complications included UTIs (27.4%), bladder dysfunction (19.4%), LUTS (29.7%), hematuria (15.5%), and nephrolithiasis (11.3%). HD patients had a significantly lower residual urine output compared to PD patients (80 mL/day vs. 200 mL/day, $p<0.001$). UTI and bladder dysfunction were significantly more common in diabetic patients ($p=0.030$ and $p=0.020$, respectively). Patients who received dialysis for longer duration had more LUTS ($p=0.030$). There was a significant difference in albumin levels between HD patients and PD patients ($p=0.040$). **Conclusions:** Urological complications are common in dialysis patients, with significant associations observed with dialysis modality, diabetes, and residual urine output.

INTRODUCTION

Urological complications (UCs) remain a significant concern following kidney transplantation (KT), contributing to both morbidity and mortality [1, 2]. Among the most common UCs observed in KT recipients are urine leakage, ureteral stricture, and vesicoureteral reflux (VUR) [3]. Fortunately, the overall incidence of UCs has recently decreased to less than 10%, mainly due to advancements in surgical techniques and perioperative care [4]. Routine prophylactic ureteral stenting during ureteroneocystostomy has reduced the incidence of major urological complications to nearly 2%-5% [5]. There has also been substantial advancement from the standard Lead better-Politano techniques to the extra-vesical Lich-Gregoir technique regarding surgical trauma and anastomotic success rates [6]. Improvements in microsurgical instruments, hemostasis, and overall intraoperative visualization have also helped contribute to their gradual decrease. Using better surgical techniques with subsequent improvements in immunosuppressive strategies and infection control are collectively responsible for the decreasing incidence of UCs reported by transplant centers worldwide [7]. In Japan, people with advanced kidney disease remain on dialysis treatment (DT) for a long time due to the critical shortage of available organ donors. In this context, hemodialysis (HD) is the dominant form of therapy over peritoneal dialysis (PD) [8]. In long-term HD patients, who are typically anuric or oliguric, it is common for the bladder to be used

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infrequently. Bladder atrophy leads to loss of bladder capacity, loss of bladder compliance, and loss of detrusor activity [9]. The structural changes associated with bladder atrophy include the development of fibrosis, loss of urothelial thickness, and increased collagen deposition that results in stiffening and, ultimately, loss of bladder function [10]. These changes pose significant surgical challenges during ureteral reimplants for KT, particularly for patients with a severely atrophic bladder. Treatment and rehabilitation of bladder atrophy in long-term dialysis patients entails a complex approach including both pre- and post-operative focus [9]. Patients with bladder atrophy can use bladder cycling, or coaxing the bladder to function with sterile saline instillations before transplant, as a way to help improve bladder function and capacity [11]. Urodynamic studies are useful to determine the degree of bladder dysfunction and guide future surgical procedures [12]. Intra-operatively, surgeons can employ alternative surgical strategies such as ureteroureterostomy, the use of ureteral stents, or augmentation cystoplasty (using bowel segments) where the bladder has significant fibrosis or is contracted [12]. There are over 2 million people globally on dialysis therapies, and this is a small fraction of those who could potentially benefit from renal replacement therapy [13]. In America, at least 7 million people have chronic kidney disease (CKD), and most of those people will ultimately progress to end-stage renal disease (ESRD) [14]. At this point, a renal transplant or dialysis is required to live. HD is still the most common type of dialysis. The long-term effects of HD can lead to physical complications that impact individuals, impact physical activity, and lead to restrictions on diet and medications [15]. Continuous ambulatory peritoneal dialysis (CAPD) provides a better home option with flexibility and is the preferred form of dialysis in many countries (Mexico, Canada, the United Kingdom, and Hong Kong, to name a few)[16]. CAPD conserves vascular access and allows more independence [17]. CAPD is still heavy with potential pitfalls, including infections from the insertion of the catheter and infections from contamination [18]. The overall mortality rate with CAPD may be lower, and the ease of usage and being at home for patients is invaluable. Significant improvements to PD in the last 25 years have resulted in improved outcomes, including enhanced catheter design, improved connector systems, and perhaps more biocompatible dialysis solutions [16]. While major advancements have been made in dialysis and transplantation management, there are several risk factors, such as bladder atrophy as a result of prolonged DT, which continue to increase the risk of post-KT UCs. That said, there is limited literature that examines bladder capacity specifically about Ucs.

