ELSEVIER

Urologic Oncology: Seminars and Original Investigations 37 (2019) 183.e9–183.e15

UROLOGIC ONCOLOGY

Clinical-Kidney cancer

National trends and economic impact of surgical treatment for benign kidney tumors

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Received 26 May 2018; received in revised form 19 September 2018; accepted 19 November 2018

Abstract

Objectives: Kidney masses suspicious for malignancy are frequently detected by cross-sectional imaging; however, little is known about the burden of surgical treatment for tumors found to be benign following excision.

Material and methods: We queried the National Inpatient Sample to identify records of individuals who received surgical treatment for renal neoplasms between 2004 and 2014. We characterized temporal treatment trends, patient demographics, treatment related complications, and charges.

Results: We identified 7,099 (8.5%) and 76,892 (91.5%) patients who were treated for benign and malignant tumors, respectively. Benign masses accounted for 14.8% of partial and 5.5% of radical nephrectomies. The rates of surgery for benign tumors have remained steady ($P = 0.058$). The frequency of inpatient death was higher in those with malignant disease (0.63% vs. 0.18%, $P < 0.0001$). Median length of stay was longer for individuals with malignant renal tumors (4.86 vs. 4.12 days, $P < 0.0001$). The total discharge bill adjusting for inflation for benign or malignant renal surgery increased each year ($R^2 = 0.428$, $R^2 = 0.719$, $P = 0.001$, $P = 0.0311$, respectively). As of 2014, the estimated national inpatient cost of management for benign renal tumors was $153 million dollars ($55,573/individual).

Conclusions: 8.5% of inpatient renal surgical admissions are performed for benign masses. There has been a trend toward decreased operative management for benign renal tumors over time. Surgical management remains a significant economic burden. Efforts to prospectively evaluate modalities for pretreatment identification should be further pursued.

Keywords: Oncocytoma; Renal neoplasm; Cost; Nephrectomy

Abbreviations: NIS, National Inpatient Sample; SEER, Surveillance Epidemiology and End Result; NCDB, National Cancer Database; ICD-9, International Classification of Diseases, Ninth Revision; LOS, Length of Stay

Introduction

With the increasing use of cross-sectional imaging, the incidence of renal cancer has dramatically risen the past few decades [1]. The largest increase in kidney cancer has been observed in the small renal mass (less than 4 cm), the majority of which are detected incidentally [1]. Historically, these tumors have been treated surgically and with the rising incidence of kidney cancer, the annual rates of kidney surgery in the United States have dramatically increased. The mainstay of surgical treatment for a localized renal mass has been radical nephrectomy; however, in recent years, there has been an emphasis on organ preservation with partial nephrectomy. Despite improvements in imaging, and availability of renal mass biopsy, preoperative factors cannot reliably differentiate between malignant tumors and benign masses. This leads many patients to pursue treatment. Prior to the widespread adoption of cross-sectional imaging, benign renal tumors were most commonly found at the time of autopsy [2]. From large series of surgically resected masses, it is now recognized

Funding: None.

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https://doi.org/10.1016/j.urolonc.2018.11.019
1078-1439/

that up to 25% of small renal masses represent benign lesions such as oncocytoma, fat-poor angiomyolipoma, or papillary adenoma [3,4]. These lesions are rarely symptomatic, and surgical excision likely did not improve the functional outcome of these patients. As all surgical forms of therapy are associated with both perioperative and long-term adverse events, many patients are exposed to unnecessary harm [5]. Efforts to identify benign tumors preoperatively with imaging or biopsy biomarkers to limit unnecessary surgery have not diffused into clinical practice within guideline statements, and therefore, surgical management of the benign renal mass continues.

The national burden of treatment for benign renal masses has been poorly characterized in the literature. This is due in part to the fact that population-based cancer registries such as the Surveillance Epidemiology and End Result program and the National Cancer Database focus on malignant disease, failing to include nonmalignant histologies. As the focus on healthcare costs intensifies, a simultaneously growing body of evidence characterizes the financial aspects of treatment at the patient level [6]. If the surgical resection of benign masses could be avoided, economic costs as well as adverse patient outcomes would be limited, thereby improving the overall healthcare system. Thus, we sought to better characterize the burden of treatment of benign small renal masses utilizing a large national dataset.

