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The Effect of Enlarged Kidneys on Calculated Body Mass Index Categorization in Transplant Recipients With ADPKD



To the Editor: Autosomal dominant polycystic kidney disease (ADPKD) is the fourth leading cause of end-stage renal disease and the most common inherited kidney disease.¹ Patients with ADPKD undergo kidney transplantation at high rates, with many undergoing unilateral or bilateral nephrectomy along with transplantation to create space for the kidney allograft or treat symptoms of chronic pain and early satiety, among others.^{1–3} Enlarged kidneys may contribute substantially to overall body weight in patients with ADPKD, and body mass index (BMI) selection criteria may exclude patients from either listing or transplantation.^{4,5} With an increasing number of obese patients on dialysis, along with an increasing percentage of obese patients with end-stage renal disease being referred for kidney transplantation,^{6,7} BMI selection and exclusion criteria are important for transplantation.⁴ To date, it is unknown how much weight enlarged organs from ADPKD contribute to BMI except by estimations from imaging studies.⁸ In this study, we examined the contribution of kidney nephrectomy

specimen weights to BMI categorization in patients with ADPKD who underwent kidney transplantation.

We conducted a retrospective study using the electronic medical record at our center. We identified patients with ADPKD who received kidney transplantation and underwent unilateral or bilateral nephrectomies between 1998 and 2015. We performed a chart review and recorded patients' demographic characteristics, BMI at the time of transplant listing, and dialysis history. Using gross pathology reports, we recorded weights of nephrectomy specimens according to designation as left kidney and right kidney on the reports. We also recorded peri- and postoperative data from operation reports. For the primary analysis, patients were divided into 6 BMI categories designated by our institution's transplantation criteria (we also report categories defined by the Centers for Disease Control and Prevention).⁹ Kidney weights by BMI categories were compared using the Kruskal-Wallis test. The association between patients' BMI at transplant listing and total kidney specimen weight was measured by the Pearson correlation coefficient. To estimate the weight that enlarged kidneys contributed to patients' recorded BMI, we generated a "calculated BMI" after nephrectomy by subtracting patients' kidney specimen weights from their body weight and dividing by height. The total weight of both kidneys was subtracted in cases of bilateral nephrectomy. Simple and weighted Cohen's kappa analyses were performed to determine the degree of agreement between patients' BMI at transplant listing and their "calculated BMI." The Committee on Human Research at University of California, San Francisco, approved this study (Institutional Review Board no. 14-15601).

Between 1998 and 2015, 477 patients with ADPKD received kidney transplantation. Seventy patients underwent transplantation and nephrectomy ([Supplementary Table S1](#)); 54.3% ($n = 38$) were women and mean \pm SD age at the time of transplantation was 49.4 ± 7.92 years; 67.1% ($n = 47$) were white; 74.3% ($n = 52$) of patients had received dialysis before transplantation, with 88.5% ($n = 46$) of this group having had hemodialysis. The median (interquartile range) dialysis vintage was 20 (9, 68) months; 80% ($n = 56$) had simultaneous transplant and nephrectomy, with 82.9% ($n = 58$) and 17.1% ($n = 12$) of patients having had bilateral nephrectomy and unilateral nephrectomy, respectively. Three patients in our study were missing left kidney specimen weights even though they underwent bilateral nephrectomy, and 1 patient did not have a BMI listing. The total mean weight of combined left and right kidney specimens was 4.03 kg ([Figure 1](#)) (individual mean weights were 2.38 kg and 2.09 kg for