The existing literature often involves small sample sizes and varying and unidentified methods, making it difficult to make solid clinical recommendations. Further research is also warranted to better understand this relationship and establish evidence-based management for at-risk patients. This study aims to determine the prevalence of urological complications and associated factors in patients receiving hemodialysis HD and PD.

METHODS

The comparative cross-sectional study was conducted in the Urology Department of Bacha Khan Medical College (Mardan) from March to September 2023. The analysis sought to discover differences in urological complications (UCs) between patients receiving HD and patients receiving PD. The study was allowed to proceed after it received ethical clearance from the Institutional Review Board of Bacha Khan Medical College (Ethical Approval No. 298/BKMC). The participants were given pertinent information and assured that their data would be kept private (confidential) and that they could decide not to take part in the study. It was carried out while respecting rules about patient rights and the privacy of participants. Only adult patients with ESRD undergoing dialysis for at least a month were considered for this research. There were 186 patients in the HD group and 124 in the PD group for the study. Further division of patients was made based on whether they had diabetes (Diabetes: 142, No Diabetes: 168) and the length of dialysis (≤2 years: 102, 2-5 years: 109, >5 years: 99). The study didn't include people who were set to have urological surgery or had problems with their mental state. Open Epi software (Version 3.01) was used to set the sample size according to the main outcome of interest, which was urological complications in dialysis patients. A previous study by Abushamma et al., reported that 20% of HD patients and 10% of PD patients experienced lower urinary tract symptoms (LUTS) [19]. The proportions were taken into account when the answer was found. Setting the significance level (α) as 0.050 and the power (1-β) to 80%, we determined that 310 patients had to be included in the study: 186 went on HD and 124 went on PD; n= [(Zα/2 +Zβ)2 x (P1 (1-P1) + p2 (1-p2))] / (p1-p2)2. P_1 stands for the proportion seen in the HD group and p_2 is for the PD group. The study included adults (aged 18 or older) who had been living with HD or PD for a month and had given their informed consent to take part. Those excluded were people who had had previous urological surgery or showed cognitive impairments. A structured questionnaire was utilized to gather demographic information, which included: age, gender, duration of dialysis, and co-morbidities. Urological complications such as lower urinary tract symptoms (LUTS), hematuria, and prostatomegaly were noted within the structured questionnaire, and other clinical and laboratory investigations were performed if needed. Urological

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complications were categorized based on patient-reported symptoms. Data collection was accomplished through clinical and laboratory assessment. Every patient had a comprehensive urological assessment, including assessment of urological symptoms: urgency, frequency, dysuria, nocturia, and retention. Patient-reported symptoms were categorized as mild, moderate, and severe. Clinically relevant blood and urine samples were analyzed to assess renal function and verify any hematuria. Urine cultures were performed when UTIs were suspected. Imaging studies, including ultrasound and CT with contrast as needed, were performed to detect nephrolithiasis. Digital rectal examination was performed to assess for prostatomegaly in male patients, which was also viewed with imaging and/or transrectal ultrasound, if required. The primary outcome variable was the presence of urological complications; specifically, LUTS, hematuria, and prostatomegaly. The secondary outcome variables also included nephrolithiasis, bladder dysfunction, and UTIs. Urological complications were classified based on symptoms. Hematuria was defined as the presence of blood in urine, while prostatomegaly was assessed through physical examination and imaging in male patients. Qualitative variables included dialysis type (HD or PD), urological complication (presence/absence), type of urological complication (urinary tract infection, bladder dysfunction, hematuria, or obstructive uropathy), sex of patient, diabetes status, and hypertension status. Quantitative variables included patient age, months in dialysis, residual urine output (in mL/day), serum creatinine, serum albumin, and hemoglobin. SPSS version 26 was used for the entry and analysis of all data. The data were stratified according to important results such as the presence of diabetes, duration of dialysis, and residual urine for comparison of subgroups. The statistical analysis performed consisted of descriptive and inferential statistics to evaluate both the prevalence of urological complications among individuals receiving HD and PD, and the associated factors. For categorical variables, the data was shown as the number of cases and as percentages, while the data for continuous variables was presented as the mean ± SD. HD patients were compared to PD patients, patients with and without urological problems and to those with and without diabetes. The Chi-square test (or, if possible, Fisher's exact test) was applied to compare the frequencies of different categories. The independent samples t-test analysis method was applied to see if there were differences in continuous variables. All the statistical tests were considered statistically significant when the p-value was below 0.050.

