# Surgeon Assessment of Renal Preservation with Partial Nephrectomy Provides Information Comparable to Measurement of Volume Preservation with 3-Dimensional Image Analysis

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**Abbreviations and Acronyms**

3D = 3-dimensional

GFR = glomerular filtration rate

PFVP = percent functional VP

PN = partial nephrectomy

RNS = renal nephrometry score

SAVP = surgeon assessment of VP

vGFR = volume adjusted GFR

VP = volume preservation

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**Purpose:** The strongest predictors of renal function after partial nephrectomy are the preoperative glomerular filtration rate and the amount of preserved parenchyma. Measuring volume preservation by 3-dimensional imaging is accurate but time-consuming. Percent functional volume preservation was designed to replace surgeon assessment of volume preservation with a less labor intensive, objective assessment. We compared volume preservation with 3-dimensional imaging, percent functional volume preservation and surgeon assessment of volume preservation as predictors of renal function after partial nephrectomy.

**Materials and Methods:** We calculated volume preservation with 3-dimensional imaging, percent functional volume preservation and surgeon assessment of volume preservation in 41 patients with preoperative and postoperative cross-sectional imaging available. Surgeon assessment was validated internally in another 75 patients. Short-term and long-term renal function was assessed with univariate and multivariate linear regression models.

**Results:** Median parenchymal preservation was 85% (range 37% to 105%) by 3-dimensional imaging, 91% (range 51% to 114%) by percent functional preservation and 88% (range 45% to 99%) by surgeon assessment. Each method strongly correlated with nadir glomerular filtration rate ($r^2 = 0.75$, 0.65 and 0.78) and latest glomerular filtration rate ($r^2 = 0.65$, 0.66 and 0.67, respectively, each $p < 0.0001$). Univariate analysis revealed that age, preoperative glomerular filtration rate, renal nephrometry score and each assessment were significant predictors of renal function ($p < 0.05$). On multivariate analysis parenchymal preservation was the strongest predictor ($p < 0.0001$). Models using volume preservation with 3-dimensional imaging, percent functional volume preservation and surgeon assessment of volume preservation were statistically similar in the ability to predict the nadir and latest glomerular filtration rates. In an additional validation cohort surgeon assessment remained strongly correlated with nadir glomerular filtration rate ($r^2 = 0.74$) and latest glomerular filtration rate ($r^2 = 0.73$, each $p < 0.0001$).

**Conclusions:** Surgeon assessment of volume preservation provides a reliable estimate of renal functional preservation with characteristics comparable to those of more time intensive alternatives. We propose that surgeon assessment of volume preservation should be routinely reported to facilitate analysis of partial nephrectomy outcomes.



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PARTIAL nephrectomy has emerged as a reference standard for renal masses amenable to such an approach.[1,2] Community and tertiary centers have seen increased use in the last 10 years with more PN for larger and more complex tumors.[3,4] Compared with total nephrectomy PN has consistently been associated with improved renal functional outcomes due to preservation of kidney parenchyma.[5–8] Recent studies further validate parenchymal preservation as the most important factor for determining renal function after PN even when considering ischemia type and time.[3,4,9,10]

Although its importance is evident, few studies show the correlation between preserved parenchyma with functional outcomes and many earlier studies relied on subjective SAVP.[11] Sophisticated computer systems have been used to provide objective 3DVP in small series of patients.[12] These approaches are not used more widely in large part because of the large amount of time needed to document this information. To limit the time and technology needed for the assessment Simmons et al proposed a method to estimate PFVP using cylindrical measurements obtained from preoperative and postoperative computerized tomography.[4] PFVP was designed to replace and improve on SAVP, and further validate VP as a strong predictor of renal function. However, its applicability preoperatively is limited and it also has not been widely adopted currently.

Although SAVP has been criticized as a subjective estimate, to our knowledge no study has been done to compare the accuracy of SAVP with that of 3DVP or PFVP in clinical practice. We compared SAVP with 3DVP and PFVP to identify the most accurate and efficient means to predict renal function after PN.

## MATERIALS AND METHODS

Institutional review board approval was received to use data maintained in our institutional kidney tumor registry. We identified 123 patients who underwent PN performed by a single surgeon between August 2009 and February 2013. Seven patients were excluded from analysis because of bilateral tumors. Preoperative, intraoperative and postoperative data were collected on all patients.

SAVP was performed routinely by the operating surgeon at the completion of surgery and recorded on the operative note along with ischemia type and time. SAVP is calculated by accounting for the amount of functional volume preserved after PN, considering the amount of parenchyma replaced by tumor (intraparenchymal portion) and the adjacent uninvolved parenchyma removed or devascularized during the procedure. Therefore, the percent preserved was calculated as (remaining viable parenchyma/total parenchyma + intraparenchymal tumor volume) (fig. 1). RNS was assigned based on retrospective review of cross-sectional imaging (computerized tomography or magnetic resonance) according to published guidelines.[13,14] Preoperative and postoperative serum creatinine measurements were recorded for each patient. Estimated GFR was calculated using CKD-EPI (Chronic Kidney Disease-Epidemiology Collaboration) formulas.[15] Early renal function (nadir GFR) was calculated using the highest serum creatinine obtained within 1 week of surgery. Late renal function was calculated based on the most recent serum creatinine measurement, which was obtained a median of 318 days (IQR 91, 628) postoperatively. PFVP and 3DVP were analyzed in all 41 cohort 1 patients by preoperative and postoperative cross-sectional imaging. The remaining 75 patients without postoperative cross-sectional imaging served as an internal validation subset (cohort 2) for SAVP analysis.

### Analyses

***Volumetric.*** We measured 3DVP using the computational modeling program TeraRecon®, version 4.4.5.49.2104. Two investigators were trained to calculate kidney volume using the FreeROI utility. While blinded to surgery details, each investigator obtained measurements of ipsilateral and contralateral kidney volumes, tumor volume, intraparenchymal tumor volume and residual (postoperative) parenchymal volume (fig. 2). Total time needed for these measurements was 25 to 40 minutes per patient. Interobserver variability was acceptable

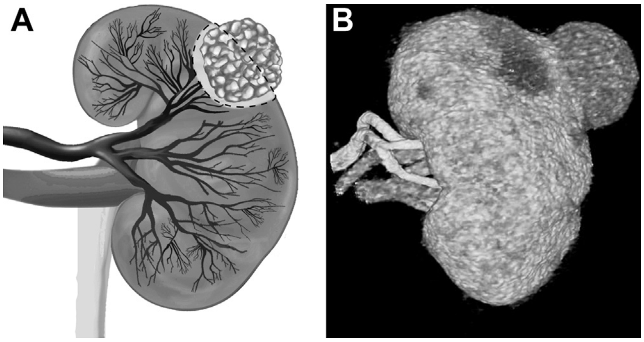


**Figure 1.** *A*, SAVP was calculated by determining functional volume preserved after PN, considering amount of parenchyma replaced by tumor (intraparenchymal portion) and adjacent uninvolved parenchyma removed or devascularized during procedure. Percent preserved reflected remaining viable parenchyma/(total parenchyma + intraparenchymal tumor volume). *B*, 3D rendering shows 3.3 cm left upper pole renal mass with volumetric measurements of 281 $cm^3$ total ipsilateral renal volume, 19 $cm^3$ tumor volume and 10 $cm^3$ intraparenchymal tumor volume. Volume preservation was 88% by 3DVP and 90% by SAVP.