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ORIGINAL ARTICLE

The impact of visceral adipose tissue on postoperative renal function after radical nephrectomy for renal cell carcinoma

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ABSTRACT

BACKGROUND: The objective of this study was to evaluate the usefulness of pre-operative visceral (VAT) and subcutaneous adipose tissue (SAT) evaluation in the prediction of acute kidney injury (AKI) and decrease of eGFR at 12 months after radical nephrectomy (RN).

METHODS: We relied on 112 patients who underwent RN between January 2010 and March 2017 at a single institution. Images from the pre-operatory CT scan were analyzed and both SAT and VAT assessments were carried out on a cross-sectional plane. eGFR was measured before surgery, at 7 days, and 12 months after surgery. ROC analysis was used to compare the diagnostic value of BMI, VAT ratio, and abdominal circumference in predicting AKI. Logistic regression models were fitted to predict the new onset of AKI, and the progression from chronic kidney disease (CKD) stage 1-3a to CKD stage 3b or from 3b to 4 at 12 months follow-up. Two logistic regression models were also performed to assess the predictors for AKI and CKD stage progression. The predictive accuracy was quantified using the receiver operating characteristic-derived area under the curve.

RESULTS: Sixty-six patients (58.9%) had AKI after RN. Thirty-five (31.3%) patients were upgraded to CKD IIIb or from CKD stage IIIb to CKD IV. In the ROC analysis, VAT% performed better than the BMI and abdominal circumference (AUC=0.66 *vs.* 0.49 and 0.54, respectively). At multivariable analyses, VAT reached an independent predictor status for AKI (OR: 1.03) and for CKD stage at 12-month follow-up (OR: 1.05). Inclusion of VAT% into the multivariable models was associated with the highest accuracy both for AKI (AUC=0.700 *vs.* 0.570) and CKD stage progression (AUC=0.848 *vs.* 0.800).

CONCLUSIONS: In patients undergoing RN, preoperative visceral adipose tissue ratio significantly predicts AKI incidence and is significantly predictive of 12-month CKD stage worsening.

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KEY WORDS: Renal cell carcinoma; Acute kidney injury; Nephrectomy; Subcutaneous fat; Intra-abdominal fat.

Radical nephrectomy (RN) represents the treatment of choice for stage T2-3 renal cell carcinoma (RCC) or localized masses smaller than 7 cm for which partial nephrectomy is not technically feasible.[1, 2] However, nephrectomy itself has a detrimental effect on renal function and could be associated with postoperative acute kidney injury[3] and new-onset of CKD[4, 5] with potential negative outcomes on cardiovascular and overall survival.[6, 7]

Obesity is an independent risk factor for the development of CKD, ESRD,[8, 9] and postoperative cardiovascular events.[10] Obesity is usually detected through Body Mass Index calculation, even if it does not evaluate the adipose tissue distribution.[11, 12] Visceral adiposity, as measured by CT scan, has been suggested to be a better predictor of kidney injury as compared to BMI and waist circumference.[13, 14] Recent studies confirm that the preoperative adipose tissue distribution in living kidney donors could predict the recovery of postoperative renal function.[15, 16] The recognition of predictive factors for long-term renal function is paramount in the management and counseling of patients suffering from kidney tumors.

The present study aims to evaluate the effect of abdominal adipose tissue distribution on AKI incidence and worsening in renal function at 12 months after RN.

Materials and methods

We evaluated data of consecutive patients who underwent radical nephrectomy for renal cell carcinoma at our institution between January 2010 and March 2017. Clinical data including age, race, gender, BMI, diabetes mellitus, hypertension, and preoperative serum creatinine were collected from patient medical records. Serum creatinine and eGFR were evaluated before surgery, on postoperative day (POD) 7 as well as at 12 months follow-up. Chronic kidney disease epidemiology (CKD-EPI) collaboration equation[17] was used to estimate GFR. Postoperative acute kidney injury at discharge was defined according to the latest classification of AKI proposed by the Acute Kidney Injury Working Group of KDIGO (Kidney Disease: Improving Global Outcomes).[18] Patients with a solitary kidney or undergoing nephrectomy for malignancies of other histology than RCC or benign pathologies were excluded from this study. The absence of available CT imaging and missing follow-up data were considered as exclusion criteria.