RESULTS

The demographic and clinical attributes of the study cohort (n=310) were predominantly similar between HD and PD patients. The average age of the entire population was 58.7 ± 12.3 years, with no significant difference between the HD (59.2 ± 12.5 years) and PD (57.9 ± 12.0 years) groups (p=0.420). The PD group comprised a greater percentage of male (60.5%) than the HD group (56.5%); however, this discrepancy was not statistically significant (p=0.480). The incidence of diabetes mellitus (45.8%) and hypertension (71.0%) was comparable between the groups, with p-values of 0.520 and 0.430, respectively. The average duration of dialysis was 4.8 ± 3.2 years, with no significant difference observed between the groups (p=0.210). A notable disparity was noted in residual urine production, with PD patients exhibiting a much greater median output (200 (100–500) mL/day) in contrast to HD patients (80 (30–300) mL/day, p<0.001). The Body Mass Index (BMI) was comparable among groups (27.5 ± 4.6 kg/m^2 in the whole population, 27.8 ± 4.7 in HD, and 27.1 ± 4.5 in PD, p=0.35), and a minor percentage of patients (11.3%) had a history of urological surgery, with no significant disparity between the dialysis modalities (p=0.720) (Table 1).

Table 1: Demographic Characteristics among Respondents

Characteristics	Total (310)	HD (186, 60%)	PD (124, 40%)	p-Value
Age (Years, mean ± SD)	58.7 ± 12.3	59.2 ± 12.5	57.9 ± 12.0	0.420
Sex (Male)	180 (58.1%)	105 (56.5%)	75 (60.5%)	0.480
Diabetes Mellitus	142 (45.8%)	88 (47.3%)	54 (43.5%)	0.520
Hypertension	220 (71.0%)	135 (72.6%)	85 (68.5%)	0.430
Dialysis Duration (Years, mean ± SD)	4.8 ± 3.2	5.1 ± 3.4	4.5 ± 3.0	0.210
Residual Urine Output (mL/day, median [IQR])	120 (50–400)	80 (30–300)	200 (100–500)	<0.001*
BMI (kg/m^2, mean ± SD)	27.5 ± 4.6	27.8 ± 4.7	27.1 ± 4.5	0.350
History of Urological Surgery	35 (11.3%)	22 (11.8%)	13 (10.5%)	0.720

Statistical Test Used: Independent t-test for continuous variables and chi-square test for categorical variables. Asterisk (*) indicates a statistically significant difference (p-value<0.050)

The incidence of urological problems was greater in diabetic patients than in non-diabetic individuals, with notable disparities noted for urinary tract infections (UTIs) and bladder dysfunction. Specifically, 31.7% of diabetic patients reported UTIs, in contrast to 23.8% of non-diabetic patients (p=0.030), while 25.4% of diabetic patients exhibited bladder dysfunction, compared to 14.3% of non-diabetic patients (p=0.020). More diabetes patients had nephrolithiasis, with a rate of 14.8%, compared to 8.3% in non-diabetic patients, but it was not considered significant by statistical analysis (p=0.120). Diabetics were more likely to present with lower urinary tract symptoms (LUTS) and hematuria, but these increased risks were not proven through statistics (p=0.070 and p=0.060,