Materials and methods

2.1. Patient population

The National Inpatient Sample (NIS), a part of the Healthcare Cost and Utilization Project, is an inpatient database that captures approximately 20% of hospital admissions in the United States. We queried the NIS to identify records of individuals with a principal diagnosis of a benign or malignant renal neoplasm treated with surgery between 2004 and 2014 [7]. *International Classification of Diseases, Ninth Revision* (ICD-9) codes (189.0: Malignant Kidney Neoplasm; 223.0: Benign Kidney Neoplasm) were used to identify patients with benign and malignant kidney neoplasms. ICD-9 procedural codes were used to identify those who had surgery and whether a partial (55.31, 55.39, and 55.4) or radical nephrectomy (55.51, 55.52, 55.53, and 55.54) was performed. A flow diagram indicating our inclusion criteria can be visualized in Fig. 1.

We evaluated patient characteristics on admission including demographics (age, sex, and race), total hospital discharge bill, and primary insurance payer (medicaid, medicare, no charge, other, private insurance, self-pay). Surgical outcome measures captured included total length of stay (LOS) and presence of inpatient mortality. The NIS includes detailed data on 29 comorbidities, many of which are part of the Charlson comorbidity index. Similar to other studies using the NIS [8], we consolidated patients into different tiers of comorbidity based on the cumulative number of chronic conditions (low [0−2], medium [3−4], and high [5 or more]). The cost of inpatient hospitalization was estimated using total inpatient hospital charges, which are the total hospital costs associated with inpatient admission. To account for inflation over the study period, hospital charges in prior years were adjusted to 2014 values using publically available consumer price indices. As the NIS is a nationally representative inpatient database, weight values were used to project national hospital charge estimates.

2.2. Statistical analysis

Chi square and Student's t tests were used to evaluate differences in sociodemographic and clinical characteristics between patients with either benign or malignant kidney neoplasms. Generalized linear regression analysis was performed to assess for trends over time. Statistical significance was considered if $P \leq 0.05$. Statistical analysis and figures were generated with JMP 11.2.1 statistical software (SAS Institute Inc., Cary, NC).

Results

A total of 7,099 (8.5%) and 76,892 (91.5%) individuals were admitted for surgical intervention for a benign or malignant kidney neoplasm (Table 1). Those with a benign renal neoplasm were older (mean age: 61.4 vs. 60.7, $P < 0.0001$), had a higher representation of females (54.6% vs. 38.5%, $P < 0.0001$), had a lower proportion of medicaid insurance (3.96% vs. 6.05%, $P < 0.0001$), a lower proportion of Hispanic race (4.69% vs. 6.79%, $P < 0.0001$), and has less total comorbidities (low [Charlson comorbidity index 1−2] of 80.4% vs. 73.6%, $P < 0.0001$). Supplemental Table 1 illustrates all captured existing comorbidities. Of note, renal failure was present in 4.8% and 7.2% of those with benign and malignant tumors. For individuals with benign tumors, 16% and 49.8% presented with pre-existing diabetes and hypertension, both of which are known risk factors for the progression to chronic kidney disease.

During the study period, a total of 26,648 and 57,343 partial and radical nephrectomy procedures were performed, respectively (Table 2). Benign renal neoplasm surgery accounted for 14.8% (3,935) of partial and 5.5% (3,153) of radical nephrectomies. As expected, tumors with different biologic behavior and likely complexity had different inpatient surgical charges and costs.

