


# Safety of renal biopsy bleeding prophylaxis with desmopressin

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## Abstract

**Background:** Percutaneous renal biopsy (PRB) is invasive, and bleeding-related complications are a concern. Desmopressin (DDAVP) is a selective type 2 vasopressin receptor-agonist also used for haemostasis.

**Aim:** To evaluate the side effects of intravenous (IV) weight-adjusted desmopressin preceding PRB.

**Methods:** This was a retrospective study of renal biopsies performed by nephrologists from 2013 to 2017 in patients who received single-dose DDAVP pre-PRB.

**Results:** Of 482 PRBs, 65 (13.5%) received DDAVP (0.3 µg/kg); 55.4% of the PRBs were native kidneys. Desmopressin indications were altered platelet function analyser (PFA)-100 results (75.3% of the patients), urea >24.9 mmol/L (15.5%), antiplatelet drugs (6.1%) and thrombocytopenia (3%). Of the 65 patients, 30.7% had minor asymptomatic complications, and 3 patients had major complications. Pre-PRB haemoglobin (Hb) <100 g/L was a risk factor for Hb decrease >10 g/L, and altered collagen-epinephrine (Col-Epi) time was a significant risk factor for overall complications. Mean sodium decrease was  $0.6 \pm 3$  mmol/L. Hyponatraemia without neurological symptoms was diagnosed in two patients; no cardiovascular events occurred.

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**Conclusion:** Hyponatraemia after single-dose DDAVP is rare. A single IV dose of desmopressin adjusted to the patient's weight is safe as pre-PRB bleeding prophylaxis.

### Keywords

Renal biopsy, bleeding, 1-deamino8-D-arginine vasopressin, secondary effect, desmopressin safety, hyponatraemia, cardiovascular event, interventional nephrology, prophylaxis, uraemia

Date received: 24 February 2021; accepted: 2 August 2021

## Introduction

Desmopressin (1-deamino8-D-arginine vasopressin (DDAVP)), is a selective agonist of type 2 vasopressin receptors and was initially developed to treat diabetes insipidus.<sup>1</sup> DDAVP also induces the release of factor VIII (FVIII) and von Willebrand factor (VWF) from endothelial cells, transiently increasing the plasma concentrations,<sup>2-4</sup> and DDAVP improves platelet adhesion to the vessel wall.<sup>5,6</sup> Owing to its haemostatic effect, DDAVP was proposed in 1977 as an alternative to plasma derivatives in patients with congenital coagulation disorders before dental extractions and other surgical procedures.<sup>3</sup> Over the years, its use as a haemostatic agent in minor surgery and bleeding has been widely expanded.

The potential adverse effects of DDAVP infusion comprise facial flushing, hypertension or hypotension, tachycardia and headache.<sup>1,5</sup> DDAVP also increases free water reabsorption in renal collecting ducts owing to its mild antidiuretic effect, which can lead to volume overload and dilutional hyponatraemia.<sup>7</sup> Some authors recommend avoiding DDAVP in patients with an increased cardiovascular and cerebrovascular risk because of occasional reports of secondary myocardial infarction.<sup>1,8-11</sup>

Percutaneous renal biopsy (PRB) is the gold standard technique to provide relevant

information to guide diagnosis and treatment in renal disease. Since the introduction of ultrasound-guided biopsy, PRB has become easier and safer.<sup>12</sup> However, as an invasive procedure, PRB is associated with complications, mainly bleeding-related (haematoma and haematuria), which are enhanced by uraemia.<sup>13,14</sup> Biochemical control and renal ultrasonography (US) before and 24 hours after kidney biopsy are required for early diagnosis of bleeding complications.<sup>15</sup>

As mentioned, DDAVP has been used to decrease Haemorrhagic complications in different surgical and invasive procedures,<sup>16</sup> with controversial results in PRB. We aimed to evaluate the side effects of intravenous DDAVP as a single weight-adjusted dose prior to PRB of both native kidneys (NK) and kidney grafts (TK).

## Methods

This retrospective, single-centre study was approved by the Institutional Review Board at the Hospital Universitario Ramón y Cajal (IRB 035/20) on 24 February 2021. Our centre is a tertiary care teaching hospital, attending a population of approximately 550,000 people in Madrid, Spain. All procedures performed in this study involving human participants were in accordance with the ethical standards of our institutional research committee

and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors. Because collected data were derived from routine clinical practice, the need for further consent was waived. The reporting of this study conforms to the STROBE statement;<sup>17</sup> the described methodology can be reproduced.

