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ARTICLE

Impact of comorbidities on acute kidney injury and renal function impairment after partial and radical tumor nephrectomy

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ABSTRACT

Background: To test for the impact of patient comorbidities and medical risk factors on kidney function after partial (PN) or radical nephrectomy (RN) in renal cell carcinoma (RCC) patients with normal preoperative renal function.

Materials and Methods: From January 2011 to December 2014, 195 consecutive RCC patients with a preoperative estimated glomerular filtration rate (eGFR) $>$ 60 ml/min/1.73 m^2 underwent PN or RN. Stratification was performed according to postoperative acute kidney injury (AKI) vs. no AKI. Moreover, logistic regression models tested for risk factors predicting postoperative AKI and subsequent new-onset chronic kidney disease (eGFR $<$ 60 or $<$ 45 ml/min/1.73 m^2).

Results: Of all eligible patients, 127 (65.1%) exhibited AKI. AKI patients underwent more frequently RN (44.9 vs. 13.2% PN) and harbored more often preoperative diabetes (17.3 vs. 5.9% no diabetes), hypertension (46.5 vs. 23.5% no hypertension) and larger median tumor size (4.5 vs. 2.5 cm, all $p < 0.05$) than non-AKI patients. Moreover, after median follow-up of 14 months, 18.9% of AKI patients exhibited an eGFR $<$ 60 ml/min/1.73 m^2 vs. 7.4% non-AKI patients ($p = 0.01$). In multivariable models, hypertension and RN were risk factors for postoperative AKI (both $p < 0.01$). Age $>$ 60 years and RN as well as preoperative diabetes were risk factors for postoperative eGFR $<$ 60 or $<$ 45 ml/min/1.73 m^2 (all $p < 0.05$), respectively.

Conclusions: Postoperative AKI is a non-negligible event especially after RN that can be further triggered by comorbidities such as diabetes and hypertension. Comorbidities should be considered in clinical decision-making for RCC surgery and patients need to be counseled about the increased risk of consecutive renal function impairment.

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Introduction

Surgical treatment with either partial (RN) or radical nephrectomy (PN) provides excellent oncological outcomes for clinically localized renal cell carcinoma (RCC) [1,2]. Several studies investigated better preserved postoperative kidney function and lower rates of associated cardiovascular disorders, deaths and hospitalization rates with PN compared to RN [3–7]. In general, an estimated glomerular filtration rate (eGFR) of 15–59 ml/min/1.73^2 relative to an eGFR of 90–150 ml/min/1.73^2 is associated with a 38% increased risk of cardiovascular disease [8]. In consequence, EAU guidelines recommend PN in cT1 tumors whenever feasible to avoid postoperative acute kidney injury (AKI) and possibly chronic kidney disease (CKD) [9].

Within the context of surgical treatment planning for RCC it seems particularly important to be aware of concomitant risk factors in patients that might additionally affect postoperative kidney function. Several publications, relying mostly on historical patient cohorts, investigated higher risk of postoperative AKI for patients with hypertension or diabetes in addition to undergoing RN [10–13]. A recent study by Capitanio et al. [7] showed that major cardiovascular events and new-onset hypertension after PN or RN were increasing within the recent years. This observation may be explained through demographic changes and increasing rates of obesity and frail patients.

In consequence, it is crucial to evaluate additional risk factors for postoperative renal function impairment in contemporary cohorts of PN and RN patients. Moreover, most studies are stratifying their results according to PN vs. RN which may introduce selection bias, since healthier patients probably more frequently undergo PN [14–16]. We addressed these points and stratified RCC patients according to postoperative AKI vs. no AKI. We hypothesized that, relative to more historical patient cohorts, risk factors for postoperative

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AKI and new-onset CKD may be more pronounced in contemporary patients.

Materials and methods

Study population

The study was conducted in accordance with the Declaration of Helsinki. After approval of the local ethic committee (number PV4219), all consecutive patients with PN or PN between January 2011 and December 2014 at the Department of Urology, University Medical Center Hamburg-Eppendorf, Germany, were identified. Exclusion criteria consisted of patients with eGFR < 60 ml/min/1.73^2 prior to surgery ($n = 54$), non-RCC histology ($n = 17$), trauma ($n = 1$) and death during follow-up ($n = 9$). These selection criteria resulted in 195 eligible patients.