Within the NIS, a slight increase in malignant kidney tumor admissions was observed from 6,238 cases in 2004 to 6,840 cases in 2014, while a slight decrease in benign kidney tumors was observed from 636 cases (9.3% of surgical admissions) in 2004 to 561 cases (7.6% of surgical admissions) in 2014 (Fig. 2). Over time, there were less benign renal masses treated with radical nephrectomy from 6.8% in 2004 compared to 4.0% in 2014, ($R^2 = 0.904$, $P < 0.0001$; Fig. 3). The estimated annual total hospital charge for inpatient renal surgery has increased from $1.3

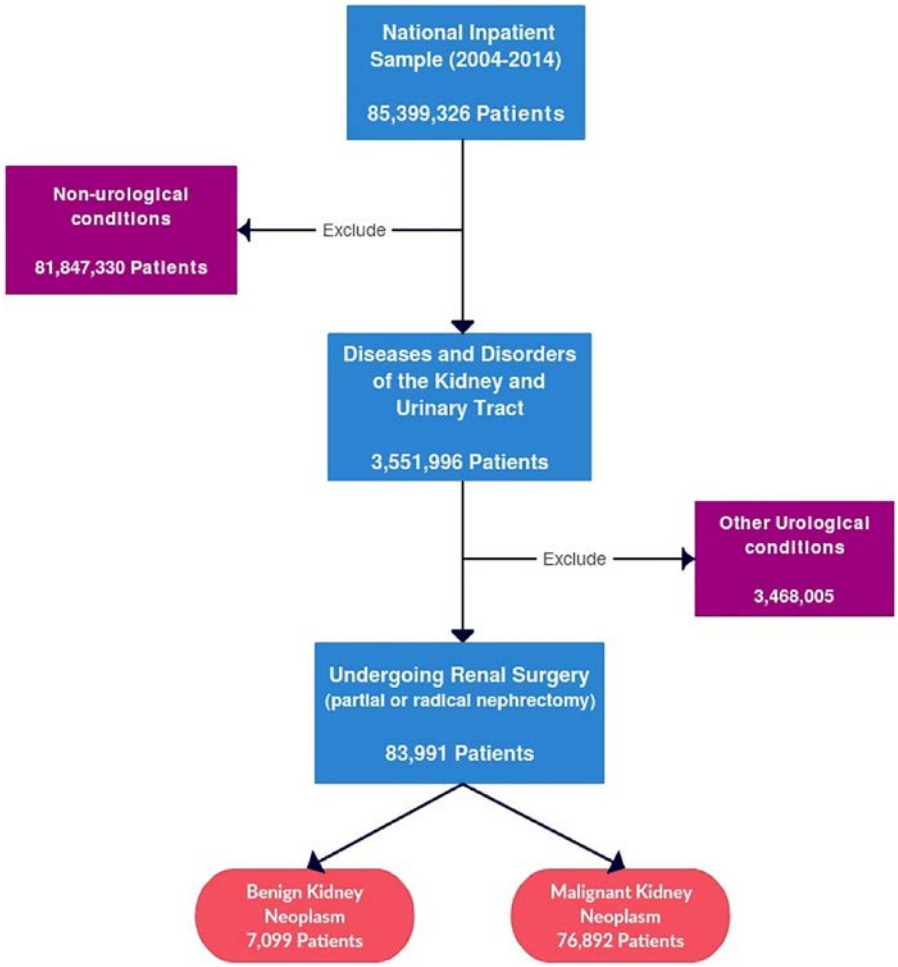

Fig. 1. Flow diagram delineating inclusion and exclusion criteria.

billion to $2.2 billion during the study period. The charges associated with both benign and malignant renal surgeries have increased in a similar fashion ($R^2 = 0.428$, $R^2 = 0.719$, $P = 0.001$, $P = 0.0311$, respectively; Fig. 4). As of 2014, the estimated annual inpatient cost for the management of benign renal tumors was $153 million dollars ($55,573/individual).

Discussion

We describe nationwide trends in the surgical management of benign renal masses. Institutional databases report that the rates of benign tumor range from 12% to 23% [9–12]; however, this likely depends on the particular study's inclusion criteria [4]. Due to the inability of reliably identifying benign tumors from national databases, the actual overall incidence, treatment, economic burden, and mortality rates due to benign renal tumors have remained unknown. Utilizing the NIS, we identified that 8.5% of inpatient admissions for renal tumor surgery were due to benign renal tumors.

