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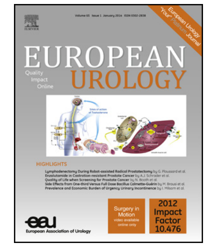

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Renal Tumor Contact Surface Area: A Novel Parameter for Predicting Complexity and Outcomes of Partial Nephrectomy

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Abstract

Background: The contact surface area (CSA) of a tumor with adjacent renal parenchyma may determine the complexity and thus the perioperative outcomes of partial nephrectomy (PN).
Objective: We devised a novel imaging parameter, renal tumor CSA, and correlate it with perioperative outcomes in patients undergoing PN.
Design, setting, and participants: Of 200 patients undergoing PN for a tumor (January 2010 to August 2011), 162 had renal protocol computed tomography scanning data available. CSA was calculated using image-rendering software (Synapse 3D, Fujifilm), and interobserver variability was determined between three independent observers.
Outcome measurements and statistical analysis: CSA was correlated to baseline demographics and perioperative outcomes as a continuous and categorical variable using multivariable logistic regression analysis. The ability of CSA to predict adverse perioperative events was compared with demographic factors and nephrometry scoring systems.
Results and limitations: The mean tumor size was 3.1 cm; CSA was 18.3 cm^2. CSA $\geq$20 cm^2 correlated with adverse tumor characteristics (greater tumor size, volume, and complexity) and perioperative outcomes (more parenchymal volume loss, blood loss, and complications) compared with CSA $<$20 cm^2. On multivariable logistic regression, CSA independently predicted operative time, complications, hospital stay, and renal functional outcomes. This predictive ability of CSA was superior to the other parameters evaluated.
Conclusions: CSA is a novel imaging parameter that quantifies the CSA of renal tumor with adjacent parenchyma. Our preliminary data indicate that CSA correlates with PN outcomes. If validated externally in a larger cohort, CSA could be incorporated into future versions of nephrometry scoring systems.
Patient summary: In this study we outline the method of calculating the contact surface area (CSA) of renal tumors with the surrounding normal kidney using image-rendering software. We found that CSA correlates with a number of important surgical outcomes including operative time, loss of renal function, and complications.

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1. Introduction

Nephron-sparing surgery is now the standard of care for most tumors ≤4 cm (T1a), and it is an emerging option for select tumors 4–7 cm (T1b), with oncologic equivalency comparable with radical nephrectomy [1,2]. With increasing evidence of the beneficial effects of preserved renal function, the indications of partial nephrectomy (PN) have been carefully expanded to include tumors with complex surgical anatomy [3,4]. Various nephrometry scoring systems such as RENAL, PADUA, and C-index are in use to objectively quantify tumor anatomy and complexity [5–7]. In addition to facilitating standardized academic reporting, nephrometry scores may even predict perioperative PN outcomes such as ischemia time, blood loss, and complications [8].

When performing PN, we believe the area of contact of a tumor with its surrounding uninvolved renal parenchyma appears to be an important driver of the extent of kidney resection and renal reconstruction performed. Thus the larger the contact surface area (CSA) of the tumor–kidney interface, the greater might be the amount of kidney tissue excised and the greater the extent of renorrhaphy required. However, to our knowledge, no method of objectively quantifying this variable exists.

We developed the novel concept of tumor CSA to capture this clinical observation using a radiologically measurable parameter. CSA combines the relevant complexities of two pertinent anatomic parameters of tumor complexity, size and degree of intraparenchymal extension, into a single radiologically measurable parameter. A method of calculating CSA based on preoperative computed tomography (CT) images using image-rendering software is described. Finally, we examine whether CSA has the potential to predict perioperative outcomes of PN.

2. Methods

We evaluated 200 patients undergoing minimally invasive PN (robotic or laparoscopic) for tumor (January 2010 to August 2011) who had consented to inclusion in our institutional review board–approved kidney cancer database. Of these, 162 consecutive patients had renal protocol CT scanning available for analysis and comprised the study cohort. Perioperative and follow-up data were obtained from this prospectively maintained database and analyzed retrospectively.

Preoperative CT volume data were evaluated using three-dimensional (3D) rendering software (Synapse 3D, Fujifilm) to calculate CSA for each tumor. First, tumor volume (in milliliters) and percentage tumor located within the renal parenchyma (percentage intraparenchymal component) were measured (Fig. 1a and 1b). After the user had manually rendered this area of interest, the

Fig. 1 – (a) Measurement of tumor volume; (b) percentage of intraparenchymal component equals the intraparenchymal volume as a proportion of total tumor volume.

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