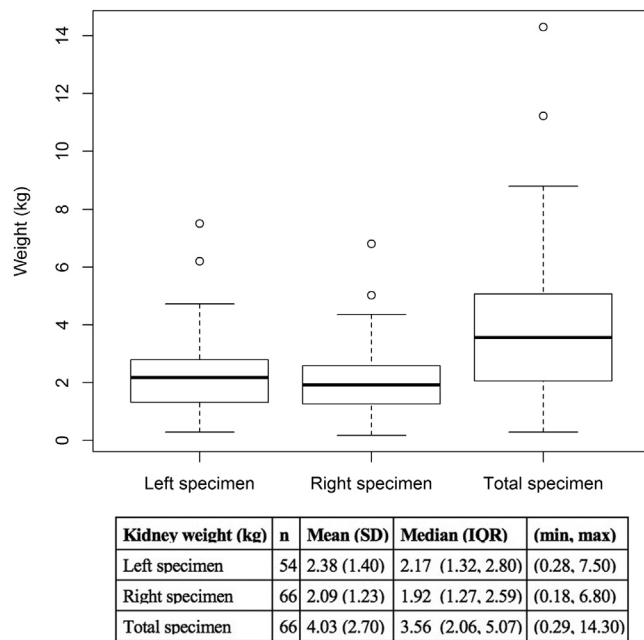


Figure 1. Box and whisker plots for left, right, and total kidney specimen weights. The average weight of total kidney specimen was 4.03 kg. IQR, interquartile range; max, maximum; min, minimum.

left and right kidneys, respectively). There were no significant differences in kidney weights among BMI categories (Supplementary Table S2). Supplementary Figure S1 shows a distribution plot demonstrating no significant correlation between patients' BMI at transplant listing and total kidney specimen weight. In our study population, 25.8% ($n = 17$) of patients were obese ($\text{BMI} > 30$), and 30.3% ($n = 20$) were overweight ($25 < \text{BMI} \leq 30$) at the time of transplant listing, as defined by the Centers for Disease Control and Prevention (Supplementary Table S3).⁹

After subtracting the weights of patient's nephrectomized kidneys from their preoperative body weight to generate a "calculated BMI," 19 patients

would have been reclassified into a new BMI category (Table 1). There were no significant demographic differences between patients who were reclassified compared with those who were not reclassified into a new BMI category (Supplementary Table S4). The mean \pm SD total kidney specimen weight of patients reclassified compared with those who were not reclassified was 5.25 ± 3.08 kg and 3.54 ± 2.40 kg ($P = 0.02$), respectively. There was no significant difference in mean graft survival (median [interquartile range] = 82 [30, 137] months for reclassified patients and 78 [22, 142] months for those who were not [$P = 0.81$]). Our data also confirm previous studies demonstrating that the left kidney is typically larger than the right kidney in ADPKD.¹⁰

Quantifying contribution of kidney weights to ADPKD patients' total BMI could be useful to patients and transplant centers, many of which use a selection criterion of $\text{BMI} < 35$.⁴ At the time of this study, our center had a patient selection criteria of $\text{BMI} < 38$ for kidney transplant listing. An exception for 1 patient with a $\text{BMI} > 39$ was made because the patient was very symptomatic from his enlarged organs. In our study, after patients' BMI category was recalculated to account for patients' kidney weights, 28.8% ($n = 19$) of the study cohort would have been reclassified into a lower BMI category. When comparing outcomes for patients who were reclassified into a new BMI category with those who were not reclassified, there were no significant differences in graft survival or days of hospitalization. Our study evaluated patients who were already successfully transplanted, thus it is unclear how BMI reclassification may impact actual kidney transplant listing eligibility or wait times.

A striking finding from our study is that our population had a significant percentage of patients who were overweight (31.4%) and obese (24.3%), which is

Table 1. Kappa coefficient and recalculated body mass index (BMI) categories

BMI at transplant listing	Calculated BMI after nephrectomy						Total
	≤ 18.5	$18.5 < \text{BMI} \leq 25$	$25 < \text{BMI} \leq 30$	$30 < \text{BMI} \leq 34$	$34 < \text{BMI} \leq 38$	> 38	
Frequency							
≤ 18.5	1	0	0	0	0	0	1
$18.5 < \text{BMI} \leq 25$	5	23	0	0	0	0	28
$25 < \text{BMI} \leq 30$	0	5	15	0	0	0	20
$30 < \text{BMI} \leq 34$	0	0	5	7	0	0	12
$34 < \text{BMI} \leq 38$	0	0	0	3	1	0	4
> 38	0	0	0	0	1	0	1
Total	6	28	20	10	2	0	66
Kappa statistics	Value		ASE		95% confidence limits		
Simple Kappa	0.5872		0.0749		0.4404 0.7341		
Weighted Kappa	0.7303		0.0477		0.6368 0.8239		

Patients with exact agreement = $47/66 = 71.2\%$ (95% confidence interval limits = 58.7–81.7)

ASE, asymptotic SE.