We identified a trend toward increased surgical admissions for malignant renal tumors among a relatively stable number of benign renal surgeries. A possible explanation could be due to the increased acceptance of active surveillance for small renal masses and improvements in preoperative evaluation, which may be anticipated to avoid future hospitalizations and reduce health care costs [13]. Benign renal neoplasms occurred more commonly in older patients and among women. While there has been a discordance in the incidence of renal cell carcinoma between men and woman (2:1 ratio), we found that benign tumors were observed in a higher proportion of women. It has been previously reported that benign tumors such as renal angiomyolipomas (AMLs), metanephric adenoma, cystic nephroma, and renal leiomyoma are more common in women [14]. Benign tumors are also observed more frequently in individuals of non-Hispanic ethnicity and in those with lower comorbidity. The lower comorbidity associated with benign tumors is somewhat surprising since selection of active surveillance could lead to healthier patients being more likely to undergo surgery for the small renal mass. However, as comorbidities such as

Table 1
Demographics and comorbidity for individuals with benign vs. malignant disease

Variable	Benign kidney neoplasm	Malignant kidney neoplasm	*P* value
Number of patients	7,099 (8.5%)	76,892 (91.5%)	
Age			
Mean (SD)	61.3 (30.7)	60.7 (32.2)	<0.0001
Median (IQR)	63 (53−72)	62 (52−71)	
Sex			
Male	3,205 (45.4%)	47,209 (61.6%)	<0.0001
Female	3,859 (54.6%)	29,490 (38.5%)	
Primary payor			
Medicaid	281 (4.0%)	4,654 (6.1%)	<0.0001
Medicare	3,048 (42.9%)	32,697 (42.5%)	
No charge	18 (0.25%)	329 (0.43%)	
Other	141 (2.0%)	1,980 (2.6%)	
Private insurance	3,471 (48.9%)	35,195 (45.8%)	
Self-pay	134 (1.9%)	1,896 (2.5%0	
Unknown	<10[a]	141 (0.18%)	
Race			
African American	601 (8.5%)	6,537 (8.5%)	<0.0001
Asian	119 (1.7%0	49,802 (1.5%)	
Caucasian	4,647 (65.5%)	49,802 (64.8%)	
Other/unknown	1,399 (19.7%)	14,200 (18.5%)	
CM composite class			
Low (0−2)	5,704 (80.4%)	56,590 (73.6%)	<0.0001
Medium (3−4)	1,199 (16.9%)	16,753 (21.8%)	
High (5+)	196 (2.8%)	3,549 (4.6%)	

SD - standard deviation; IQR - interquartile range; CM - Co-Morbidity
[a] To prevent patient identifiability, the Health Care Utilization Project does not allow reporting of any cell sizes of <10 patients.

hypertension, chronic kidney disease, obesity, and smoking are linked to renal tumors [15], this observation may influence the frequency of benign tumors.

As many benign tumors are smaller than their malignant counterparts, there was an observed difference in surgical procedure performed with partial nephrectomy performed more often on benign lesions. For both benign and malignant renal tumors, there has been an increased adoption of organ preservation [16]. While the NIS does not provide histologic characterization of tumor samples, many of these benign tumors are likely renal oncocytomas, since most AMLs are commonly identified by preoperative imaging. The lipid-poor AMLs are less common [17] and would be more likely to account for some cases. While many benign lesions did not require surgery, it must also be noted that occasionally some benign lesions can be large or symptomatic and surgery may be necessary in these situations.

Within the NIS, there was an annual average of 645 patients who received surgical management for benign renal tumors, (287 radical and 359 partial nephrectomies/

Table 2
Surgical outcomes and inpatient costs for individuals with benign vs. malignant disease

Variable	Benign kidney neoplasm	Malignant kidney neoplasm
Number of patients	7,099 (8.5%)	76,892 (91.5%)
Length of stay (d)		
Mean (SD)	4.12 (7.10)	4.86 (10.6)
Median (IQR)	4 (2−5)	4 (3−5)
Total discharge		
Mean (SD)	$42,149 ($82,718)	$48,606 ($116,559)
Median (IQR)	$33,259 ($23,293−49,301)	$36,260 ($23,879−55,518)
Inpatient death		
No	7,085 (99.8%)	76,378 (99.4%)
Yes	13 (0.18%)	487 (0.63%)
Surgical procedure		
Partial nephrectomy	3,945 (55.6%)	22,703 (29.5%)
Radical nephrectomy	3,153 (44.4%)	54,189 (70.5%)