### **Patients**

We retrospectively analysed all renal biopsies in our centre from January 2013 until December 2017, inclusive. Patients receiving DDAVP prior to PRB were identified, and their biochemistry data and cardiovascular history to 1 month post-PRB were collected and examined. A control group was selected with the same baseline characteristics as the DDAVP group. Controls underwent renal biopsy during the same period without receiving DDAVP, and their biochemistry data and cardiovascular history to 1 month post-PRB were also collected and examined.

As we described previously,<sup>18</sup> all PRBs were performed by a single operator, either an experienced consultant nephrologist or a trainee under the direct supervision of a consultant nephrologist from our Diagnostic and Interventional Nephrology section. NK biopsies were performed in the prone position, and TK biopsies were performed in the supine position, targeting the left lower renal third for NK and cranial third for TK.

All biopsies were performed in an inpatient setting with real-time US guidance using a Toshiba Xario<sup>®</sup> 300 (Toshiba Medical Systems, Tokyo, Japan) ultrasound device with a 3.5-MHz curvilinear probe and 16-G or 14-G automated core biopsy needle (Acecut<sup>®</sup>; TSK Laboratory, Tochigi, Japan). Patients were admitted on the date of the procedure and discharged 24

hours later, provided there were no complications after a structured Doppler US (mapping all kidney sections in two-dimensional (2D) and Doppler modes) and blood laboratory evaluation. Our post-PRB protocol comprised mandatory bed rest in the supine position and close monitoring of blood pressure, heart rate and urine voiding to identify macroscopic haematuria (every 15 minutes for the first hour, hourly for 3 hours and every 6 hours, thereafter). Intravenous fluids were prescribed at the treating physician's discretion because we do not administer intravenous fluids routinely in our post-PRB care protocol.

Data on demographics, kidney type, biopsy indication, blood results and post-PRB complications were collected from our renal computerised registry and laboratory registry to 1 month post-DDAVP administration.

### **DDAVP administration criteria**

The DDAVP administration criteria in our centre comprise renal disease (defined as creatinine  $>176.84 \mu\text{mol/L}$  or estimated glomerular filtration rate (eGFR)  $<60 \text{ mL/minute/1.73 m}^2$ ), urea  $>24.9 \text{ mmol/L}$  (uraemia), altered platelet function analyser (PFA)-100 (Dade International Inc., Miami, FL, USA) results and a high risk of bleeding owing to other causes (i.e., thrombocytopenia  $<150,000/\text{mm}^3$ ). When given, DDAVP (Minurin<sup>®</sup>,  $4 \mu\text{g/mL}$ ; Ferring GmbH, Kiel, Germany) was administered intravenously as a single dose of  $0.3 \mu\text{g/kg}$  within 1 hour of the procedure.

### **Statistical analysis**

Statistical analysis was performed using SPSS 20 software (IBM Corp., Armonk, NY, USA). Results were expressed as median and interquartile range (IQR) for non-parametric continuous variables, and

continuous variables were presented as mean  $\pm$  standard deviation (SD). Data comparisons between groups were performed using the  $\chi^2$  test for categorical data and the Mann–Whitney U test for continuous non-parametric data. Univariate logistic regression analysis was performed to evaluate the risk factors and confounding variables. All probabilities were two-tailed, and p-values  $<0.05$  were considered statistically significant. Multivariate analysis was deemed unsuitable owing to the low number of events.

## Results

During the study period, 482 PRBs were performed, and 65 (13.5%) patients received a single intravenous dose of DDAVP (0.3  $\mu\text{g}/\text{kg}$ ) to enhance platelet function. Adequate diagnostic yield was obtained from biopsies in 90.4% of KT biopsies and 86.1% of NK biopsies.

