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Superiority of magnetic resonance imaging in small renal mass diagnosis where image reports mismatches between computed tomography and magnetic resonance imaging

Jinu Kim, Jong Soo Lee, Youngheun Jo, Woong Kyu Han

Department of Urology, Urological Science Institute, Yonsei University College of Medicine, Seoul, Korea

Purpose: To analyze malignancy of computed tomography (CT) and magnetic resonance imaging (MRI) results in the same renal mass.

Materials and Methods: We retrospectively reviewed 1,216 patients who underwent partial nephrectomy from January 2017 to December 2021 in our institute. Patients who had both CT and MRI reports prior to surgery were included. We compared the diagnostic accuracy between the CT and the MRI. The patients were divided into two groups according to the consistency of reports: the 'Consistent group' and the 'Inconsistent group'. The Inconsistent group was further divided into two subgroups. Group 1 is the case that showed benign findings on CT but malignancy on MRI. Group 2 is the cases of malignancy on CT but benign on MRI.

Results: 410 patients were identified. Benign lesion was identified in 68 cases (16.6%). The sensitivity, specificity and diagnostic accuracy of MRI was 91.2%, 36.8%, and 82.2% respectively, whereas that of CT was 84.8%, 41.2%, and 77.6% respectively. Consistent group were 335 cases (81.7%) and inconsistent group were 75 cases (18.3%). The mean mass size was significantly smaller in the inconsistent group compared to the consistent group (consistent group vs. inconsistent group: 2.31±0.84 cm vs.1.84±0.75 cm, p<0.001). Also, the Group 1 had higher odds of malignancy compared to Group 2 in the renal mass size 2–4 cm (odds ratio, 5.62 [1.02–30.90]).

Conclusions: Smaller mass size affects the discrepancy of CT and MRI reports. In addition, MRI showed better diagnostic performance in mismatch cases in the small renal masses.

Keywords: Kidney neoplasms; Magnetic resonance imaging; Renal cell carcinoma; Tomography, X-ray computed

INTRODUCTION

Kidney cancer is the sixth-most common cancer among males and the ninth-most common among females in the United States [1]. With advances in imaging technologies, most kidney cancers are detected early. Computed tomography (CT) and magnetic resonance imaging (MRI) are often used to diagnose small renal masses (≤4 cm in radiographic diameter). Contrast-enhanced CT is a commonly used technology for this purpose. Most renal masses can be diagnosed

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Corresponding Author: Woong Kyu Han https://orcid.org/0000-0002-2527-4046
Department of Urology, Urological Science Institute, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea
TEL: +82-2-2228-2310, FAX: +82-2-312-2538, E-mail: hanwk@yuhs.ac

at early onset using contrast-enhanced CT. Its enhanced pattern helps diagnose certain histopathologies. On the other hand, MRI offers exceptional soft tissue contrast and provides numerous functional parameters and useful data for the analysis of renal-specific characteristics of the masses [2]. T2-weighted scans are useful to characterize certain histopathologies, while T1-weighted gradient images allow the detection of macroscopic or microscopic fat [2]. Enhancement patterns on multiparametric MRI scans have been reported to distinguish subtypes of renal cell carcinoma (RCC) [3].

Despite these advances in imaging, approximately 10% to 30% of small renal masses, presumed to be RCC in preoperative imaging tests, were reported to be benign after surgery [4-8]. Percutaneous renal mass biopsy, known to be safe and with high diagnostic accuracy, is typically used to confirm the characteristics of the renal mass before surgery. However, not all the renal masses can be biopsied, and sometimes they are in the dangerous location to perform. Furthermore, even after the biopsy, the possibility of nondiagnostic results must be tolerated [9-11]. For these reasons, in many cases, surgical removal is decided based on image reports, without biopsy.

