National trends of preoperative imaging modalities before partial nephrectomy for renal masses in the U.S. from 2007–2015

Jae Heon Kim[1,2*]; Shufeng Li[3*]; Yash Khandwala[1,4]; Francesco Del Giudice[5]; Kyung Jin Chung[1]; Hyung Keun Park[1]; Benjamin I. Chung[1]
[1]Department of Urology, Stanford University Medical Center, Stanford, CA, United States; [2]Department of Urology, Soonchunhyang University Hospital, Soonchuhyang University Medical College, Seoul, Korea; [3]Department of Urology and Dermatology, Stanford University Medical Center, CA, United States; [4]University of California, San Diego School of Medicine, San Diego, CA, United States; [5]Department of Urology, Sapienza University of Rome, Rome, Italy [*]These authors have contributed equally.

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Abstract

Introduction: Although the performance of partial nephrectomies (PNx) for renal masses has increased rapidly over the years, only a few studies investigated the frequency and patterns of preoperative imaging modalities. The aim of this study was to investigate the frequency and patterns in preoperative imaging modalities before PNx.
Methods: A total of 21 445 patients who underwent PNx between 2007 and 2015 were selected from a national representative population in the MarketScan database and included in this study. The annual incidence and proportion of PNx, as well as the use of each preoperative imaging modality were analyzed.
Results: Both annual crude number and frequency rate of PNx decreased or became static since 2012. Computed tomography (CT) shows the greatest proportion of the crude number and percentage; despite a slight decrease in percentage, it is still >80%. Among the combinations, CT alone and CT combined with ultrasonography showed the highest performance rate during the complete observational period. The proportion of all other combinations, which include other complex combinations except CT alone, CT plus ultrasonography, CT plus magnetic resonance imaging (MRI), and CT plus MRI plus ultrasonography, was 13.95% in 2007, but increased to 19.04% in 2014.
Conclusions: CT still plays a major role in preoperative imaging for renal masses, whereby CT alone and CT combined with ultrasonography account for a major proportion of the preoperative imaging patterns. The use of other imaging combinations, as well as renal biopsies, shows an increasing trend. Additional studies are needed to investigate whether this trend in preoperative imaging is related to the frequency rate of PNx.

Introduction

The prevalence of small, localized renal masses among renal-cell carcinomas (RCC) has increased over the years in the United States, representing almost half of all newly diagnosed RCC cases.[1] The increased use of pre-operative imaging modalities explains the increase in the number of incidental small renal masses.[1] Both American and European urology guidelines recommend nephron-sparing surgery as the standard treatment strategy for small renal masses, especially T1 renal masses.[2]

The use of partial nephrectomy (PNx) is currently increasing compared with the decrease in the use of radical nephrectomy.[3-5] This trend is observed because a preservation of renal function is seeked whenever feasible, which might compromise overall survival after radical nephrectomy. To date, urologists have focused on the extended role of PNx in T2- (larger tumors) and even in T3-stage cases with sinus fat invasion state.[6, 7] They have been concerned with reduction of postoperative complications or sequelae, oncological outcomes and procedure types in other studying subjects undergoing PNx.[8]

However, the increasing use of PNx has resulted in a markedly high incidence of benign pathologies after PNx.[9, 10] Although a few studies investigated potential risk factors for the detection of histologically benign pathologies after PNx,[11, 12] no study so far has focused on general trends in pre-operative imaging modalities, which might represent a crucial factor regarding the high prevalence of benign pathologies following PNx. Considering the high accuracy in predicting pathologies before PNx,[13] the trends and patterns of pre-operative imaging modalities and its combinations should be investigated precisely.