Adipose tissues evaluation

Images from the staging contrast-enhanced Computed Tomography scan performed within 60 days before surgery were analyzed by our dedicated team of radiologists. Subcutaneous adipose tissue (SAT), visceral adipose tissue (VAT), total adipose tissue (TAT), and abdominal circumference assessment were carried out in the portal venous phase, on a cross-sectional plane passing through the umbilical plane. Aquarius Software, version 4.413 (Terarecon, Foster City, CA, USA) automatically identified fat and muscle tissues using predefined values; fat density ranged from 150 to 50 HU, and muscle density ranged from 0 to 200 HU. The software classified VAT and SAT based on intersected muscle density as is shown in Figure 1. The complete method used to measure various tissues has been previously published.[19] VAT% was calculated using the formula: VAT%=(VAT/TAT) ×100.

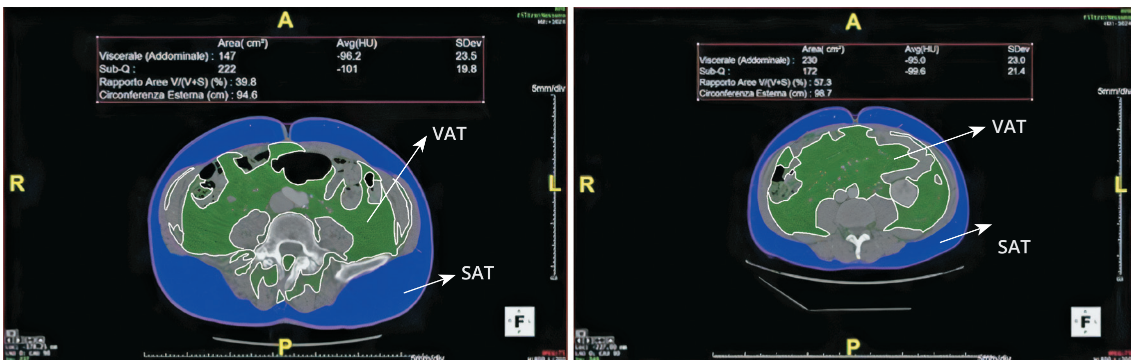

Figure 1.—Radiological measurement of visceral and subcutaneous adipose tissue. Two patients with a similar BMI (26.3 *versus* 26.1 kg/m²) and abdominal circumference. The patient on the left has a favorable (39.8%) VAT% compared to the right one (57.3%). SAT: surrounding dark grey area (blue in the online version); VAT: internal gray area outlined in white (green in the online version).

Statistical analysis

Medians and interquartile ranges were used to report continuous variables. Frequencies and proportions were used to report categorical variables.

Univariable and multivariable binary logistic regression models were used to predict the onset of AKI, as defined by KIDGO. The same analysis was performed to predict the worsening of CKD stage, defined as a progression from CKD stage 1-3a to stage 3b or from stage 3b to stage 4. We also developed two logistic regression models to identify the independent predictors of AKI and CKD stage progression. Model 1 included as predictors age, BMI, abdominal circumference. Model 2 included as predictors the same variables of Model 1 plus VAT%. The discrimination of the accuracy of the models was quantified using the receiver operating characteristic-derived area under the curve, where 100% indicates perfect prediction and 50% is considered equivalent to the toss of a coin. All statistical analyses were performed with SPSS software, version 23 (IBM Corp., Armonk, NY, USA), assuming a two-sided test at the conventional 0.05 level of significance.