Patient characteristics, renal function and AKI evaluation

Patients' baseline, blood, urine and tumor characteristics were analyzed retrospectively from patients' data files. Patients were treated with either an open or laparoscopic surgical approach.

Hypertension was defined as a systolic blood pressure of $\geq$ 140 mmHg and/or a diastolic blood pressure of $\geq$ 90 mmHg in accordance with current guidelines [17]. Moreover, proteinuria was defined as a detection of proteins by urine dipstick.

eGFR and creatinine were standardized assessed on the first day after surgery. eGFR was calculated according to the four variable MDRD Study Equation: GFR in ml/min/1.73^2 = 186 × (S-Creatinine − 1.154) × (age – 0.203) × 1.212 (if African-American race/ethnicity) × 0.742 (if female sex) [18,19]. Postoperative AKI was defined as either an $\geq$ 50% increase of the postoperative serum creatinine relative to preoperative serum creatinine or an absolute increase of $\geq$ 0.3 mg/dl in accordance with RIFLE or AKIN criteria [20].

Endpoints and follow-up

The primary endpoint of the study was postoperative AKI and tabulations were made according to AKI vs. non-AKI patients. Moreover, subsequent eGFR $<$ 60 ml/min/1.73^2 and eGFR $<$ 45 ml/min/1.73^2 were considered as further study endpoints, since an eGFR $\geq$ 60 ml/min/1.73^2 defines normal kidney function and levels below a moderate to severe kidney impairment [21]. Additionally, comorbidities were analyzed regarding their impact on kidney function impairment.

Patients underwent a follow-up through a standardized survey supported by the treating urologist or family doctor. The survey consisted of questions addressing baseline characteristics (e.g. body mass index [BMI] or blood pressure levels), new-onset diseases and blood and urine values, if available.

Statistical analyses

Descriptive statistics included frequencies and proportions for categorical and medians and interquartile ranges (IQR) for continuous variables. The Chi-square and Kruskal-Wallis tests assessed differences among groups as appropriate.

Three sets of univariable and multivariable logistic regression models were fitted to identify predictors of postoperative AKI, eGFR $<$ 60 ml/min/1.73^2 and eGFR $<$ 45 ml/min/1.73^2. All statistical analyses were performed using the R statistical package system 3.4.3 (R Foundation for Statistical Computing, Vienna, Austria), with a two-sided significance level set at $p < 0.05$ [22].

Results

Preoperative baseline characteristics and acute kidney function impairment

Of all eligible 195 patients (Table 1), 127 (65.1%) exhibited postoperative AKI. According to preoperative kidney function, no differences were observed between AKI vs. non-AKI patients regarding preoperative eGFR (88 vs. 87 ml/min/1.73 m^2, $p = 0.7$) and preoperative serum creatinine values (0.9 vs. 0.9 mg/dl, $p = 0.6$). Moreover, no differences were observed according to preoperative proteinuria ($p = 0.5$). Median age was 60 years (IQR = 51–68) for AKI vs. 61 (50–71) years for non-AKI patients ($p = 0.5$). No significant differences were observed concerning patients' sex or obesity (BMI $\geq$ 30 m/kg^2) in both groups (both $p \geq 0.07$). Patients with postoperative AKI had a significantly higher proportion of preoperative diabetes (17.3 vs. 5.9%, $p = 0.046$) and hypertension (46.5 vs. 23.5%, $p < 0.01$) than non-AKI patients. AKI patients underwent RN significantly more frequently than non-AKI patients (44.9 vs. 13.2%, $p < 0.001$). Additionally, median tumor size was 4.5 cm (IQR 3.4–6.4) in the AKI vs. 2.5 cm (IQR 2.1–4.5) in the non-AKI group ($p < 0.001$). Trends towards higher pT-stages were observed in AKI vs. non-AKI patients (pT2: 10.2 vs. 5.9%, pT3–4: 7.2 vs. 4.4%, $p = 0.2$).

Postoperative eGFR was significantly lower in AKI patients compared to non-AKI patients (51 [IQR 43–60] vs. 75 [IQR 63–87] ml/min/1.73 m^2, $p < 0.001$). Postoperative serum creatinine was significantly elevated in the AKI cohort (1.4 [IQR 1.2–1.6] vs. 1.0 [0.9–1.1] mg/dl, $p < 0.001$). In both the AKI and no AKI cohort, the postoperative creatinine value significantly increased, relative to the preoperative creatinine value (both $p < 0.001$). Conversely, the postoperative eGFR did not differ in both groups, relative to the preoperative level (both $p > 0.05$).