Shaded boxes indicate reclassified patients.

consistent with the trend of a rising prevalence of obesity in patients with ADPKD.^{8,11,12} Obesity remains a well-established risk factor for the incidence of chronic kidney disease^{13–15} and end-stage renal disease,^{16,17} and it has recently been shown to be associated with disease progression in PKD.⁸ Healthy weight loss should be encouraged in patients with ADPKD who are overweight or obese.¹⁸

This study has a few limitations. First, we used BMI recorded at the time of transplant listing rather than the time of transplantation. Given the time patients were on the waitlist (33.2 ± 26.6 months), patients' weights may have been different at the time of transplantation. It is possible that motivated patients in this study intentionally lost weight to become eligible for transplantation. Our data are limited to a single center with ADPKD expertise, and therefore may not be generalizable to other transplant centers. This study focused solely on kidney transplant recipients and thus limits the generalizability of our results to obese patients with ADPKD who were ineligible for transplant listing due to BMI criteria. Nevertheless, we believe that these data support the role for encouraging healthy weight loss independent of substantial weight contribution from enlarged kidneys. It is also important to note that 12% of patients had kidneys >8 kg, and these patients may pose particularly challenging cases with regard to operative safety, although our prior work suggests that nephrectomy is safe in this setting.¹⁹ Strengths of our study include availability of weights of kidney nephrectomy specimens as well as relatively large numbers of patients undergoing simultaneous kidney transplant and nephrectomy, which is not the practice at all transplant centers. Previous studies accounting for obesity in these patients have relied on estimates based on magnetic resonance imaging to estimate total kidney volume.¹⁰

Our study adds to the literature in important ways. We determined that there are no significant differences among weights of nephrectomized specimens across patients' BMI categories. Even though these data were obtained from successfully transplanted patients, by estimating the average weight contribution of each kidney to be approximately 2 kg, nephrologists might be able to use these data to motivate patients to lose weight to qualify for transplant listing. Future studies should prospectively evaluate patients on the transplant waitlist and those unable to be listed to determine patterns of weight loss and kidney specimen weights at the time of eventual transplant, and to correlate kidney specimen weights with imaging. More research is also needed to investigate optimal methods for weight loss in this population and the impact of obesity on transplant wait times for patients with ADPKD.^{5,20}

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DISCLOSURE

MP is a site principal investigator for the Kadmon KD019-211 trial and Otsuka REPRISSE trial, as well as a consultant for Abalone Bio, Inc. BKL has received honoraria for consulting work from Otsuka Pharmaceutical Co., Ltd., Alexion Pharmaceuticals Inc., and Novartis AG. All the other authors declared no competing interests.

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AUTHOR CONTRIBUTIONS

Research idea and study design: JF, CF, MP; data acquisition: MT, JF; data analysis/interpretation: YG, MP, OK, BKL; supervision or mentorship: MP, CF. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

SUPPLEMENTARY MATERIAL

Table S1. Study population.

Table S2. Summary of kidney weights by body mass index (BMI) categories.

Table S3. Centers for Disease Control and Prevention (CDC) obesity categories and body mass index (BMI) categorization at transplant listing.

Table S4. Comparative outcomes of patients with versus without BMI reclassification.

Figure S1. Distribution plot showing association between patients' BMI at transplant listing and total kidney weight. Linear correlation between BMI at listing and total specimen weight was measured with the Pearson correlation coefficient. Supplementary material is linked to the online version of the paper at www.kireports.org.

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Renal Health: An Innovative Application to Increase Adherence to Treatment Through Self-monitoring for Patients With CKD and Provide Information for the General Population



To the Editor: A growing global public health problem in recent years is chronic kidney disease (CKD), due to its increasing prevalence. Approximately 10% of the general global population currently suffers from CKD.^{1–3} In Brazil, approximately 126,583 patients underwent dialysis in 2017,⁴ and a total of 5929 kidney transplantations were performed in 2017.⁵

CKD treatment, especially dialysis, is recognized for the high demand in care. Adherence to therapy and control of all associated comorbidities is a difficult task for both patients and caregivers. The complex disease context requires a high level of patient involvement and self-care skills.⁶ Improving patient education and awareness is one of the most effective strategies to increase adherence to treatment, although an ideal level of adherence is yet to be realized even in industrialized countries.^{7–9}

The use of technology for health promotion, more specifically the personalized care proposed by the mHealth field (mobile health), offers new opportunities for supporting preventive care and monitoring diseases with the possibility to customize to individual needs. In many societies, public access to technology has been