Results

One hundred and twenty patients undergone RN, for renal cell carcinoma at our institution between January 2010 and March 2017, of these eight patients (6.6%) were excluded due to the absence of available CT imaging or missing follow-up data. A total of 112 patients were included in the study. All patients were Caucasian. Table I reports the baseline characteristics of the population. Median patient age was 67.0 (IQR=56-75) years and 82 patients (73.2%) were male. Median visceral adipose tissue and subcutaneous adipose tissue were 147 cm^2 (IQR 105-214) and 186 cm^2 (134-249) respectively, resulting in a median VAT% of 44 (IQR 35-53). Median preoperative and 7th POD eGFR were 71 (IQR 54-84) and 52 mL/min (IQR 42-63) respectively, with a median reduction of 17 ml/min (IQR 6-29). Among all patients, 58 (51.7%) developed AKI according to the KDIGO criteria. Median 12-month serum creatinine was 1.4 mg/dL (IQR 1.1-1.6) and median 12 months eGFR was 52.0 mL/min (IQR 39.0-64.0) with a mean eGFR% loss of 21.5% as compared to preoperative eGFR. Thirty-five (31.3%) patients were upgraded to CKD IIIb or from CKD stage IIIb to CKD IV.

At multivariable analyses, only VAT% (OR=1.05, 95% CI 1.00-1.09, P=0.018) represented independent predictors of postoperative AKI. The full model is reported in Table II. Preoperative eGFR (OR=0.97, 95% CI 0.94-0.99, P=0.027), and VAT% (OR=1.03, 95% CI 0.99-1.06, P=0.033) resulted to be independent predictors of worsening of CKD stage at 12 months' follow-up. The full model is reported in Table III.

The AUC of the two models predicting AKI was 0.570, and 0.700, respectively. The AUC of the two models in the prediction of CKD stage

Table I.—*Clinic and demographics characteristics of cohort.*

Variable	Median [IQR] or N. (%)
N. of patients	112
Age (year)	67 [56-75]
Male	82 (73.2%)
Body Mass Index	26.1 [23.8-27.7]
Hypertension	53 (47.3%)
Diabetes	15 (13.4%)
Histology	
Clear cell	96 (85.7%)
Papillary type I	4 (3.6%)
Papillary type II	5 (4.5%)
Chromophobe	7 (6.2%)
T stage	
T1a	21 (18.8%)
T1b	31 (27.7%)
T2a	14 (12.5%)
T2b	4 (3.6%)
T3a	31 (27.7%)
T3b	8 (7.1%)
T3c	2 (1.8%)
T4	1 (0.9%)
Preoperative serum creatinine (mg/dL)	1.0 [0.9-1.2]
Preoperative eGFR (mL/min)	71.0 [54-84]
CKD stage	
Stage I	20 (17.9%)
Stage II	60 (53.6%)
Stage IIIa	20 (17.9%)
Stage IIIb	8 (7.1%)
Stage IV	4 (3.6%)
Visceral adipose tissue (cm^2)	147 [105-214]
Subcutaneous adipose tissue (cm^2)	186 [134-249]
VAT%	44 [35-53]
Abdominal circumference (cm)	95 [70-123]

eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease; VAT: visceral adipose tissue.

TABLE II.—*The univariate and multivariate analysis used to predict AKI.*

Variable	Univariate			Multivariate		
	P value	OR	95% CI	P value	OR	95% CI for OR
Age >65 years	0.88	0.93	0.38-2.28			
Sex (male)	0.14	2.06	0.77-5.52			
BMI (continuous)	0.79	1.01	0.90-1.14			
Hypertension	0.55	1.31	0.53-3.21			
Diabetes	0.79	1.19	0.31-4.60			
Preoperative eGFR (continuous)	0.018	1.01	0.99-1.03	0.39	1.01	0.98-1.05
VAT% (continuous)	0.022	1.04	1.00-1.08	0.018	1.05	1.00-1.09

OR: odds ratio; CI: confidence interval; eGFR: estimated glomerular filtration rate; VAT: visceral adipose tissue.