Patients receiving DDAVP had a median age of 54.5 years (IQR: 47–66), 66% were men, 55.4% of the biopsies were performed in NKs and 44.6% of the biopsies were performed in KTs. Mean PFA-100 results pre-PRB showed a collagen-adenosine diphosphate (Col-ADP) time of  $141 \pm 52$  s and collagen-epinephrine (Col-Epi) time of  $184 \pm 66$  s (reference ranges: Col-Epi, 0–170 s and Col-ADP, 0–126 s). The mean platelet count was  $201.049 \pm 71.11 \times 10^9/\text{L}$ . The median estimated glomerular filtration rate (eGFR) using the Modification of Diet in Renal Disease Study-4 (MDRD-4) equation<sup>19</sup> was  $18 \text{ mL}/\text{minute}/1.73 \text{ m}^2$  (IQR: 12–37), with a median creatinine of  $265.21 \mu\text{mol}/\text{L}$  (IQR: 176.8–397.81). Systolic and diastolic blood pressure measured before the intervention were  $143 \pm 32$  mmHg and  $84 \pm 11$  mmHg, respectively. Patients had a mean haemoglobin of  $110.6 \pm 22.5 \text{ g}/\text{L}$  before the biopsy and  $105.6 \pm 22.6 \text{ g}/\text{L}$  24 hours after the biopsy. In the control group, 64.6% were men,

44.6% of the biopsies were in KTs and 55.4% were in NKs. The only statistically significant differences between the groups were for items influencing the DDAVP indications: eGFR, platelet count, PFA-100 result and haemoglobin levels.

Comparisons between the two groups are summarised in Table 1.

### DDAVP indications

The DDAVP indications were altered PFA-100 results (75.3%), uraemia (15.5%), antiplatelet drugs (6.2%) and thrombocytopenia (3%). All patients with altered PFA-100 results underwent a pre-PRB work-up to determine whether the change was due to any modifiable factor, such as food products, herbs or medications. Among all patients, 71% did not take antiplatelet agents pre-PRB, and 24.6% used anticoagulation and/or antiplatelet therapy that was either suspended 8 to 12 days prior to PRB or replaced by low molecular weight heparin (LMWH), which was withdrawn 24 hours before the procedure. The remaining 4.4% of the patients were taking no medications of any kind.

### PRB complications and risk factors

Of the 65 patients receiving DDAVP, 30.7% (20 patients) had minor asymptomatic complications detected by routine ultrasonography: 7 arteriovenous fistulae (AVF), 12 small perinephric haematomas (defined as  $<2$  cm diameter) and 1 patient with both complications. None of the patients required intervention, and all AVFs closed spontaneously within 1 month post-procedure. Three patients (4.6%) had major complications, defined as surgical or radiological intervention and/or requiring blood products; two underwent selective renal embolisation, and one required only blood products. The remaining 64.6% (42/65) of the

**Table 1.** Patient demographics.

CHARACTERISTIC	GROUP				p-value
	DDAVP	CONTROL			
	Mean $\pm$ SD (median when specified)	Range	Mean $\pm$ SD (median when specified)	Range	
Number (N) = 65					
AGE (years)	54.5 (IQR 47–66) Median 54.5 (IQR 47–66)	30–84	54 (IQR 45–66.5)	14–87	0.79
Gender	43 men (66%) 22 women (34%)		42 men (64.6%) 23 women (35.4%)		0.85
KIDNEY	36 native (55.4%)		36 native (55.4%)		1
NUMBER OF GLOMERULI	Mean 10.74 $\pm$ 7.8 Median 10	0–41	Mean 11.27 $\pm$ 7.4 Median 10	0–34	0.7
PLATELET COUNT ( $\times 10^9/L$ )	201.049 $\pm$ 71.11	75.3–413	225.215 $\pm$ 72.9	109–483	0.018
Col-ADP time (s)	141 $\pm$ 52	0–126	86 $\pm$ 15		0.001
Col-Epi time (s)	184 $\pm$ 66	0–170	116 $\pm$ 20		0.001
Hb pre-biopsy (g/L)	110 $\pm$ 22	81–170	128 $\pm$ 23	87–173	0.001
Hb post-biopsy (g/L)	105 $\pm$ 22	125–161	125 $\pm$ 21	83–176	0.001
eGFR (MDRD4, mL/minute/1.73 m <sup>2</sup> )	Mean 27.25 $\pm$ 22.28 Median 18 (IQR 12–37)	2.1–102	Mean 50.13 $\pm$ 37.58 Median 33 (IQR 24–65)	7–174	0.001
BPs pre-biopsy (mmHg)	143 $\pm$ 32	100–212	153 $\pm$ 22	109–210	NS
BPd pre-biopsy (mmHg)	84 $\pm$ 11	60–99	86 $\pm$ 10	61–110	NS
Sodium pre-biopsy (mmol/L)	138.12 $\pm$ 3.69	128–145	139 $\pm$ 3.1	131–147	0.77
Sodium post-biopsy (mmol/L)	136.62 $\pm$ 3.98	124–144	138.9 $\pm$ 3.1	130–146	0.028

DDAVP: 1-deamino8-D-arginine vasopressin; SD, standard deviation; Col-ADP: collagen-adenosine diphosphate; Col-Epi: collagen-epinephrine; Hb: haemoglobin; eGFR: estimated glomerular filtration rate; BPs: systolic blood pressure; BPd: diastolic blood pressure.

patients did not develop complications derived from the procedure.