Previous studies described the analysis of concordance between CT scans and pathological results and between MRI scans and pathological results. Only a few studies involved the analysis of the agreement between CT scans, MRI scans, and pathological results for a single mass simultaneously. The purpose of this study is to determine the diagnostic accuracy of CT and MRI in the same small renal masses and investigate the characteristics of cases with discrepant findings.

MATERIALS AND METHODS

We retrospectively reviewed 1,216 cases of partial or radical nephrectomy that occurred between January 2017 and December 2021 in our institution. Cases which had previously evaluated both CT and MRI scan were included. The mean renal mass size was measured via CT scan images. Exclusion criteria were 1) renal mass size greater than 4 cm or presence of multiple renal masses; 2) known genetic diseases such as Von Hippel–Lindau disease or Birt–Hogg–Dubé syndrome; and 3) previously confirmed histology by ultrasound-guided renal mass biopsy. Finally, 410 patients were included in the study; all patients had undergone partial nephrectomy, with no cases of radical nephrectomy. The present retrospective study was reviewed and approved by the Institutional Review Board of Yonsei University College of Medicine (approval no. 4-2022-1210). Informed consent was waived by the Institutional Review Board because of the study's retrospective design.

Contrast-enhanced CT and contrast-enhanced MRI were performed to evaluate each small renal mass. Two experienced radiologists evaluated the scans of the renal masses. If the image reports had multiple results, we considered only the first results to assess its malignancy, because it was assumed that the first result was the most probable disease. Imaging reports were divided into two main categories: benign and malignant reports. Benign reports included angiomyolipoma (AML), hemorrhagic cyst, nodule, cystic lesion (Bosniak I, II, and IIF), and other benign findings, while the malignant category included RCC, atypical RCC, Bosniak III, Bosniak IV, and cystic RCC. Sensitivity, specificity, and diagnostic accuracy were calculated for each type of scan. The diagnostic accuracy was calculated by the following formula: (True positive+True negative)/(True negative+False positive+False negative+True negative). Furthermore, patients were divided into two groups: the consistent group and the inconsistent group, according to the consistency of the CT and MRI results. The consistent group included patients with both CT and MRI reports indicating benign or both reports indicating malignant, whereas the inconsistent group included cases with a CT report indicating benign and an MRI report indicating malignant and vice versa. We defined group 1 as the group with a CT report indicating benign and an MRI report indicating malignant. Conversely, we defined group 2 as the group with a CT report indicating malignant and an MRI report indicating benign. The example case of group 1 and group 2 were described in the Fig. 1 and 2. The

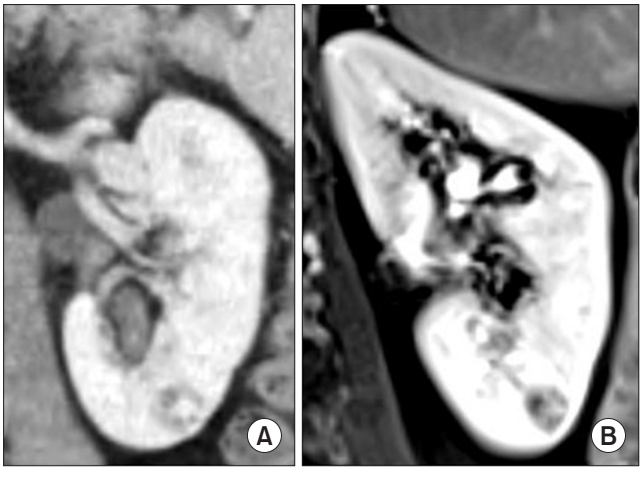

Fig. 1. Example of group 1. Contrast-enhanced computed tomography scan (A) was reported as 'fat poor angiomyolipoma' and magnetic resonance imaging T1-weighted image scan (B) was reported as 'cystic renal cell carcinoma (RCC)'. The final pathology was reported as clear cell RCC.