TABLE III.—*The univariate and multivariate analysis used to predict 12 months CKD stage worsening.*

Variable	Univariate			Multivariate		
	P value	OR	95% CI	P value	OR	95% CI for OR
Age >65 years	0.027	0.33	0.13-0.88	0.28	0.56	0.19-1.60
Sex (male)	0.98	0.99	0.36-2.66			
Hypertension	0.22	0.58	0.23-1.40			
Diabetes	0.73	0.81	0.23-2.78			
BMI (continuous)	0.24	1.07	0.95-1.21			
Preoperative eGFR (continuous)	0.004	0.96	0.94-0.98	0.027	0.97	0.94-0.99
VAT% (continuous)	0.026	1.03	1.01-1.07	0.033	1.03	1.02-1.05

OR: odds ratio; CI: confidence interval; eGFR: estimated glomerular filtration rate; VAT: visceral adipose tissue.

progression was 0.800, and 0.848, respectively; our data showed the importance of inclusion of VAT to better identify patients at higher risk of AKI and CKD stage progression.

Discussion

In this study, we found a potential role for the evaluation of the adipose tissue distribution, measured during the preoperative contrast-enhanced CT scan, in the prediction of both postoperative AKI incidence and CKD stage progression in a cohort of patients treated with RN for RCC.

It is clinically relevant to identify the patients that will show a decrease in renal function after oncological kidney surgery. Historically, factors known to influence the renal function after the surgical management of RCC are represented by the type of surgery (partial *vs*. radical nephrectomy; open *vs*. mini-invasive),[20-22] the preoperative renal function, and patient age.[23] Moreover, diabetes and uncontrolled hypertension are also reported to be crucial predictors of ESRD regardless of the treatment delivered. Partial nephrectomy seems to be associated with a lower risk of ESRD relative to RN.[7] Larcher *et al.* reported that nephron-sparing surgery significantly decreases the risk of 10-years other cause mortality relative to RN to the increasing pre-operative Charlson Comorbidity Index, while such advantage was not consistently demonstrated in all patients suffering from kidney cancer.[24] Moreover, in a study including more than 2000 patients treated for unilateral cT1 RCCC, RN was associated with an increased risk of chronic kidney disease compared with PN, but not associated with cancer-specific mortality or all-cause mortality.[25] According to Bhindi *et al.*, age, diabetes, preoperative eGFR, preoperative proteinuria, and tumor size were predictors of long-term eGFR at any point in time beyond 30 days, with preoperative eGFR being the strongest individual predictor.[26] Recently Xu *et al.* proposed a nomogram to predict the risk of AKI in patients undergoing RN, they found that patients with a higher preoperative eGFR were less subject to AKI.[27] In our study, we confirm the power of preoperative eGFR in the prediction of renal function.

Our findings could have a major clinical implication. The standard preoperative measurement of obesity is usually performed through BMI and waist circumference. It has been demonstrated that BMI is associated with the development of CKD,[8, 9] and postoperative cardiovascular events.[10] Body Mass Index, however, does not precisely correlate with adipose tissue distribution.[28] Several studies reported a close correlation between VAT distribution and CKD incidence.[13, 14, 29] The VAT is known to work as an endocrine organ that secretes adipokines and various bioactive proteins, its accumulation causes the onset of various metabolic and circulatory diseases and is correlated with various diseases forming the metabolic syndrome.[30] Moreover, obesity causes renal impairments via infiltration of free fatty acids in the kidney and increasing the circulatory level of inflammatory adipokines.[31] Following this trend, our results demonstrated that preoperative VAT ratio could be a prognostic factor for immediate and long term post-operative renal function worsening and should be taken into consideration during the pre-operative assessment of patients with RCC.