In the control group, there were 24 complications (36.4%); all were minor and asymptomatic and detected by routine ultrasonography. The complications comprised 8 AVFs, 13 small perinephric haematomas, 1 patient with both AVF and small perinephric haematoma and 2 self-limited haematuria episodes without a relevant decrease in haemoglobin. There was no statistically significant difference regarding complications when comparing the control group with the DDAVP group.

In both groups, a trend towards a higher complication rate in NK biopsy was observed ( $p = 0.003$ ). When analysing each subgroup separately, this tendency was

confirmed in the control group ( $p = 0.001$ ) but not in the DDAVP group. Table 2 summarises the complication rates.

Pre-PRB haemoglobin  $< 100$  g/L was identified as a significant risk factor for a haemoglobin decrease  $> 10$  g/L ( $p = 0.03$ ), and altered Col-Epi time was identified as a significant risk factor for overall complications ( $p = 0.018$ ). Pre-PRB blood pressure, uraemia, female gender and the number of biopsy passes showed no statistical significance. Table 3 contains a summary of the results of the univariate analysis performed for patients receiving DDAVP ( $n = 65$ ). Variables included were those that influence the PRB complication rate: platelet count pre-biopsy, haemoglobin level, blood pressure, number of needle passes and

**Table 2.** Complication rate analysis.

KIDNEY TYPE	Group			
	DDAVP		CONTROL	
	NK	TK	NK	TK
COMPLICATIONS				
Overall	19	4	15	9
Minor complications	16	4	15	9
Major complications	3	0	0	0
p-value	0.001		0.37	

DDAVP: 1-deamino8-D-arginine vasopressin; NK: native kidney; TK: kidney graft.

**Table 3.** Univariate analysis p-values for the factors related to complications in patients receiving DDAVP.

	Haemoglobin decrease >10 g/L	Complications
Col-ADP >126 s	0.63	0.12
Col-EPI >170 s	0.53	0.018
Platelets <100,000/mm <sup>3</sup>	0.35	0.085
>3 biopsy passes	0.12	0.66
Haemoglobin <100 g/L	0.03	0.84
DiasBP >90 mmHg	0.96	0.9
SysBP >160 mmHg	0.63	0.69
Uraemia	0.28	0.068
Altered bleeding time*	0.92	0.98
I4-G needle	0.71	0.14

DDAVP: 1-deamino8-D-arginine vasopressin; Col-ADP: collagen-adenosine diphosphate; Col-Epi: collagen-epinephrine; SysBP: systolic blood pressure; DiasBP: diastolic blood pressure. \*Altered bleeding time: Col-Epi >170 seconds and/or Col-ADP >126 seconds.

bleeding time results to assess platelet function. Platelet count was categorised as  $50 \times 10^9/L$  to  $100 \times 10^9/L$  or  $>100 \times 10^9/L$ ; systolic blood pressure as  $>160$  mmHg or  $<160$  mmHg; diastolic blood pressure as  $>90$  mmHg or  $<90$  mmHg; pre-PRB haemoglobin levels as  $<100$  g/L or  $>100$  g/L; abnormal bleeding time as per laboratory definition and needle passes  $<3$  or  $\geq 3$ . A multivariate analysis was deemed unsuitable owing to the low number of events.

### Desmopressin complications

The mean sodium decline in the 24 hours post-DDAVP administration was  $0.6 \pm 3$  mmol/L. Hyponatraemia (defined as sodium  $<135$  mmol/L) without neurological symptoms was diagnosed in two patients (3%); the sodium level in one patient deteriorated from 128 mmol/L to 124 mmol/L, and the sodium level in another patient decreased by 12 mmol/L in 24 hours (from 139 mmol/L to 127 mmol/L). Compared with the control group, the sodium decline was slightly but significantly higher in the DDAVP group ( $p = 0.028$ ). Both patients in the DDAVP group experiencing decreased sodium recovered to a normal plasma level within 24 to 36 hours without intervention. The first of these patients underwent an NK biopsy, with an eGFR of 6 mL/minute/1.73 m<sup>2</sup>, and the second underwent a KT biopsy, with an eGFR of 17 mL/minute/1.73 m<sup>2</sup>.