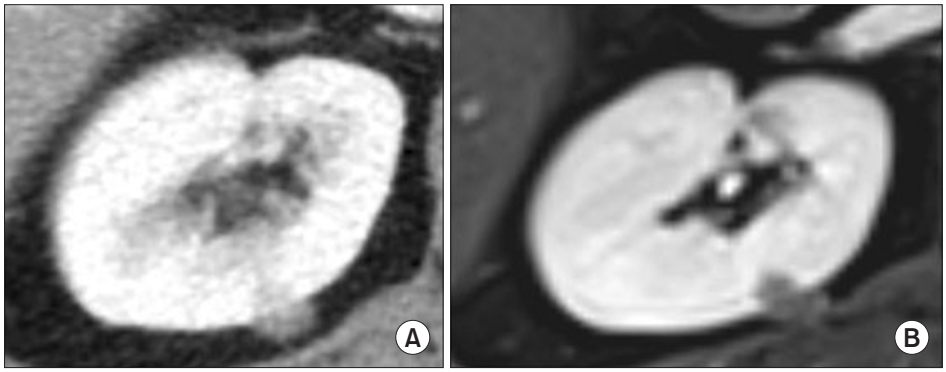

Fig. 2. Example of group 2. Contrast-enhanced computed tomography scan (A) was reported as 'small renal cell carcinoma (RCC)' and magnetic resonance imaging T1-weighted image scan (B) was reported as 'fat poor angiomyolipoma is more likely'. The final pathology after surgery was reported as an angiomyolipoma.

Table 1. Patient characteristics (n=410)

Variable	Value
Age (y)	54.61±12.66
Male	256 (62.4)
Female	154 (37.6)
Mass size (cm)	2.22±0.84
Surgical methods	
Open partial nephrectomy	20 (4.9)
VAMS partial nephrectomy	30 (7.3)
Laparoscopic partial nephrectomy	3 (0.7)
Robot-assisted partial nephrectomy	353 (86.1)
SP robot-assisted partial nephrectomy	4 (1.0)
Pathological results	
Malignancy (n=342)	
Clear cell RCC	273 (66.6)
Chromophobe RCC	29 (7.1)
Papillary RCC	
Type 1	21 (5.1)
Type 2	12 (2.9)
Unclassified	2 (0.5)
MiT family translocation RCC	2 (0.5)
Mixed epithelial and stromal tumor	2 (0.5)
Unclassified RCC	1 (0.2)
Benign (n=68)	
Angiomyolipoma	37 (9.0)
Oncocytoma	11 (2.7)
Multilocular cystic renal neoplasm	10 (2.4)
Other[a]	10 (2.4)

Values are presented as mean±standard deviation or number (%).
VAMS, video-assisted mini-laparotomy surgery; SP, single port; RCC, renal cell carcinoma.
[a]:Simple cortical cyst, localized cystic disease, lymphoid tissue.

Table 2. Pathologically confirmed malignant mass vs. benign mass, according to mass size

Size (cm)	Malignant	Benign
0–2	129 (78.7)	35 (21.3)
2.1–3	123 (84.2)	23 (15.8)
3.1–4	90 (90.0)	10 (10.0)

Values are presented as number (%).

final pathology assessment was compared and analyzed between these two subgroups.

Statistical analyses were performed using SPSS software, version 26 (IBM Corp.). Continuous variables were compared using the independent t-test, and categorical variables were compared using Fisher's exact test. For all statistical analyses, a p-value less than 0.05 was considered statistically significant.

RESULTS

Among the 410 study patients, the mean patient age was 54.61 years; 256 patients were male (62.4%), and 154 patients were female (37.6%). Most of the patients (353; 86.1%) had undergone robot-assisted partial nephrectomy followed by partial nephrectomy via video-assisted mini-laparotomy surgery or open partial nephrectomy. The sensitivity, specificity, and accuracy of the MRI and CT scans were 91.2%, 36.8%, and 82.2%, and 84.8%, 41.2%, and 77.6%, respectively.