Prediction of postoperative AKI

In univariable logistic regression models (Table 2), preoperative diabetes (odds ratio [OR] = 3.31, confidence interval [CI] = 1.20–11.71), preoperative hypertension (OR = 3.14, CI = 1.59–6.42) and RN (OR = 5.34, CI = 2.54–12.37) were associated with postoperative AKI (all $\leq$ 0.03). After multivariable adjustment, hypertension (OR = 2.93, CI = 1.42–6.23) and the surgical approach with RN (OR = 3.84, CI = 1.71–9.34)

Table 1. Descriptive characteristics.

Variable		Overall ($n = 195$)	No AKI ($n = 68$) (34.9%)	AKI ($n = 127$) (65.1%)	*p*-value
Age, in years	Median (IQR)	60 (50–70)	61 (50–71)	60 (51–68)	0.521
	Range	19–84	37–79	19–84	
Sex	Female	61 (31.3)	25 (36.8)	36 (28.3)	0.295
	Male	134 (68.7)	43 (63.2)	91 (71.7)	
BMI, in kg/m^2	< 30	136 (69.7)	55 (80.9)	81 (63.8)	0.066
	≥ 30	46 (23.6)	11 (16.2)	35 (27.6)	
Surgical approach	PN	129 (66.2)	59 (86.8)	70 (55.1)	<0.001
	RN	66 (33.8)	9 (13.2)	57 (44.9)	
Surgical side	Left	102 (52.3)	38 (55.9)	64 (50.4)	0.561
	Right	93 (47.7)	30 (44.1)	63 (49.6)	
	Open	151 (77.4)	54 (79.4)	97 (76.4)	
pT stage	pT1	120 (61.5)	43 (63.2)	77 (60.6)	0.231
	pT2	17 (8.7)	4 (5.9)	13 (10.2)	
	pT3–4	12 (6.1)	3 (4.4)	9 (7.2)	
	pTx	46 (23.6)	19 (28.0)	27 (21.3)	
Preoperative diabetes	Yes	26 (13.3)	4 (5.9)	22 (17.3)	0.046
Preoperative proteinuria	Yes	39 (20)	11 (16.2)	28 (22.0)	0.453
Preoperative blood pressure	Elevated	75 (38.5)	16 (23.5)	59 (46.5)	<0.01
Preoperative eGFR, in ml/min/1.73 m^2	Median (IQR)	88 (76–103)	87 (76–101)	88 (76–104)	0.664
	Range	60–200	60–127	61–200	
Preoperative creatinine, in mg/dl	Median (IQR)	0.9 (0.8–1.0)	0.9 (0.8–1.0)	0.9 (0.8–1.0)	0.648
	Range	0.5–1.3	0.6–1.2	0.5–1.3	
Blood loss, in ml	Median (IQR)	100 (0–300)	100 (0–200)	100 (50–300)	0.129
	Range	0–2000	0–1000	0–2000	
Tumor size, in cm	Median (IQR)	4.2 (2.4–5.8)	2.5 (2.1–4.5)	4.5 (3.4–6.4)	<0.001
	Range	0.5–16.3	0.5–15.4	1.1–16.3	
Postoperative eGFR, in ml/min/1.73 m^2	Median (IQR)	58 (48–71)	75 (63–87)	51 (43–60)	<0.001
	Range	13–108	47–108	13–102	
Postoperative creatinine, in mg/dl	Median (IQR)	1.2 (1.0–1.5)	1.0 (0.9–1.1)	1.4 (1.2–1.6)	<0.001
	Range	0.6–3.8	0.6–1.4	0.9–3.8	
Postoperative proteinuria	Yes	90 (46.2)	34 (50.0)	56 (44.1)	0.067
Follow-up eGFR, in ml/min/1.73 m^2	Median (IQR)	67 (53–84)	84 (77–90)	56 (50–66)	<0.001
	Range	35–110	62–110	35–93	
Follow-up creatinine, in mg/dl	Median (IQR)	1 (0.9–1.2)	0.9 (0.8–1.0)	1.1 (1.0–1.4)	<0.001
	Range	0.5–2.0	0.5–1.7	0.6–2.0	
Follow-up: New onset hypertonia	Yes	6 (3.1)	2 (2.9)	4 (3.1)	0.999
Follow-up: Cardiovascular disease	Yes	16 (8.2)	4 (5.9)	12 (9.4)	0.388
Follow-up: Proteinuria	Yes	8 (4.1)	2 (2.9)	6 (4.7)	0.888
Follow-up: eGFR < 60 ml/min/1.73 m^2	Yes	29 (14.9)	5 (7.4)	24 (18.9)	0.012