None of the patients treated with DDAVP developed adverse cardiovascular events after receiving the medication (to 1 month post-dosage).

### Discussion

Patients with renal failure have a bleeding tendency owing to platelet dysfunction secondary to uraemia, with diminished aggregation and adhesion, as well as elevated nitric oxide, uraemic toxins, prostaglandin F<sub>2</sub> $\alpha$  (PGF<sub>2</sub> $\alpha$ ) and cyclic guanosine monophosphate (GMPc), among other changes. Bleeding tendency is even higher in patients with a haematocrit of  $<30\%$ .<sup>20,21</sup>

Renal biopsy is a very important tool for nephrologists, and as an invasive procedure, biopsy can be associated with bleeding complications despite recent improvements in the technique. Owing to its haemostatic properties, DDAVP has been proposed as a prophylactic measure to reduce the incidence of post-PRB

bleeding complications. Previous authors studied the effect of DDAVP administration on the incidence of post-biopsy bleeding complications in patients undergoing ultrasound-guided PRB without previous coagulopathy. However, there were controversies owing to the potential side effects of DDAVP<sup>22</sup>, and the studies included only NK biopsies. A single-centre randomised controlled trial involving 162 patients analysed the use of DDAVP in low-risk NK biopsies (creatinine:  $\leq 1.5$  mg/dL, eGFR  $\geq 60$  mL/minute/1.73 m<sup>2</sup>), administered subcutaneously 1 hour before the procedure. Results showed a significantly decreased risk of bleeding complications after kidney biopsy procedures, mainly haematoma formation ( $p = 0.01$ ), without other side effects but with a transient mild increase (5%) in heart rate.<sup>15</sup> A retrospective study was conducted in 2014 including patients undergoing central catheter insertion and kidney biopsies. Patients were stratified according to eGFR, and those who received intravenous DDAVP were compared with those who did not, in all subgroups. There were no significant differences in bleeding rates between all groups, and no significant side effects were noted secondary to DDAVP administration.<sup>23</sup> A larger observational study by Peters et al.<sup>24</sup> analysed the effect of administering subcutaneous DDAVP (0.3  $\mu$ g/kg) before NK biopsies, including 576 patients with impaired renal function (defined as creatinine  $>150$  mmol/L); 87% of all biopsies were performed by radiologists, and 204 patients received DDAVP (35%).

The results showed fewer overall biopsy-related complications when DDAVP was administered, with a stronger effect in women compared with men (0% vs 12.1%, respectively;  $p = 0.006$ ) and no reported side effects.<sup>24</sup> Another study, published in 2019, compared the bleeding complication rates between groups when using intranasal DDAVP.<sup>25</sup> The study involved

194 patients with creatinine  $>132.4$  mmol/L but not requiring dialysis; 94 received DDAVP as a single intranasal dose of 150  $\mu$ g regardless of weight. The results showed a significantly lower rate of perinephric haematomas when DDAVP was used, but 94% of the patients developed an asymptomatic decrease in serum sodium. The mean sodium decrease was 4.5 mEq/L, with 8 of 94 (8.5%) patients reaching serum sodium levels  $<130$  mEq/L and requiring a longer hospital stay.<sup>25</sup> Finally, Lim et al.<sup>26</sup> analysed 436 biopsies performed in their centre either by radiologists or nephrologists, including NKs and TKs. All patients had a creatinine level  $>150$  mmol/L, and 15.5% had a serum sodium between 130 mmol/L and 135 mmol/L before DDAVP was administered. DDAVP was given intravenously at a median dose of 0.2  $\mu$ g/kg within 1 hour prior to the procedure, at the physician's discretion; i.e., the protocol was not standardised. As routine electrolytes were not evaluated post-biopsy, the authors detected only symptomatic hyponatraemia, observing that up to 6.9% of all biopsies were associated with an abnormal sodium level of between 119 mmol/L and 122 mmol/L. The authors did not define what symptoms were considered relevant to measure electrolyte levels. DDAVP administration and pre-biopsy sodium levels were independent and statistically significant risk factors for hyponatraemia in the series. Table 4 summarises the latest published studies of DDAVP use in renal biopsy.

