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# The incidence of unsuccessful partial nephrectomy within the United States: A nationwide population-based analysis from 2003 to 2015

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**Abstract**

**Purpose:** Partial nephrectomy (PN) remains underutilized within the United States and few reports have attempted to explain this trend. The aim of this study is to evaluate the nationwide incidence of unsuccessful PN and factors that predict its occurrence.

**Methods:** Using the Premier Healthcare Database, we retrospectively analyzed a weighted sample of 66,432 patients undergoing curative surgery for renal mass between 2003 and 2015. PN intent was denoted by presence of insurance claims for the administration of mannitol. Unsuccessful PN was defined as an event in which patients were administered mannitol but received radical nephrectomy. A multivariate logistic regression model was generated to identify factors predicting unsuccessful PN.

**Results:** Overall rates of unsuccessful PN declined from 33.5% to 14.5% since 2003. Conversion to radical nephrectomy occurred most frequently during laparoscopic (34.7%) and least frequently during robotic approach (13.6%). There was significant difference in the rate of unsuccessful PN between very high and very low volume surgeons (open: 39.4% vs. 13.3%, laparoscopic: 51.2% vs. 32.2%, and robot assisted: 27.1% vs. 9.4%, all $P < 0.001$). After adjustment for patient- and hospital-related factors, surgical approach (laparoscopic vs. open, odds ratio = 1.74, 95% CI: 1.31–2.30, $P < 0.001$) and annual surgeon volume (very high vs. very low, odds ratio = 0.27, 95% CI: 0.21–0.34 $P < 0.001$) were associated with unsuccessful PN.

**Conclusions:** Although the rate of unsuccessful PN appears to be declining, it still remains common for low volume surgeons and with the laparoscopic surgical approach. Further evaluation of its effect on health care outcomes is necessary. 

*Keywords:* Nephrectomy; Mannitol; Laparoscopy; Robotic surgical procedures; Conversion to open surgery

## 1. Introduction

Partial nephrectomy (PN), when technically feasible, has been touted as an option for management of small renal tumors [1]. The postoperative renal preservation of PN has been shown to reduce the risk of chronic renal insufficiency and related cardiovascular mortality in all patients regardless of contralateral renal function [2–5]. Current guidelines now recommend PN as a first-line treatment for small, localized renal masses [6,7]. Radical nephrectomy (RN) for small renal masses should only be reserved for patients with a high-complexity tumor that is not technically amenable to PN or for whom PN may result in unacceptable morbidity [1].

Still, there is some reluctance by smaller, nonacademic hospitals to adopt this technically challenging surgery.

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Low-volume hospitals and surgeons especially have been found to have lower rates of PN use compared to their counterparts, which may suggest a pattern of suboptimal care for certain patients [8–11]. One possible explanation for the underutilization of PN is the occurrence of undocumented intraoperative conversion from PN to RN. Surgeon inexperience in PN or minimally invasive surgery, or both, increased tumor complexity, and patient comorbidity such as poor baseline renal function may all be potential risk factors for unsuccessful PN [12,13].

Unfortunately, there has been a dearth of literature evaluating the trends and risk factors of unsuccessful PN using nationally representative data. The prevailing studies are mostly from single institutions that are susceptible to surgeon reporting bias and hospital clustering. Moreover, few studies have examined the effect of provider inexperience or selection of minimally invasive surgery (laparoscopic or robot-assisted surgery) on rates of unsuccessful PN. As low volume, rural treatment centers provide care for a large percentage of US patients, further investigation is needed to explain their relatively high rates of RN utilization [9,14,15]. We thus sought to compare rates of conversion from PN to RN by provider volume and surgical approach using intraoperative mannitol administration as an indicator for nephron sparing intent.

## 2. Methods

### 2.1. Data source

The Premier Healthcare Database (Premier Inc., Charlotte, NC), was utilized to identify patients undergoing curative surgery for renal mass between January 2003 and December 2015. Nearly, 20% of all-payer inpatient discharges (approximately 50 million in aggregate) within the United States are captured by this dataset, but hospital-specific projection weights for each discharge provided by Premier Inc. allow for nationally representative estimates to be inferred. These weights were created using a stratified comparison of the patients within Premier's database to discharge data from all US hospitals that responded to the American Hospital Association Annual Survey. Similarly, adjustment was also made for hospital clustering to account for similarities in practice patterns within each center such as surgical technique or supportive care practices. A prior landmark study similarly harvested the Premier Healthcare Database to evaluate surgical trends further validating our methodology [16,17]. All numbers reported in this study refer to projected estimates and all data accessed were deidentified, exempting our study from Institutional Review Board approval.

### 2.2. Study cohort

Patients undergoing elective PN (55.4) or RN (55.51) for the treatment of a renal mass were identified using International Classification of Disease, Ninth Revision codes. Indications such as infection, trauma, and donor nephrectomy were excluded. A nationally representative cohort of 127,891 patients receiving PN and 354,130 RN in the United States were retrieved from Premier Healthcare Database between 2003 and 2015. The use of intraoperative mannitol was documented using billing codes. Patients without receipt of the mannitol were subsequently excluded. Our final cohort was comprised of 66,432 patients of whom 53,526 received PN and 12,906 received RN at 374 US hospitals.

### 2.3. Covariates

Patients characteristics included age, sex, race (white, black, and others), comorbidities (Charlson comorbidity index of 0, 1, or $\geq$2), and insurance status of the patients. Hospital characteristics included academic status of the hospital (teaching vs. nonteaching), bed size ($<$300, 300–500, or $>$500), and location (rural vs. urban). Annual hospital and surgeon PN volumes were calculated and presented as quintiles. Volumes at or below the 20th percentile for each index year were considered to be very low ($<$6 cases per hospital and $<$2 cases per surgeon annually) and volumes above the 80th percentile were considered to be very high ($>$33 cases per hospital and $>$11 cases per surgeon annually). The middle 60 percentile were combined into an intermediate category. Indeed, the terms very high volume surgeon and hospital may have distinct implications depending on practice setting; however, the nationally representative nature of our data includes both rural and nonteaching institutions allowing for broad generalizability of our conclusions within the United States.

### 2.4. Indicator for conversion

Mannitol is used for renal preservation during PN as it has been suggested to minimize ischemic or reperfusion injury [18]. Consequently, mannitol prescriptions during cases that result in RN likely were intended to be a partial resection. The most likely time of mannitol administration was found to be immediately before renal artery clamping, further suggesting that surgeries ending in RN with mannitol receipt were likely converted intraoperatively [18]. The conversion of PN to RN in our cohort was defined as an event in which patients received mannitol—suggesting PN intent—but were billed for RN. The term "unsuccessful" was used to describe cases of intraoperative conversion from intended PN to RN, denoted by the use of mannitol during RN. It does not, however, comment on the validity of the decision, as in many cases conversion may have actually been clinically indicated by intraoperative findings such as deep sinus fat invasion, positive margins, or significant tumor progression.