Notably, our study confirms the similar results obtained in the kidney transplantation field. Hori et al show that the preoperative VAT distribution affects the renal function after donor nephrectomy,[16] and Lee *et al.* demonstrated that renal function recovery after donor nephrectomy can be predicted by VAT ratio.[15] Cho *et al.* reported that more than 30% of patients who underwent radical RN experienced post-operative AKI, and identified older age, male sex, high BMI, and high preoperative GFR as independent risk factors for postoperative AKI.[3] In addition, obesity was found to be a predictor of the incidence of AKI in a study analyzing both partial and radical nephrectomy patients.[32] Finally, male gender and preoperative eGFR were associated with AKI after RN also in a study from Ellis *et al.*[33]

Recently, a study by Antonelli *et al.* reported that renal function could have an oncological role in patients undergoing surgery for RCC.[34] Interestingly, increased visceral obesity was also found to be associated with higher Fuhrman grade in patients with cT1a renal cell carcinoma[35] and an association between VAT% and risk of disease recurrence was observed among patients with localized renal cell carcinoma.[36] Despite the fact that the oncological role of adipose tissue distribution was beyond the scope of our work, we did not confirm this significance in our cohort (data not shown).

To our knowledge, this is the first study to correlate the distribution of abdominal adipose tissue with AKI incidence and the eGFR decrease after radical nephrectomy for RCC. Future studies examining the role of VAT ratio in different populations and in Nephron Sparing Surgery are needed.

Limitations of the study

Few points deserve further consideration. Firstly, this study includes a relatively small number of patients and the data have been analyzed retrospectively. Secondly, all participants were Caucasian, and is known that compared to Asians, white populations tend to have a higher BMI. Lastly, our pre-operative protocol did not include measurement of proteinuria, which is reported to be a predictor of kidney function outcomes.

Conclusions

In conclusion, our study demonstrated that the preoperative abdominal visceral adipose tissue ratio significantly predicts the AKI incidence and the 12 months' CKD stage worsening. An accurate evaluation of the adipose tissues' distribution could add information to identify patients at risk of developing AKI and CKD.

References

1. Ljungberg B, Albiges L, Abu-Ghanem Y, Bensalah K, Dabestani S, Fernández-Pello S, *et al.* European Association of Urology Guidelines on Renal Cell Carcinoma: The 2019 Update. Eur Urol 2019;75:799–810.

2. Veccia A, Dell'oglio P, Antonelli A, Minervini A, Simone G, Challacombe B, *et al.* Robotic partial nephrectomy versus radical nephrectomy in elderly patients with large renal masses. Minerva Urol Nefrol 2020;72:99–108.

3. Cho A, Lee JE, Kwon GY, Huh W, Lee HM, Kim YG, *et al.* Post-operative acute kidney injury in patients with renal cell carcinoma is a potent risk factor for new-onset chronic kidney disease after radical nephrectomy. Nephrol Dial Transplant 2011;26:3496–501.

4. Scosyrev E, Messing EM, Sylvester R, Campbell S, Van Poppel H. Renal function after nephron-sparing surgery versus radical nephrectomy: results from EORTC randomized trial 30904. Eur Urol 2014;65:372–7.

5. Mashni JW, Assel M, Maschino A, Russo M, Masi B, Bernstein M, *et al.* New Chronic Kidney Disease and Overall Survival After Nephrectomy for Small Renal Cortical Tumors. Urology 2015;86:1137–43.

6. Capitanio U, Terrone C, Antonelli A, Minervini A, Volpe A, Furlan M, *et al.* Nephron-sparing techniques independently decrease the risk of cardiovascular events relative to radical nephrectomy in patients with a T1a-T1b renal mass and normal preoperative renal function. Eur Urol 2015;67:683–9.

7. Capitanio U, Larcher A, Terrone C, Antonelli A, Volpe A, Fiori C, *et al.* End-Stage Renal Disease After Renal Surgery in Patients with Normal Preoperative Kidney Function: Balancing Surgical Strategy and Individual Disorders at Baseline. Eur Urol 2016;70:558–61.

8. Hsu CY, Iribarren C, McCulloch CE, Darbinian J, Go AS. Risk factors for end-stage renal disease: 25-year follow-up. Arch Intern Med 2009;169:342–50.