1. Malignancy of the small renal mass

Of the 410 study patients, 342 cases (83.4%) were diagnosed as malignant, and 68 cases (16.6%) were diagnosed as benign in the final histopathology report. The most common malignancy type was clear cell RCC (273 cases, 66.6%), and the second-most common type was papillary RCC (35 cases, 8.5%). Among the cases confirmed as benign, the most common type was AML (37 cases, 9.0%) followed by oncocytoma (11 cases, 2.7%). The basic characteristics of the patients are described in Table 1. Table 2 lists the distribution of malignant and benign cases, according to tumor size. The odds ratio (OR) between malignancy and mass size was 1.59 (95% confidence interval [CI], 1.15–2.21; p<0.001).

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Table 3. Mass characteristics of patients in the consistent group vs. the inconsistent group, according to mass size

Variable	Consistent group (n=335)	Inconsistent group (n=75)	p-value
Age (y)	54.93±12.69	53.17±12.52	0.277
Mass size (cm)	2.31±0.84	1.84±0.75	<0.001
Number of cases			-
0–2 cm	120 (35.8)	44 (58.7)	
2.1–3 cm	124 (37.0)	22 (29.3)	
3.1–4 cm	91 (27.2)	9 (12.0)	

Values are presented as mean±standard deviation or number (%).

2. Consistency of the imaging reports

In the CT and MRI reports, 335 cases (81.7%) were in the consistent group, and 75 cases (18.3%) were in the inconsistent group. In the inconsistent group, 50 cases (66.7%) had a CT report indicating benign and an MRI report indicating malignant (group 1), 25 cases (33.3%) had a CT report indicating malignant and an MRI report indicating benign (group 2). A comparison of mass size in the consistent and inconsistent groups is provided in Table 3. The mean mass size was significantly smaller in the inconsistent group than in the consistent group (p<0.001). The OR between consistency and mass size was 2.08 (95% CI, 1.48–2.91; p<0.001).

A comparison of imaging technologies and final pathology results in groups 1 and 2 of the inconsistent group is provided in Table 4. In the 0- to 2-cm subgroup, there was no significant difference in malignancy between the two groups. However, in the 2- to 4-cm renal mass subgroup, group 1 had higher odds of a malignant finding compared to group 2 (OR, 5.62).

Table 4. Characteristics of the subgroups of the inconsistent group

Preoperative image report	Benign pathology	Malignant pathology	OR (95% CI)
0–2 cm (n=44)			0.96 (0.26–3.60)
Group 1 (n=28)	9 (32.1)	19 (67.9)	
Group 2 (n=16)	5 (31.3)	11 (68.7)	
2.1–3 cm (n=22)			3.67 (0.56–24.13)
Group 1 (n=15)	4 (26.7)	11 (73.3)	
Group 2 (n=7)	4 (57.1)	3 (42.9)	
3.1–4 cm (n=9)			N/A
Group 1 (n=7)	0 (0.0)	7 (100.0)	
Group 2 (n=2)	1 (50.0)	1 (50.0)	
2.1–4 cm (n=31)			5.62 (1.02–30.90)
Group 1 (n=22)	4 (18.2)	18 (81.8)	
Group 2 (n=9)	5 (55.6)	4 (44.4)	

Values are presented as number (%).
Group 1, CT-benign & MRI-malignancy reports; Group 2, CT-malignancy & MRI-benign reports.
OR, odds ratio; CI, confidence interval; NA, not available; CT, computed tomography; MRI, magnetic resonance imaging.

DISCUSSION

In this study, we analyzed the CT and MRI findings for patients with small renal masses and compared them with the final histopathological results. Among our study population, a benign mass was found in 16.6% of cases with a mass smaller than 4 cm. However, when the size was limited to less than 2 cm, the incidence of a benign finding increased to 21.3%. We also found that 18.3% of cases had discrepant findings between CT and MRI reports for these small renal masses. Therefore, when there is a small renal mass, it is better to characterize the mass using both methods rather than with either CT or MRI alone. In particular, discrepancies between CT and MRI reports are more common when the mass size is small. In cases of the inconsistent CT and MRI results, the actual pathology was more likely to be malignant when the MRI finding indicated malignant.