SD - standard deviation; IQR - interquartile range; CM - Co-Morbidity

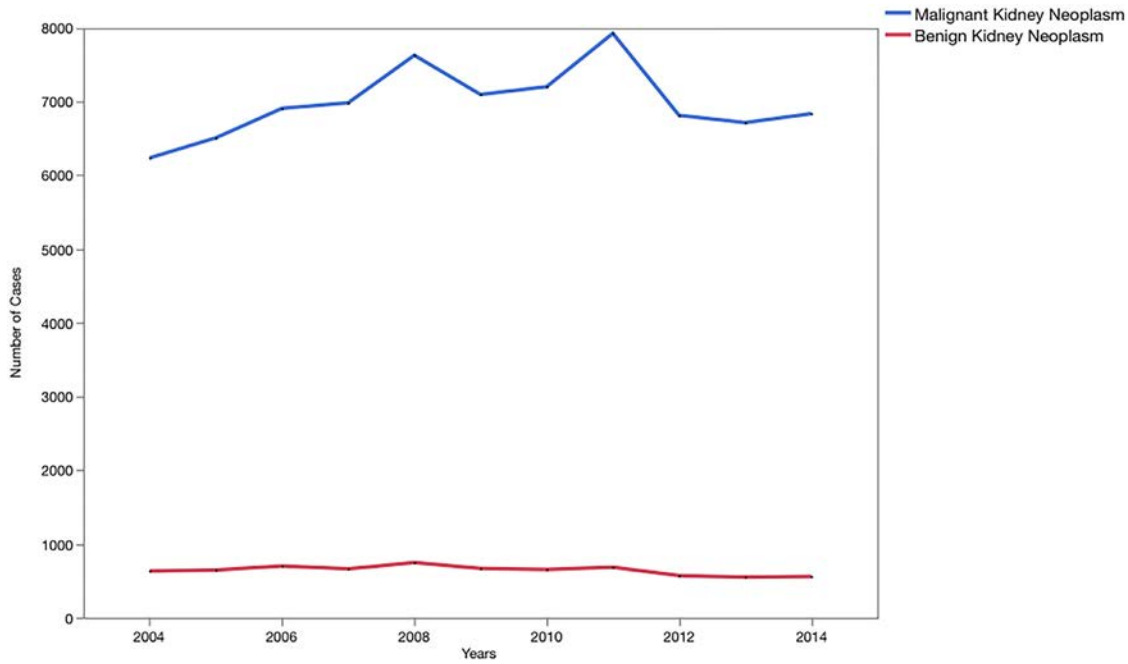

Fig. 2. 2004 to 2014, number of benign and malignant cases admitted each year for renal surgery (partial + radical)

year). This would be approximately 1,500 and 1,800 radical and partial nephrectomies annually. Patients who had surgery for a benign renal mass had a mean unadjusted hospital LOS of 4.1 days and a mortality rate of 0.2%. Although the LOS for patients with benign renal masses was lower than for those with malignant tumors, this represents a significant loss of work due to surgery and recovery. While mortality was low, there were likely avoidable deaths had the benign nature of these tumors been recognized. The national costs associated with hospitalizations for renal masses have increased substantially, from $1.3 billion in 2004 to $2.2 billion in 2014. Although patients with benign