Furthermore, contrary to the general opinion of urologists regarding the gradually increasing incidence of renal malignancies and the use of PNx, a recent SEER annual report confirmed that the incidence of renal malignancy no longer shows an increasing trend, but rather a slightly decreasing or static trend. Moreover, based on the data from the California Cancer Registry, Morris et al[14] reported that the incidence of not only all RCCs but also all localized RCCs indicated for PNx no longer shows an increasing trend. This study was the first report to show that the incidence of localized RCC is not increasing.[14]

The aim of our study was to investigate the trends in pre-operative radiological imaging techniques for renal masses, as well as to investigate the frequency trend of PNx using national representative data derived from the MarketScan database. To the best of our knowledge, our recent study represents the first to investigate the real performance status of pre-operative imaging modalities for renal masses before PNx.

Methods

Data source

Data were derived from the nationally representative Truven Health Analytics MarketScan Commercial Claims and Encounters, and Medicare Supplemental databases (Truven Health Analytics. MarketScan Research. https://marketscan.truvenhealth.com /marketscanportal/). The data reflected the confidentiality requirements of the Health Insurance Portability and Accountability Act of 1996. Use of data from this database without informed consent was approved by the institutional review board of Stanford University.

Study population

All adults aged above 18 with a primary procedure code (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*], and the Current Procedural Terminology [CPT] surgical codes) for elective PNx (55.4) with a related diagnosis between January 1, 2007, and December 31, 2015, were selected. We selected all PNx procedures performed in the inpatient service from 2007 and considered the surgery date as the index date. To determine pre-operative imaging, the following CPT codes were used: CT (74150, 74160, and 74170); magnetic resonance imaging (MRI; 74181, 74182, and 74183); ultrasonography (USG; 76700, 76705, 76770, and 76775); and renal mass biopsy (50200 and 50205).

Main outcome measures

Our study included two main outcomes: annual PNx trend and annual trend in pre-operative imaging pattern before PNx. The annual PNx trend included two measures: the actual frequency and the frequency rate per 100,000. The annual trend associated with the pre-operative imaging pattern before PNx included the actual number and proportion (of annual number of PNx patients) with each pre-operative imaging modality and the annual trend associated with the combination of pre-operative imaging modalities. Surgery date was regarded as the index date, and pre-operative imaging within 1 year was considered as pre-operative imaging for PNx. The performance of each imaging modality was defined as any type of CT (those patients with performance of CT regardless of any other imaging modalities), MRI, USG, or biopsy. Patterns of imaging combinations were categorized as CT alone, CT plus USG, CT plus MRI, CT plus MRI plus USG, and other combinations (MRI only, MRI+USG, any other combination with biopsy).

Statistical analysis

Frequency rate per year was calculated using the frequency density rate as the number of new PNx cases in the relevant year multiplied by 100,000 and divided by the number of persons at risk (enrolled total cohort in the relevant year). Regarding the temporal changes in pre-operative imaging patterns annually, we used the actual frequency numbers and proportions together. To determine the significance of trend with time, a linear regression for the line of fit was conducted. Post-hoc subgroup analysis was performed by dividing the patients into age groups of <65 and ≥65 years. All analyses were conducted with SAS 9.3 (SAS Institute, Cary, NC).

Results

Study population

A total of 21445 patients with an *ICD-9-CM* code of 55.4 were identified from 2007 to 2015 using the Truven database system. Owing to the insufficient records of patients in 2015, 1216 patients were excluded. In addition, the patients without any records of pre-operative imaging within 1 year from the index date were also excluded (n = 1602). Finally, 18,627 patients were selected for final inclusion into analyses (Figure 1).

Annual frequency and frequency rate of PNx
Both the annual crude number and frequency rate of PNx are described in Figure 2. Until 2012, similarly, both the crude number and frequency rate showed an increasing trend with a coefficient of 2.19 (95% CI: 1.41, 2.97). However, the crude number showed a sharp decrease in 2013 (n = 2549) and then a slight increase in 2014 (n = 2579). The frequency rate tended to decline to 6.8 in 2013 and further down to 6.5 in 2014.