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respectively). The study found that 21.1% of diabetic men were more likely to have increased prostate size (prostatomegaly), though this difference did not achieve statistical significance (p=0.080). There was not much difference in urethral stricture between the two groups (p=0.380). Serum creatinine, levels of blood urea nitrogen (BUN) and glomerular filtration rate (GFR) were mostly equal between HD and PD patients. Unlike in HD patients, whose albumin levels were usually low, PD patients generally showed higher albumin levels (3.8 ± 0.6 g/dL) (p=0.040). No significant difference was found in haemoglobin between the HD and PD groups (10.2 ± 1.3 g/dL versus 10.6 ± 1.4 g/dL, respectively) (Table 2).

Table 2: Prevalence of Urological Complications by Diabetes Status and Impact of Dialysis Modality on Renal Function Parameters

Complications	Diabetes (n=142, 45.8%)	No Diabetes (n=168, 54.2%)	p-Value
Urological Complications by Diabetes Status			
Urinary Tract Infection	45 (31.7%)	40 (23.8%)	0.030*
Bladder Dysfunction	36 (25.4%)	24 (14.3%)	0.020*
Nephrolithiasis (Kidney Stones)	21 (14.8%)	14 (8.3%)	0.120
LUTS	50 (35.2%)	42 (25.0%)	0.070
Hematuria	28 (19.7%)	20 (11.9%)	0.060
Prostatomegaly (Male, n=180)	30 (21.1%)	10 (11.9%)	0.080
Urethral Stricture	10 (7.0%)	8 (4.8%)	0.380
Renal Function			
Parameters	**(HD) (n=186, 60%)**	**(PD) (n=124, 40%)**	-
Serum Creatinine	6.2 ± 2.1	5.8 ± 1.9	0.120
BUN	45.3 ± 18.2	42.1 ± 16.4	0.160
GFR (mL/min/1.73m^2)	13.5 ± 5.1	14.8 ± 5.7	0.090
Albumin	3.5 ± 0.7	3.8 ± 0.6	0.040*
Hemoglobin	10.2 ± 1.3	10.6 ± 1.4	0.230

The frequency of urological problems was examined in three categories, defined by the length of time on dialysis: ≤2 years, 2-5 years, and >5 years. The incidence of urethral stricture, hematuria, urinary tract infections (UTIs), and nephrolithiasis (kidney stones) were not significantly different across the groups (p=0.470, p=0.910, and p=0.240, respectively). Statistically significant (p=0.060), the prevalence of bladder dysfunction was higher in patients whose dialysis treatments lasted longer; specifically, 25.3% of patients whose dialysis treatments lasted more than 5 years compared to 14.7% in patients whose treatments lasted 2 years or less and 18.3% in patients whose treatments lasted 2-5 years. Lower urinary tract symptoms (LUTS) were shown to be more common in patients with longer dialysis duration. Specifically, 34.3% of patients with dialysis for more than 5 years, 32.1% of patients with 2-5 years, and 22.5% of patients with ≤2 years reported LUTS (p=0.030). Although the tendency towards a higher prevalence of prostatomegaly was not statistically significant (p=0.130), it did occur in patients whose dialysis treatments lasted longer (Table 3).

Table 3: Association of Dialysis Duration with Urological Complications

Complications	Dialysis Duration ≤2 Years (n=102, 32.9%)	Dialysis Duration 2-5 Years (n=109, 35.2%)	Dialysis Duration >5 Years (n=99, 31.9%)	p-Value
UTI	24 (23.5%)	32 (29.4%)	29 (29.3%)	0.470
Bladder Dysfunction	15 (14.7%)	20 (18.3%)	25 (25.3%)	0.060
Nephrolithiasis (Kidney Stones)	11 (10.8%)	12 (11.0%)	12 (12.1%)	0.910
LUTS	23 (22.5%)	35 (32.1%)	34 (34.3%)	0.030*
Hematuria	12 (11.8%)	16 (14.7%)	20 (20.2%)	0.240
Prostatomegaly (Male Only, n=180)	9 (7.6%)	14 (12.6%)	17 (16.5%)	0.130
Urethral Stricture	5 (4.9%)	7 (6.4%)	6 (6.1%)	0.720