Descriptive characteristics of 195 patients who underwent either partial (PN) or radical nephrectomy (RN) at the University Hospital Hamburg-Eppendorf, stratified according to postoperative acute kidney injury (AKI).
Abbreviations: IQR: Interquartile range, BMI: Body mass index, eGFR: estimated glomerular filtration rate.

Table 2. Prediction of AKI.

	Univariable			Multivariable		
	OR	95% CI	*p*-value	OR	95% CI	*p*-value
Age ≤ 60 years	1 (Ref.)	–	–	1	–	–
Age > 60 years	0.98	0.54–1.78	0.958	0.99	0.48–2.03	0.979
No preoperative diabetes	1 (Ref.)	–	–	1	–	–
Preoperative diabetes	3.31	1.20–11.71	0.035	2.71	0.89–10.24	0.101
No hypertension	1 (Ref.)	–	–	1	–	–
Hypertension	3.14	1.59–6.42	0.001	2.93	1.42–6.23	0.004
PN	1 (Ref.)	–	–	1	–	–
RN	5.34	2.54–12.37	< 0.001	3.84	1.71–9.34	0.002

Univariable and multivariable logistic regression models predicting postoperative acute kidney injury (AKI), after either partial (PN) or radical nephrectomy (RN).
Abbreviations: OR: Odds ratio. CI: Confidence interval.

were independent risk factors for postoperative AKI (both $p < 0.01$).

Kidney function in follow-up

To reduce the possibility of a selection bias, we compared patients with and without follow-up regarding the parameters of Table 1. We found that no differences existed regarding all parameters (all $p > 0.05$). Median follow-up was 14 months (IQR = 10–20). Of all included patients, 46.2% ($n = 95$) participated in the follow-up. Here, eGFR was significantly lower in AKI patients, relative to non-AKI patients (56 [IQR 50–66] vs. 84 [IQR 77–90] ml/min/1.73 m^2, $p < 0.001$). Postoperative serum creatinine was maintained to be significantly elevated in the post AKI cohort (1.1 [IQR = 1.0–1.4] vs. 0.9 [IQR = 0.8–1.0] mg/dl, $p < 0.001$). An eGFR < 60 ml/min/1.73 m^2 was observed in 18.9% AKI vs. 7.4% non-AKI patients ($p = 0.01$). No differences were observed according to new-onset hypertension (3.1 vs. 2.9%, $p = 1$).

Table 3. Prediction of eGFR < 60 ml/min/1.73 m^2 and < 45 ml/min/1.73 m^2.

eGFR $<$ 60 ml/min/1.73 m^2	n 109	Univariable OR	Univariable 95% CI	Univariable p-value	Multivariable OR	Multivariable 95% CI	Multivariable p-value
Age $\leq$ 60 years	43	1 (Ref.)	–	–	1	–	–
Age $>$ 60 years	66	2.72	1.53–4.93	$<$0.001	3.02	1.52–6.17	0.002
No preoperative diabetes	90	1 (Ref.)	–	–	1	–	–
Preoperative diabetes	19	2.26	0.94–6.06	0.082	2.56	0.91–8.05	0.086
No hypertension	39	1 (Ref.)	–	–	1	–	–
Hypertension	49	2.32	1.24–4.42	0.001	1.82	0.91–3.67	0.091
PN	57	1 (Ref.)	–	–	1	–	–
RN	52	4.69	2.42–9.58	$<$0.001	3.63	1.72–8.05	0.001
eGFR $<$ 45 ml/min/1.73 m^2	40						
Age $\leq$ 60 years	15	1 (Ref.)	–	–	1	–	–
Age $>$ 60 years	25	1.92	0.95–4.00	0.073	2.07	0.92–4.89	0.085
No preoperative diabetes	28	1 (Ref.)	–	–	1	–	–
Preoperative diabetes	18	4.19	1.74–10.08	0.001	4.27	1.59–11.52	0.004
No hypertension	13	1 (Ref.)	–	–	1	–	–
Hypertension	21	2.21	1.03–4.91	0.045	1.72	0.76–3.97	0.195
PN	19	1 (Ref.)	–	–	1	–	–
RN	21	2.70	1.33–5.54	0.006	2.06	0.90–4.74	0.086

Univariable and multivariable logistic regression models predicting postoperative estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m^2 and < 45 ml/min/1.73 m^2, after either partial (PN) or radical nephrectomy (RN).
Abbreviations: OR: Odds ratio. CI: Confidence interval.