Annual frequency of pre-operative imaging modalities
Figure 2 shows the crude number and percentage of each imaging modality by year. The annual trend associated with the crude number of imaging procedures (Figure 3A) is similar to that of the crude number of PNx. CT yielded the maximum crude number and percentage; despite a slight decrease in the percentage of CT with a coefficient of -1.29 (95% CI: -3.35, 0.77), it is still >80% (Figure 3B). USG is the second most frequently used pre-operative imaging modality, with a significant increase in percentage with a coefficient of 0.60 (95% CI: 0.23, 0.74) (43.56% in 2007 and 55.45% in 2014). MRI accounts for approximately 30–33% of the cases from 2007 to 2014 with a coefficient of 1.12 (95% CI: -0.45, 2.69). Biopsy showed a significant increase with a coefficient of 1.53 (95% CI: 0.89, 2.16), from 5.28% in 2007 to 9.58% in 2014.

Annual trend associated with a combination of pre-operative imaging modalities
The crude numbers associated with combination patterns are shown in Figure 3A. Among the combinations, CT alone and CT combined with USG showed the highest numbers during the whole year, with a similar trend as PNx. However, the proportion of CT alone and CT combined with USG no longer showed an increasing trend (Figure 4B). The proportion of CT alone decreased significantly with a coefficient of -0.68 (95% CI: -1.12, -0.24) from 38.37% in 2007 to 28.46% in 2014. The crude number and proportion of all other combinations that include other complex combinations except CT alone, CT plus USG (coefficient=1.03 (95% CI: -0.06, 2.13)), CT plus MRI (coefficient=-1.85 (95% CI: -4.00, 0.30)), and CT plus MRI plus USG (coefficient=0.45 (95% CI: -1.57, 2.48)) represent a steady state. The proportion of other combinations showed a significant increasing trend (coefficient=1.12 (95% CI: 0.54, 1.70).

Post hoc subgroup analysis
Figure 5 shows the crude number and frequency rate (/100000) of PNx in two age groups, ≥65 and <65 years. The total crude number of PNx in the <65-year age group showed a sharp decrease in 2013. The frequency rate of PNx in the ≥65-year age group showed a steady increase from 2007 to 2014. Figure 5 shows the crude number and percentage of each pre-operative imaging modality. The percentage of CT showed a decreasing trend in both groups (Figure 6B). The trend for MRI showed a similar pattern. However, USG and biopsy showed a prominently increasing pattern in the ≥65-year age group (Figure 6B).

Discussion

To the best of our knowledge, we are the first to report the most recent frequency analysis of PNx and the annual trends in pre-operative imaging techniques with combined modalities. Contrary to the general concept suggesting that the use of PNx is steadily increasing and rapidly replacing the significant role of radical nephrectomy,[3-5] our data showed no definitive increase since 2012.

The absence of an increasing trend in the absolute frequency number of PNx might be attributed to the incidence of renal malignancy itself showing no increasing trend. The most recent SEER data showed that the average annual percentage change (AAPC) from 13 SEER areas from 2005 to 2014 was −0.9 (SEER Cancer Statistics Review 1975–2014). Moris et al[14] also reported using California Cancer Registration data that the incidence of RCC showed a steadily increasing pattern until 2008 and 2009. However, the increasing trend was reversed from 2008 and 2009, and the incidence was stabilized. Furthermore, the incidence of RCCs <4 cm in size warranting PNx, showed a declining trend since 2009, with an AAPC of −0.3.

Although our study is the first to report the decreasing or static patterns of the crude numbers and frequencies of PNx, the proportion of PNx compared with that of radical nephrectomy still showed an increasing trend.[14] Urologists have focused on the expansion of the indications for PNx even to T3 stages with sinus fat invasion[6, 7] and have been concerned with perioperative complications, including ischemia time and blood loss, and postoperative complications, including postoperative exacerbation in renal function.[8] Several reports have focused on the benign pathology after PNx.[9-12] Considering the socioeconomic burden of PNx and related complications among patients with benign pathology, several studies focused more on the critical role of pre-operative imaging modalities, which are now increasingly accurate in predicting RCC.[13, 15-17] However, no studies have been conducted regarding pre-operative imaging trends or patterns before PNx for renal masses so far. Our additional goal was to investigate the trends and patterns in pre-operative imaging modalities.