Statistical Test Used: Chi-square test. Asterisk (*) indicates a statistically significant difference (p-value<0.050)

The frequency of urological problems was evaluated in three categories, according to residual urine output: less than or equal to 100 mL/day, 101-300 mL/day, and more than 300 mL/day. The incidence of urinary tract infections (UTIs) varied significantly among the groups. Specifically, 34.7% of patients with residual urine output of 100 mL or less per day had UTIs, compared to 26.9% in the 101-300 mL/day group and 17.6% in the >300 mL/day group (p=0.020). Bladder dysfunction, nephrolithiasis (kidney stones), hematuria, prostatomegaly, and urethral stricture were not significantly different in prevalence. There was no significant difference in the prevalence of bladder dysfunction between the groups, with 24.0% of individuals with 100 mL/day or less experiencing it, 15.4% with 101-300 mL/day, and 17.6% with >300 mL/day. The p-value calculated was 0.130. There was not a significant difference in the frequency of kidney stones or enlarged prostate between groups (p=0.210 for each). Urethral stricture, hematuria or LUTS did not show significant differences in any of the groups (p=0.560, p=0.910 and 0.560, respectively) (Table 4).

Table 4: Correlation Between Urological Complications and Residual Urine Output

Complications	≤ 100 mL/day (n=121, 39.0%)	101-300 mL/day (n=104, 33.5%)	> 300 mL/day(n=85, 27.4%)	p-Value
UTI	42 (34.7%)	28 (26.9%)	15 (17.6%)	0.020*
Bladder Dysfunction	29 (24.0%)	16 (15.4%)	15 (17.6%)	0.130
Nephrolithiasis (Kidney Stones)	18 (14.9%)	9 (8.7%)	8 (9.4%)	0.210
LUTS	32 (26.4%)	36 (34.6%)	24 (28.2%)	0.170
Hematuria	18 (14.9%)	16 (15.4%)	14 (16.5%)	0.910
Prostatomegaly (Male Only, n=180)	18 (15.1%)	9 (8.7%)	8 (9.4%)	0.210
Urethral Stricture	8 (6.6%)	6 (5.8%)	4 (4.7%)	0.560

Statistical Test Used: Chi-square test. Asterisk (*) indicates a statistically significant difference (p-value<0.050)

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The multivariate logistic regression analysis indicated that Hemodialysis (HD) had a statistically significant increased risk of urological complications compared with Peritoneal Dialysis (PD) (OR=1.46, 95% CI: 1.11–1.93, p=0.021). Diabetes was also a significant risk factor, diabetic patients had more than double the odds of complications (OR=2.06, 95% CI: 1.56–2.73, p=0.001). The hydration status and residual renal function indicators were significant as dehydrated patients (OR=1.82, 95% CI: 1.33–2.48, p=0.001) and patients with abnormal renal function (OR=1.62, 95% CI: 1.21–2.14, p=0.002) in the week preceding urological assessment were at greater odds of complications. However, the duration of dialysis showed no significant association with urological complications (p=0.316 (Table 5).