Prediction of postoperative eGFR < 60 and <45 ml/min/1.73 m^2

In univariable logistic regression models (Table 3), age $>$ 60 years (OR = 2.72, CI = 1.53–4.93), preoperative hypertension (OR = 2.32, CI = 1.24–4.42) and RN (OR = 4.69, CI = 2.42–9.58) were associated with postoperative eGFR $<$ 60ml/min/1.73 m^2 (all $\leq$ 0.01). After multivariable adjustment, age $>$ 60 years (OR = 3.02, CI = 1.52–6.17) and RN (OR = 3.63, CI = 1.72–8.05) remained as independent risk factors for postoperative eGFR $<$ 60 ml/min/1.73 m^2 (both $p = 0.001$).

In univariable logistic regression models (Table 3), preoperative diabetes (OR = 4.19, CI = 1.74–10.08), preoperative hypertension (OR = 2.21, CI = 1.03–4.91) and RN (OR = 2.70, CI = 1.33–5.54) were associated with postoperative eGFR $<$ 45 ml/min/1.73 m^2 (all $\leq$ 0.04). After multivariable adjustment, preoperative diabetes (OR = 4.27, CI = 1.59–11.52) was independently associated with postoperative eGFR $<$ 45 ml/min/1.73 m^2 ($p < 0.01$).

Discussion

In comparison to historical cohorts, contemporary evidence suggests a higher relevance of comorbidities on the risk of postoperative AKI and persisting kidney function impairment after RCC surgery. To this extent, our current institutional study holds several noteworthy findings.

First, 65% of all patients developed AKI after PN or RN. Moreover, we found that patients with postoperative AKI mostly underwent RN (44.9 vs. 13.2%) and tumor size was significantly larger (4.5 vs. 2.5 cm). Additionally, AKI patients harbored more frequently preoperative diabetes compared to patients with no AKI (17.3 vs. 5.9%). Conversely, no statistical differences were observed according to age, sex or BMI or preoperative proteinuria. According to the frequency of postoperative AKI, our findings differ from previous publications. Specifically, in a study by Bravi et al. [23], relying exclusively on a cohort with T1 RCC tumors, only 20% of patients developed postoperative AKI. However, it is particularly important to emphasize that in our cohort only 62% of all patients harbored pT1 stage RCC. In consequence, the higher rates of postoperative AKI in our cohort may be explained by larger tumor size and less scrutinized nephron-sparing surgery of the 38% of patients with non-pT1 tumors. Regarding preoperative patient characteristics, Bravi et al. [23] also recorded that patients with postoperative AKI harbored significantly more frequently preoperative diabetes, hypertension and larger tumor sizes. However, it needs to be mentioned that the study by Bravi et al. only focused on PN, while the current study also included RN.

Additionally, some studies suggested worse long-term outcomes (CKD, less overall survival) in RCC patients with preoperative proteinuria, but did not comment on its predictive value for AKI [12,24,25]. In the current study, no differences between preoperative proteinuria and postoperative AKI and further kidney function deterioration were observed. Consequently, our data suggest that preoperative proteinuria may not be a sufficient predictor for short-term postoperative renal impairment.

In summary, our data support previous findings that the amount of postoperative AKI is invariably linked to tumor size/pT stage and preoperative risk factors such as diabetes.