Our study data are comparable with those from previous studies. Srougi et al. [6] analyzed findings of 305 patients of renal masses. Among masses smaller than 3 cm, 22.9% were benign. Three centimeters was used as a cut-off value as metastasis is more likely in renal masses larger than 3 cm [12,13]. Bertolo et al. [14] analyzed 524 patients who had undergone robotic partial nephrectomy for a renal mass smaller than 4 cm: In masses smaller than 2 cm, 23.6% were benign, and in masses between 2 cm and 4 cm, 14.1% were benign, indicating that smaller masses are more likely to be benign. Xiong et al. [5] examined 303 patients who had undergone either partial or radical nephrectomy for previously diagnosed RCC on CT. They confirmed 31 benign cases (10.1%); 5 of 20 cases (25%) were benign renal masses smaller than 2 cm, and 13 of 100 cases (13%) were benign renal masses between 2 cm and 4 cm. Kwon et al. [15] studied the diagnostic accuracy of MRI in small indeterminate masses. They evaluated 120 small renal masses using both CT and MRI scans for diagnosis and concluded that MRI was better able to distinguish indeterminate masses compared to CT. However, some of their cases were diagnosed clinically but not confirmed histopathologically.

CT is a commonly used image modality for evaluating small renal masses Contrast-enhanced CT uses corticomedullary, nephrographic, and excretory phases to describe the characteristics of small renal masses. However, CT requires contrast media for accurate diagnoses, which is difficult for patients with chronic kidney disease or with an allergy to the contrast agent. Multiparametric MRI, on the other

hand, is a combination of conventional morphological and functional imaging using magnetic resonance. Diffusion-weighted imaging or the apparent diffusion coefficient are used for the characterization of small renal masses during multiparametric MRI [16-18]. However, compared to CT, MRI requires a longer scan time and is more expensive, limiting its use. For this reason, most previous studies have focused on CT rather than MRI in small numbers of patients [2,17,19,20].

Our study revealed that 18.3% of CT and MRI reports on small renal masses had discrepant findings, indicating that both methods should be considered in diagnosing small renal masses. We confirmed that the size of the tumor correlated with the consistency between the CT and MRI results—that is, the smaller the tumor, the lower the concordance between the CT and MRI findings. In addition, the use of both methods together rather than either alone better predicted malignancy. Also, in the groups with discrepant results, both malignant/benign probabilities are possible, but cases with an MRI finding of malignant are more likely to be malignant according to the final histopathological outcome, so MRI scans may better characterize small renal masses.

Our study has several limitations. First, as a retrospective study, selection bias may be present. Second, cases treated with thermal ablation therapy after the percutaneous biopsy rather than partial nephrectomy or radical nephrectomy of the small renal mass were not included. Finally, since imaging readings are evaluated with reference to the previous image results, MRI taken later may have a bias advantage in reading compared to CT.

CONCLUSIONS

Although CT and MRI are reasonable imaging modalities for the detection and characterization of small renal masses, predicting malignancy from the two results was inconsistent in some cases. This inconsistency appears related to a smaller renal mass size. Among these two imaging methods, MRI exhibited better diagnostic performance in predicting malignancy compared to CT. Therefore, benign findings should be confirmed by the addition of an MRI.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHORS' CONTRIBUTIONS

Research conception and design: Jinu Kim and Woong Kyu Han. Data acquisition: Youngheun Jo. Statistical analysis: Jinu Kim. Data analysis and interpretation: Jong Soo Lee. Drafting of the manuscript: Jinu Kim. Critical revision of the manuscript: Woong Kyu Han. Supervision: Woong Kyu Han. Approval of the final manuscript: all authors.

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