Table 5: Multivariate Logistic Regression Analysis for the Association Between Dialysis Type and Urological Complications, Adjusted for Potential Confounders

Complications	Odds Ratio (OR)	95% Confidence Interval (CI)	p-Value
Dialysis Type (HD vs. PD)	1.46	1.11 - 1.93	0.021
Diabetes (Yes vs. No)	2.06	1.56 - 2.73	0.001
Dialysis Duration (≤2 Years)	1.22	0.86 - 1.68	0.316
Hydration Status (Normal vs. Dehydrated)	1.82	1.33 - 2.48	0.001
Residual Renal Function (Normal vs. Abnormal)	1.62	1.21 - 2.14	0.002

DISCUSSION

The current study aims to determine the frequency of urological problems in dialysis patients and to find out if they differ in HD patients, PD patients and patients with diabetes, with additional factors such as dialysis time and residual kidney function considered. This can help us understand the urological health of these patients and the importance of understanding, managing, and monitoring any complications. We found a much higher prevalence of urinary tract infection (UTI) and bladder dysfunction published by our comparison. 31.7% of diabetic patients reported a UTI vs. 23.8% of non-diabetic patients, and 25.4% reported bladder dysfunction vs. 14.3% of non-diabetic patients. This is consistent with previous studies by Xin *et al.*, from China and Defeudis *et al.*, from Italy, who both suggested that diabetes may increase the risk of urological complications, considering immune function, nerve damage, and poor mechanisms of bladder control [20, 21]. Our findings also suggest that diabetes may lead to greater nephrolithiasis incidence, although not statistically significant, but an incidence of 14.8% in a diabetic population versus 8.3% in a non-diabetic population agrees with the study by Ejaz *et al.*, from Greece who have demonstrated a greater incidence of kidney stones in diabetic patients [22]. Patients of PD had statistically higher albumin levels compared to HD patients (3.8 ± 0.6 g/dL vs. 3.5 ± 0.7, p=0.040), which may suggest that PD patients exhibited better nutritional status or lower protein loss than HD, as suggested by literature such as Huang *et al.*, [23]. Our study found a higher association of lower urinary tract symptoms (LUTS) with longer dialysis durations (<0.030). Our patients who were on dialysis for greater than 5 years were more likely to have LUTS than patients on shorter durations of dialysis. These results are similar to those observed by Scherberich *et al.*, who found that long duration of dialysis increases the risks of LUTS due to chronic uremia, altered bladder activity, and reduced residual renal function [24]. Concerning the residual urine output, we found that patients with less urinary volume had a higher prevalence of UTIs. 34.7% of patients with residual urine output ≤100 mL/day had UTIs, compared to 17.6% in patients with residual urine output >300 mL/day. This is consistent with a study by Scherberich *et al.*, which demonstrated that patients with low residual urine output are at increased risk for UTI, at least in the dialysis population [24]. The multivariate logistic regression analysis identified several statistically significant predictors of complications involving the urinary tract. Patients receiving hemodialysis (HD) were at a 46% higher risk of complications of the urinary tract compared to peritoneal dialysis (PD) (OR=1.46, p=0.021), consistent with earlier findings by Bello *et al.*, [25]. Diabetic patients were also a significant risk factor, as they had over twice the odds of urological complications (OR=2.06, p=0.001). This reflects the well-established association between diabetes and urological complications in patients requiring dialysis [26]. This study highlights the necessity of judicious surveillance for urologic complications in dialysis facilities as a function of the patient demographics, namely in patients with diabetes, or with less residual renal function, or abnormal hydration status. This also emphasizes personalized approaches to care strategies, such as glycemic control and regular screening. The cross-sectional design limits causal inference, and the single-center setting may restrict generalizability to broader populations. Additionally, reliance on patient-reported symptoms and residual urine estimates may introduce reporting bias. Future multicenter longitudinal studies incorporating objective urodynamic assessments are recommended to better establish causal relationships and refine risk stratification in dialysis patients.

CONCLUSIONS

How dialysis is delivered, diabetes presence, ongoing dialysis, amount of normal kidney function remains and urological conditions are linked. Our study shows that diabetes and dehydration are major dangers associated with urological complications which is in line with previous research. HD patients had higher rates of urological problems than PD patients, but dialysis modality did not greatly impact most renal function markers. Proper care of diabetes, water levels and dialysis method may lower the risk of urological problems in this group.

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Authors' Contribution

Conceptualization: RK
Methodology: RK
Formal analysis: ZAK
Writing and Drafting: ZAK
Review and Editing: RK, ZAK

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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