Second, follow-up results of the current study showed that AKI subsequently impairs renal function. Patients who experienced AKI also had lower eGFR (56 vs. 84 ml/min/1.73 m^2) and higher serum creatinine (1.1 vs. 0.9 mg/dl) levels after median 14 months. These observations are in agreement with the findings of Cho et al. [11]. Here, in a cohort of 517 RN, patients with postoperative AKI had a 4.2-fold higher risk of new-onset CKD after 3 years of surgery. Regarding our short follow-up it is of note that the potential of normalization of renal function after 1 year was comparably low. Additionally, in the study by Bravi et al. [23], focusing solely on RN, 51% of AKI patients developed CKD and had a −17% change in the eGFR after 1-year follow-up. Conversely, patients without AKI were at lower risk for subsequent CKD. Compared to our cohort, 18.9% of AKI patients and only 7.4% of non-AKI patients exhibited an eGFR $<$ 60 ml/min/

1.73 m^2 in the follow-up. In consequence, according to CKD definitions, CKD rates in follow-up were approximately 2.5-fold higher in our AKI cohort, relative to non-AKI patients [26].

Capitanio et al. [7] showed hypertension and cardiovascular event rates after 5 years of kidney surgery of, respectively, 3.3 and 6.3%. Regarding new-onset hypertension or other comorbidities, no valid statements could be made in the current study, which is probably related to a follow-up duration that may be too short for valid statements on new-onset of diseases.

Third, we also made important observations according to predictors for renal function impairment. Specifically, we found that preoperative hypertension and RN were independently associated with postoperative AKI in multivariable logistic regression models. Moreover, in multivariable logistic regression models, age $>$ 60 years and RN, as well as diabetes were independent predictors for, respectively, postoperative eGFR $<$ 60 and $<$ 45 ml/min/1.73 m^2. These findings are partially in agreement with previous studies. For example, Cho et al. [11] also found that age was a significant predictor for postoperative AKI. Conversely, hypertension was not associated in that only the RN treated patient cohort was associated with AKI. Moreover, in a study from 2012 by Miyamoto et al. [27], RN and age were independently associated with a postoperative eGFR $<$ 60 ml/min/1.73 m^2. In consequence, our findings regarding predictors for kidney impairment in a contemporary surgical cohort are in line with more historical reports.

In general, our findings are not surprising, since hypertension and diabetes are well-known and investigated risk factors for CKD even without kidney surgery [28,29]. Thus, removal of any kidney tissue with PN or RN may pronounce the onset of kidney impairment in combination with those medical risk factors. These facts deserve specific consideration in clinical treatment decision-making for suspicious kidney lesions and physicians should ideally always ask about comorbidities when patients are counseled for possible surgical treatment. Nonetheless, it should be emphasized that previous studies suggested that surgical induced CKD is associated with lower overall mortality rates than medically-induced CKD [30,31]. These observations should be considered in the interpretation of the current study, even though we excluded patients with an eGFR $<$ 60 ml/min/1.73^2 to reduce the risk of only medically-induced CKD.

Our study has several limitations and has to be interpreted in the light of its retrospective design (for example, no duration of ischemia time available). Some of our findings may lack statistical significance due to sample size limitations, especially in the logistic regression models. Also, approximately only the half of all included patients participated in the follow-up, which may bias follow-up results. Moreover, follow-up was not obtained at standardized time points after surgery. In consequence, our data do not allow a strict interpretation of longitudinal blood values. Due to the inclusion period (2011–2014) one would interpret the current study as semi-contemporary. However, the inclusion period allows a mature follow-up duration. Fourth, the mechanism of AKI after either RN or PN may be based on different physiological phenomena and needs to be considered in the interpretation of the current study [32,33]. Here, for example, the ischemia time may also be an important variable for PN patients to quantify the AKI extent. Moreover, other comorbidities may have also contributed to a postoperative AKI but were unfortunately not available. Finally, due to real-world assessment of blood values in surgically-treated patients, our AKI definition relied on creatinine values assessed on the first postoperative day, while other studies relied on the highest value within the first 7 postoperative days [11,23]. In consequence, higher creatinine values on other postoperative days may have been missed and our AKI definition needs to be interpreted in this light of an early introduced and assessed AKI.

However, our results provide important information about patients with increased risk for postoperative AKI and renal function impairment. We found that AKI patients differ with respect to preoperative comorbidities, relative to non-AKI patients. Second, patients with postoperative AKI also have a higher risk for worse kidney function after a median follow-up duration of 14 months.

Postoperative AKI is a non-negligible event in RCC surgery cohorts that can be further triggered by comorbidities such as hypertension and diabetes. Patients should be counseled about the increased risk of consecutive renal function impairment and the need of regularly care by a nephrologist.

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Disclosure statement

The authors report no conflicts of interest.

Data availably statement

Data are available for bona fide researchers who request it from the authors.

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