9. Stenvinkel P, Zoccali C, Ikizler TA. Obesity in CKD—what should nephrologists know? J Am Soc Nephrol 2013;24:1727–36.

10. Antonelli A, Mari A, Longo N, Novara G, Porpiglia F, Schiavina R, *et al.*; Collaborators. Role of Clinical and Surgical Factors for the Prediction of Immediate, Early and Late Functional Results, and its Relationship with Cardiovascular Outcome after Partial Nephrectomy: Results from the Prospective Multicenter RECORd 1 Project. J Urol 2018;199:927–32.

11. Fox CS, Massaro JM, Hoffmann U, Pou KM, Maurovich-Horvat P, Liu CY, *et al.* Abdominal visceral and subcutaneous adipose tissue compartments: association with metabolic risk factors in the Framingham Heart Study. Circulation 2007;116:39–48.

12. Kim S, Cho B, Lee H, Choi K, Hwang SS, Kim D, *et al.* Distribution of abdominal visceral and subcutaneous adipose tissue and metabolic syndrome in a Korean population. Diabetes Care 2011;34:504–6.

13. Stępień M, Stępień A, Wlazeł RN, Paradowski M, Banach M, Rysz M, *et al.* Obesity indices and adipokines in non-diabetic obese patients with early stages of chronic kidney disease. Med Sci Monit 2013;19:1063–72.

14. Xu X, Zhao Y, Zhao Z, Zhu S, Liu X, Zhou C, *et al.* Correlation of visceral adiposity index with chronic kidney disease in the People's Republic of China: to rediscover the new clinical potential of an old indicator for visceral obesity. Ther Clin Risk Manag 2016;12:489–94.

15. Lee HH, Kang SK, Yoon YE, Huh KH, Kim MS, Kim SI, *et al.* Impact of the Ratio of Visceral to Subcutaneous Adipose Tissue in Donor Nephrectomy Patients. Transplant Proc 2017;49:940–3.

16. Hori S, Miyake M, Morizawa Y, Nakai Y, Onishi K, Iida K, *et al.* Impact of Preoperative Abdominal Visceral Adipose Tissue Area and Nutritional Status on Renal Function After Donor Nephrectomy in Japanese Living Donors for Renal Transplantation. Ann Transplant 2018;23:364–76.

17. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, *et al.*; CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration). A new equation to estimate glomerular filtration rate. Ann Intern Med 2009;150:604–12.

18. Kidney Disease: Improving Global Outcomes (KDIGO) Transplant Work Group. KDIGO clinical practice guideline for the care of kidney transplant recipients. Am J Transplant 2009;9(Suppl 3):S1–155.

19. Chung SJ, Kim D, Park MJ, Kim YS, Kim JS, Jung HC, *et al.* Metabolic syndrome and visceral obesity as risk factors for reflux oesophagitis: a cross-sectional case-control study of 7078 Koreans undergoing health check-ups. Gut 2008;57:1360–5.

20. Bianchi L, Schiavina R, Borghesi M, Chessa F, Casablanca C, Angiolini A, *et al.* Which patients with clinical localized renal mass would achieve the trifecta after partial nephrectomy? The impact of surgical technique. Minerva Urol Nefrol 2020;72:339–49.

21. Li J, Zhang Y, Teng Z, Han Z. Partial nephrectomy versus radical nephrectomy for cT2 or greater renal tumors: a systematic review and meta-analysis. Minerva Urol Nefrol 2019;71:435–44.

22. Grivas N, Kalampokis N, Larcher A, Tyritzis S, Rha KH, Ficarra V, *et al.*; J-ERUS/YAU Robotic Urology Working Group. Robot-assisted versus open partial nephrectomy: comparison of outcomes. A systematic review. Minerva Urol Nefrol 2019;71:113–20.

23. Mason R, Kapoor A, Liu Z, Saarela O, Tanguay S, Jewett M, *et al.* The natural history of renal function after surgical management of renal cell carcinoma: Results from the Canadian Kidney Cancer Information System. Urol Oncol 2016;34:486.e1–7.