Our study provides the most recent evidence supporting the role of CT, which still plays a major role in pre-operative imaging. Based on the pattern of the combined use of imaging modalities, CT alone and CT combined with USG accounted for the highest proportion of pre-operative imaging. Although CT is still the standard modality to predict renal masses and associated with high accuracy,[13] over the last decade, radiologists have shown the excellent predictive outcome of MRI and renal mass biopsy.[15-18]

The question about urologists focusing less on additional imaging modalities, including MRI persists. A substantial gap exists between urologists and radiologists in terms of radiological interpretation. Most reports investigating the accuracy of MRI in predicting RCCs among small renal masses were based on retrospective studies,[15-18] and the retrospective interpretation of MRI varies from real-time interpretation in real clinical practice. Eventually, the ultimate interpretation technologies of CT or MRI in predicting RCCs in small renal masses. as shown in previous studies require quite time, which is not feasible in real clinical practice. Concerning this issue, Kim et al [18] reported that the diagnostic accuracies of CT and MRI are not high in predicting RCCs in small renal masses.

CT and MRI showed 79.7% and 88.1% sensitivity, and 44.4% and 33.3% specificity, respectively, based on a subjective radiologic interpretation in real clinical practice.

Although our study clearly indicates an increasing trend associated with the use of other imaging modalities, including MRI and renal biopsy, several limitations remain. One important limitation of our study is the fact that we were not able to show the substantial role of MRI or renal biopsy in the context of patients with histologically benign pathologies. Furthermore, we could not determine the role of RNx compared with PNx in this study. Other limitations include the lack of additional information pertaining to the procedural type of PNx (robotic, laparoscopic, or open PNx). In addition, although we calculated the frequency of PNx using the MarketScan population database, it was not meant to be the standardized rate. Lastly, due to limited follow-up information, the role of active surveillance was not observed.

Conclusion

Clinicians are undecided as to the most practical option for treatment of small renal masses, including CT alone or CT plus USG, or additional imaging modalities such as MRI and biopsy for small renal masses, to reduce the incidence of benign pathologies after PNx prevent unnecessary surgery and related complications. Avoiding unnecessary surgery is more important than the issue of cost-effectiveness. Hence, the current trend reflecting the use of other combination modalities and renal mass biopsy represents a positive phenomenon.

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Figures and Tables

Fig. 1. Deposition of the study population.