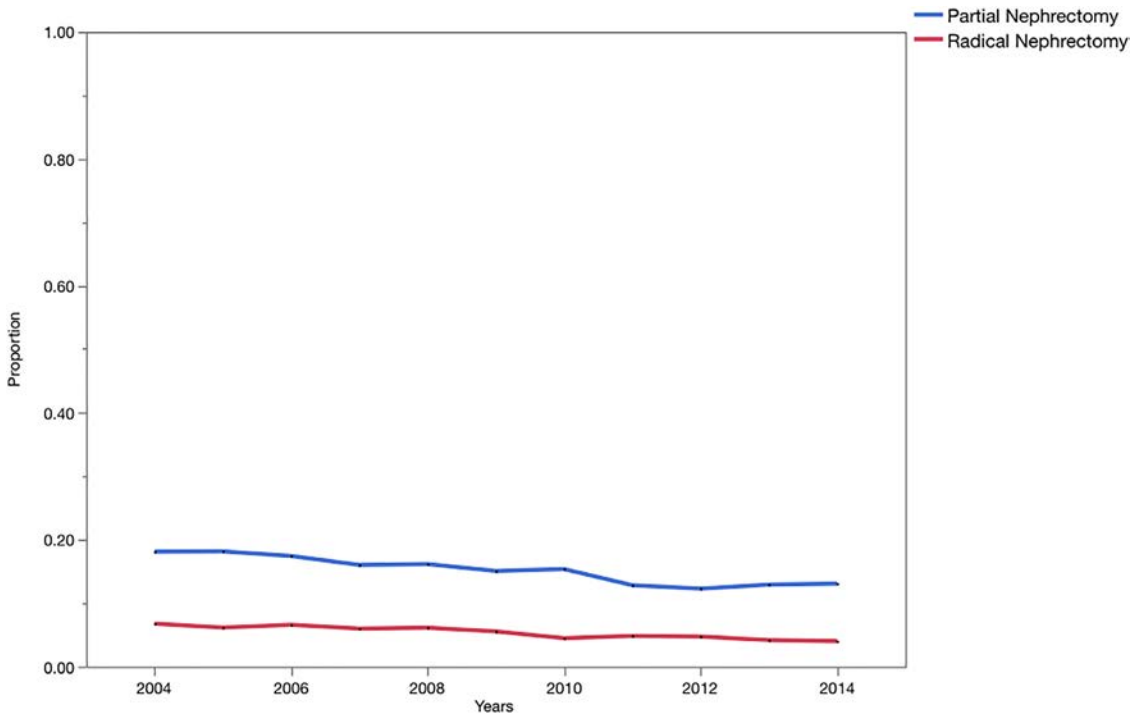

Fig. 3. Of each type of renal surgery, proportion of cases as benign kidney neoplasm over time.

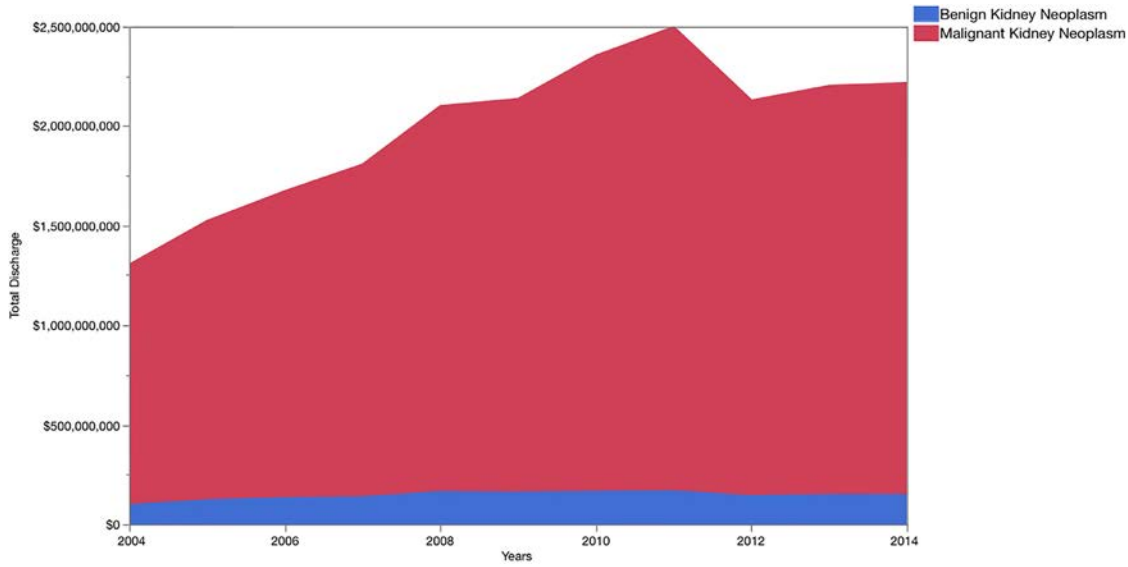

Fig. 4. Total hospital charges for benign and malignant tumors per year (projected to US population).

renal masses have a lower mean hospital charge, the management of benign renal masses was estimated to have an inpatient cost of $153 million as of 2014.