Although our study has a few limitations, such as the retrospective design (which implies a degree of lost data and bias), and that DDAVP use is justified only when renal function or platelets are abnormal, making it unethical to perform proper control group matching, there are several differences in our study compared with previous reports that should be highlighted. First, in our study, almost all

**Table 4.** Recent published studies of DDAVP use in renal biopsy.

First author	Year	Journal	Total number of patients	Patients receiving DDAVP (n)	Outcome	Kidney biopsy performed by	DDAVP route of administration and dose
C. Manno <sup>15</sup>	2011	<i>Am J Kidney Dis</i>	162	80	Bleeding complications	Nephrologist	Subcutaneous 0.3 µg/kg
S. Radhakrishnan <sup>23</sup>	2014	<i>Nephron Clin Pract</i>	43	13	Bleeding complications	Radiologist	Intravenous 0.3 µg/kg
B. Peters <sup>24</sup>	2018	<i>Nephrology</i>	576	204	Overall complications	Radiologist and Nephrologist	Subcutaneous 0.3 µg/kg
N.S. Rao <sup>25</sup>	2019	<i>Clin Kidney J</i>	194	89	Bleeding complications	Nephrologist	Intranasal 150 µg
CC Lim <sup>26</sup>	2020	<i>Int J Urol</i>	436	226	Overall complications	Radiologist and Nephrologist	Intravenous 0.2 µg/kg
R.H. Sosa Barrios (current study)	2021		482	65	Overall complications	Nephrologist	Intravenous 0.3 µg/kg

DDAVP: 1-deamino8-D-arginine vasopressin.

patients underwent biochemical blood analysis, including electrolytes, after the procedure, regardless of symptoms, which makes it unlikely that any minor asymptomatic hyponatraemia after DDAVP administration has been omitted. Likewise, all patients underwent structured routine and Doppler ultrasonography 24 hours post-PRB; therefore, it is improbable that any minor asymptomatic complication was missed. Second, all biopsies were performed by nephrologists (single operator), using intravenous DDAVP, with the dosage adjusted to the patient's weight, and both NKs and TKs were included. Additionally, our follow-up to identify any secondary effects of DDAVP use was much longer than that reported in previous studies, including Lim et al.'s report, in which the authors reported the general nephrology follow-up findings. Furthermore, DDAVP was prescribed not only in patients with abnormal renal function but also in patients with other causes of higher bleeding tendency, such as thrombocytopenia. The lack of a statistically significant difference when comparing complication rates between our DDAVP and control groups, despite worse parameters favouring bleeding in the DDAVP group, supports the efficacy of DDAVP's haemostatic effects in diminishing bleeding complications. Our study showed a trend towards a higher complication rate in NK biopsies, but when analysing each subgroup, this was not confirmed in the control group, which could be because of the low number of events.

In contrast to previous publications, in our series, only 3% of the patients developed hyponatraemia post-DDAVP, and none were symptomatic or required specific treatment. No cardiovascular events to 1 month post-PRB were detected. In addition, similar to previous studies, we found that a low haemoglobin level (<100 g/L) was a risk factor for developing a relevant haemoglobin decrease, and altered bleeding



time independently increased the risk of overall complications after PRB.<sup>27–29</sup> Both can be identified easily and could be resolved before the procedure to reduce the associated risks.

To our knowledge, this is the first report evaluating the safety of intravenous single-dose DDAVP, adjusted to a patient's weight, that included both NK and TK biopsies, which were performed exclusively by nephrologists. This study highlights that a single dose of DDAVP adjusted to a patient's weight pre-PRB is safe given that secondary effects derived from its use were very rare, in contrast to findings in previous studies. Nonetheless, prospective studies are needed to confirm these findings.

## Conclusion

Hyponatraemia is a rare complication after DDAVP administration as a single dose pre-PRB. No cardiovascular events were detected with DDAVP, post-PRB, in this study. Therefore, a single intravenous dose of DDAVP adjusted to patient's weight is safe as a bleeding prophylaxis pre-PRB and may be used in patients with a higher risk of haemorrhagic complications, such as those with uraemia or taking medications associated with this risk. Basal sodium determination could be useful to minimise the risk of hyponatraemia.

## Declaration of conflicting interest

All authors declare there are no conflicts of interest.

## Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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