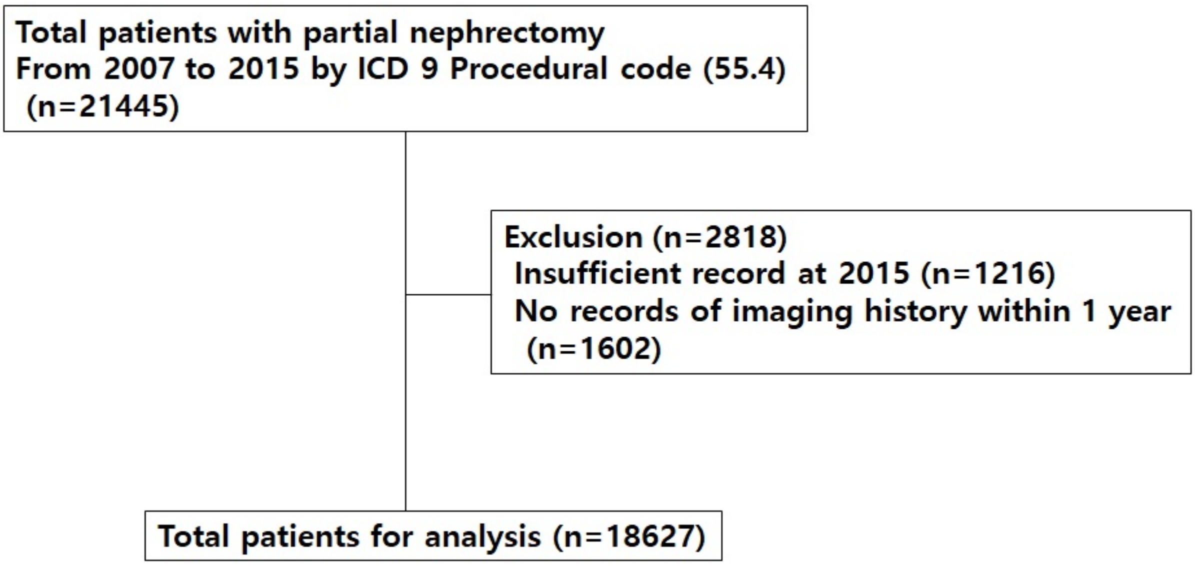

Fig. 2. Annual frequency and frequency rate of partial nephrectomy.

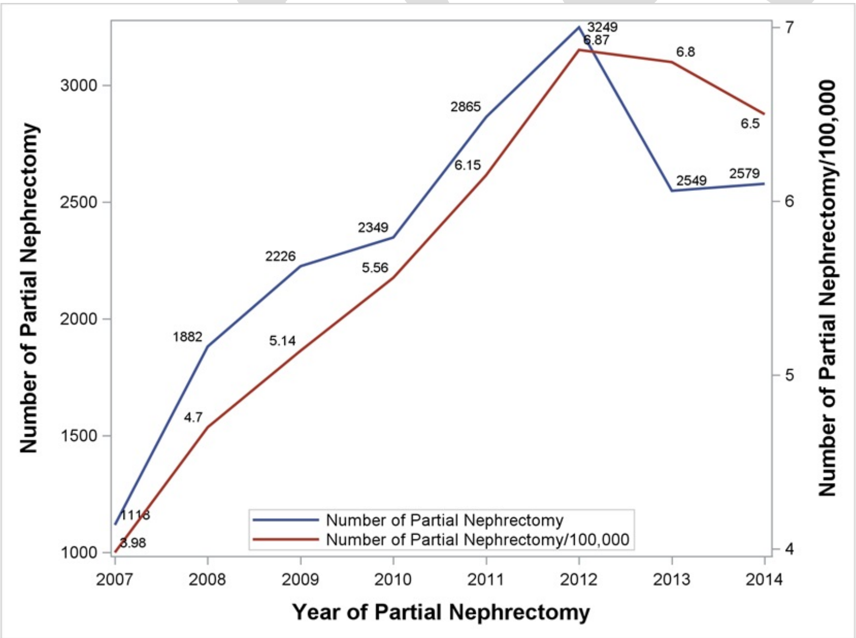

Fig. 3. Annual frequency and proportions of preoperative imaging modalities.

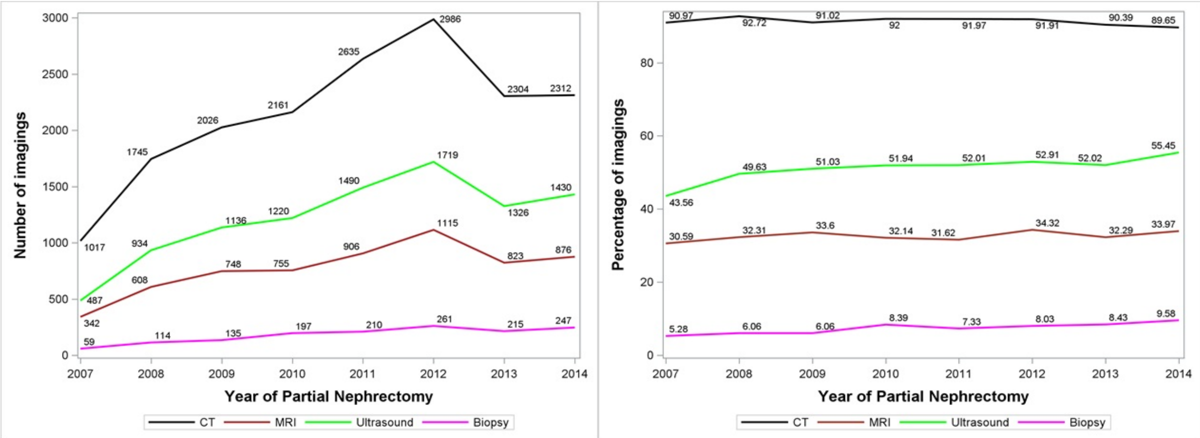

Fig. 4. Annual frequency and proportions of combination patterns in preoperative imaging modalities.