In light of long-term risks, efforts to decrease unnecessary surgical treatment of asymptomatic benign small renal masses are highly warranted. The American Urological Association guidelines consider partial nephrectomy the gold standard for small renal masses due to a reduction in the incidence of chronic kidney disease [1,18]. While it is encouraging to observe an increase in partial nephrectomy, all surgical forms of therapy have inherent long-term risks, including poorer renal function when compared to appropriate controls [5]. There are also rising rates of end-stage renal disease in patients with renal malignancies, likely related to prior kidney tumor treatment [19]. We observe that benign tumors are still occasionally resected via radical nephrectomy, which further underscores the need to identify and avoid unnecessary treatment when feasible.

Surgical intervention is often chosen by patients with benign renal masses due to an inability to distinguish between benign and malignant renal neoplasms. Surgery is most clearly warranted for symptomatic individuals with benign lesions, but for asymptomatic individuals, additional diagnostic methods are needed to improve discrimination of benign entities to reduce unnecessary costs that arise from the treatment of lesions that have no clear indications for surgery. An approach to help distinguish benign renal tumors has been described using ^{99m}Tc-sestamibi single photon emission tomography (SPECT)/computed tomography scan [20,21]. Despite its ability to image mitochondrial rich tumors, the ^{99m}Tc-sestamibi scan may have difficulty distinguishing between oncocytoma and often mitochondrial-rich, chromophobe renal cell carcinoma. Molecular biomarkers that differentiate benign from pathologic patterns are needed in the diagnostic arena but to date, no reliable biomarkers have been found [22].

Active surveillance for small renal masses has low utilization but may be useful to avoid overtreatment of benign tumors. Studies have suggested that active surveillance has comparable outcomes to immediate surgical intervention in elderly individuals and has similar metastasis-free survival in comparison to radical nephrectomy [23,24]. Though active surveillance does not guarantee avoidance of treatment; however, its increased adoption would likely decrease surgical intervention for small benign renal tumors.

Our study has several limitations. Because the NIS is a sample of inpatient hospital admissions, it is subject to sampling error. There is no information regarding surgical indications (such as a preoperative diagnosis of a renal mass) or tumor characteristics including the various benign histologies. While we stress that unnecessary surgical intervention for benign renal tumors should be avoided, some conditions, such as an aberrantly large benign mass or symptomatic lesion may inevitably require surgery. Given these limitations, it is not possible to determine whether these treatments could have been unavoidable. Since the NIS also lacks information on hospital readmission, we may be underestimating the actual costs and mortality associated with the surgical treatment of benign renal tumors. Procedures such as percutaneous ablation are often performed on an outpatient basis, and we fail to capture these cases with our methodology. Additionally, since physician professional fees are not accounted for as inpatient charges, the numbers presented here may be an underestimation of total costs. Finally, the reliability of the NIS data set is limited to the accuracy of ICD-9 methodology. Despite these limitations, the NIS data set allows for an analysis of nationwide

trends as well as the characterization of benign lesions that may be otherwise missed in other national databases.

Conclusions

Benign renal surgery accounts of over 8% of inpatient surgical admissions for renal tumors and accounts for an estimated $150 million in preventable treatment costs. We observed a trend of decreased operative management for benign renal tumors over time, but unnecessary surgeries continue to represent an expensive and avoidable harm to patients. Efforts to develop reliable modalities for pretreatment identification to avoid unnecessary treatment for benign tumors are needed to decrease patient morbidity and healthcare cost.

Conflicts of interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.urolonc.2018.11.019.

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