24. Larcher A, Capitanio U, Terrone C, Volpe A, De Angelis P, Dehó F, *et al.* Elective Nephron Sparing Surgery Decreases Other Cause Mortality Relative to Radical Nephrectomy Only in Specific Subgroups of Patients with Renal Cell Carcinoma. J Urol 2016;196:1008–13.

25. Gershman B, Thompson RH, Boorjian SA, Lohse CM, Costello BA, Cheville JC, *et al.* Radical Versus Partial Nephrectomy for cT1 Renal Cell Carcinoma. Eur Urol 2018;74:825–32.

26. Bhindi B, Lohse CM, Schulte PJ, Mason RJ, Cheville JC, Boorjian SA, *et al.* Predicting Renal Function Outcomes After Partial and Radical Nephrectomy. Eur Urol 2019;75:766–72.

27. Xu L, Li C, Zhao L, Zhou B, Luo C, Man X, *et al.* Acute kidney injury after nephrectomy: a new nomogram to predict postoperative renal function. BMC Nephrol 2020;21:181.

28. Pinto-Sietsma SJ, Navis G, Janssen WM, de Zeeuw D, Gans RO, de Jong PE; PREVEND Study Group. A central body fat distribution is related to renal function impairment, even in lean subjects. Am J Kidney Dis 2003;41:733–41.

29. Fried LF, Lee JS, Shlipak M, Chertow GM, Green C, Ding J, *et al.* Chronic kidney disease and functional limitation in older people: health, aging and body composition study. J Am Geriatr Soc 2006;54:750–6.

30. Gómez-Hernández A, Beneit N, Díaz-Castroverde S, Escribano Ó. Differential Role of Adipose Tissues in Obesity and Related Metabolic and Vascular Complications. Int J Endocrinol 2016;2016:1216783.

31. Wahba IM, Mak RH. Obesity and obesity-initiated metabolic syndrome: mechanistic links to chronic kidney disease. Clin J Am Soc Nephrol 2007;2:550–62.

32. Schmid M, Abd-El-Barr AE, Gandaglia G, Sood A, Olugbade K Jr, Ruhotina N, *et al.* Predictors of 30-day acute kidney injury following radical and partial nephrectomy for renal cell carcinoma. Urol Oncol 2014;32:1259–66.

33. Ellis RJ, Del Vecchio SJ, Ng KL, Dimeski G, Pascoe EM, Hawley CM, *et al.* Factors associated with acutely elevated serum creatinine following radical tumour nephrectomy: the Correlates of Kidney Dysfunction-Tumour Nephrectomy Database study. Transl Androl Urol 2017;6:899–909.

34. Antonelli A, Minervini A, Sandri M, Bertini R, Bertolo R, Carini M, *et al.* Below Safety Limits, Every Unit of Glomerular Filtration Rate Counts: Assessing the Relationship Between Renal Function and Cancer-specific Mortality in Renal Cell Carcinoma. Eur Urol 2018;74:661–7.

35. Zhu Y, Wang HK, Zhang HL, Yao XD, Zhang SL, Dai B, *et al.* Visceral obesity and risk of high grade disease in clinical t1a renal cell carcinoma. J Urol 2013;189:447–53.

36. Park YH, Lee JK, Kim KM, Kook HR, Lee H, Kim KB, *et al.* Visceral obesity in predicting oncologic outcomes of localized renal cell carcinoma. J Urol 2014;192:1043–9.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions.—Alberto Olivero: protocol/project development, data collection, data analysis, manuscript writing/editing. Luca Basso: protocol/project development, data collection, data analysis. Emanuele Barabino: protocol/project development, data collection, data analysis. PM: protocol/project development, data collection. Nicolò Testino: protocol/project development, data collection. Francesco Chierigo: manuscript writing/editing. Paolo Dell'Oglio: manuscript writing/editing, data analysis. Carlo E. Neumaier: protocol/project development. Nazareno Suardi: manuscript writing/editing. Carlo Terrone: protocol/project development, data analysis, manuscript writing/editing. All authors read and approved the final version of the manuscript.

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