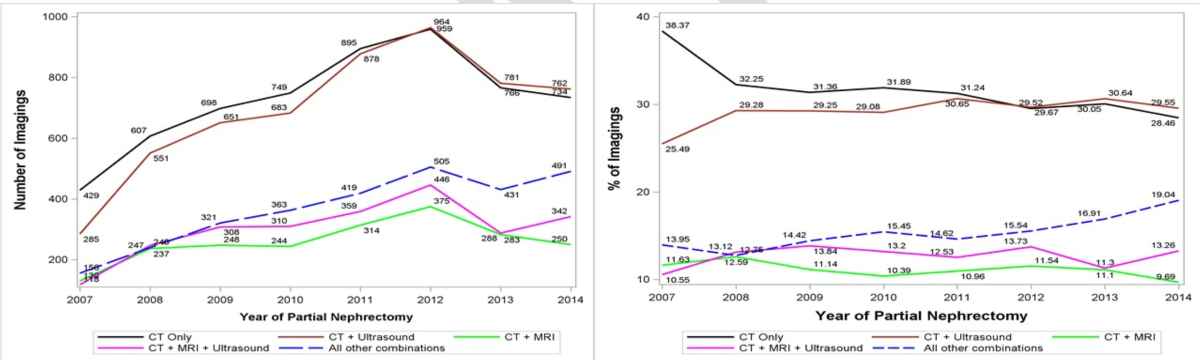

Fig. 5. Crude number and frequency rate (/100 000) of partial nephrectomy in the two age groups: ≥65 and <65 years.

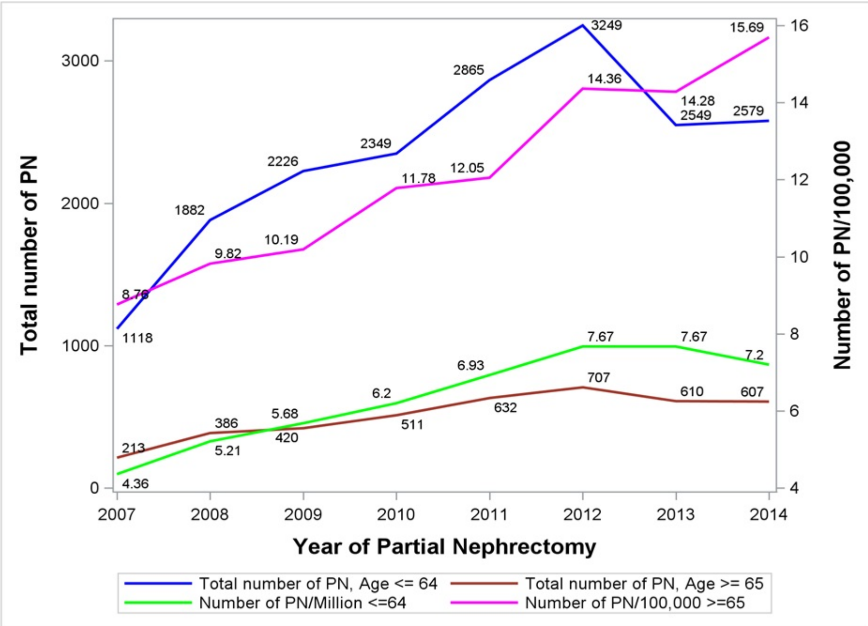

Fig. 6. Crude number and percentage of each preoperative imaging modality: ≥65 and <65 years.