STAGING AND DIFFERENTIAL DIAGNOSIS OF RENAL CELL CARCINOMA: A COMPARISON OF MAGNETIC RESONANCE IMGING (MRI) AND COMPUTED TOMOGRAPHY (CT)

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The usefulness of magnetic resonance imaging (MRI) was compared with that of computed tomography (CT). Twenty-nine patients with renal cell carcinoma, 3 with angiomyolipomas and 1 with renal pelvic cancer, were examined by both MRI and CT. MRI and CT showed similar results in staging cases of renal cell carcinoma. However, MRI may be more sensitive in detecting the venous extension, metastatic adenopathy, and adjacent organ invasion. In predicting the involvement of perinephric fat, however, MRI is only marginally superior to CT.

To demonstrate the usefulness of MRI in differentiating renal cell carcinoma from other renal tumors, the density of renal tumor and that of the psoas muscle were determined using a densitiometer, and the percent (%) contrast (the intensity of the renal tumor / the intensity of the psoas muscle × 100) was calculated. In most patients with clear cell type renal carcinoma, the % contrast value in the T1 weighted images was about 100. In the T2 weighted images, the maximum value of the % contrast value was 50 or less in most patients. In one patient with spindle cell type (sarcomatoid type) carcinoma, the % contrast value was 109 in the T1 weighted images, but was 65-85, at most, in the T2 weighted images. In patients with renal angiomyolipomas, the % contrast values were calculated exclusive of the fatty components. The % contrast value of the T1 weighted images was 50 or less in all 3 patients, and that of the T2 weighted images was 50 or more in 2 patients and 21-38 in the others. Calculation of the % contrast value may possibly enable one to differentiate between various types of renal cell carcinoma and other renal masses.

Key words: MRI, CT, Renal tumor, Staging, Differential diagnosis

INTRODUCTION

Accurate preoperative staging and diagnosing of renal cell carcinomas are important in planning surgical treatment, and in determining long-term prognoses. During the past few decades, advances in imaging have had a significant impact on the evaluation of renal cell carcinomas. Ultrasound, computed tomography (CT)[1-4], and angiography have been used for this purpose.

Recently, the value of magnetic resonance imaging (MRI) in diagnosing renal diseases has been reported[5-8]. Hricak et al.[9] compared MRI and CT for evaluating renal cell carcinomas, and concluded that MRI should play an important role in the diagnosis and staging of renal neoplasms. Fein et al.[10], however, suggested that MRI was no more valuable than CT in staging renal cell carcinomas. We investigated the usefulness of MRI as compared with CT for preoperative staging and differentiation of renal cell carcinoma from other renal tumors, especially renal angiomyolipomas.

MATERIAL AND METHODS

Subjects included 29 patients with renal

Table 1. Diagnosis and imaging modes used.

	No. diagnosis	No. T1 weighted image	No. T2 weighted image	No. Proton density image
renal cell carcinoma	29	27	29	28
renal pelvic cancer	1	1	1	1
renal angiomyolipoma	3	3	3	2

cell carcinomas (23 males and 6 females, aged 33-82), 1 patient with renal pelvic cancer (58 year-old male) that was difficult to differentiate from renal cell carcinoma, and 3 patients with renal angiomyolipomas (1 male aged 18 years and 2 females aged 11 years and 40 years), as indicated in Table 1. Histologic examinations of the 29 renal cell carcinoma cases revealed that 27 cases were of the clear cell type or mixed clear cell type, 1 had papillary adenocarcinoma and 1 was of the spindle cell type (sarcomatoid type).

Staging of the renal cell carcinoma cases using MRI and CT, were reviewed independently by a radiologist and a urologist.

MRI was conducted using a superconducting NMR-CT, SIGNA (General Electric CO., Milwaukee) with a magnetic field of 1.5T. T1 weighted images were obtained using the spin echo method with a repetition time (TR) of 600 ms and an echo time (TE) of 30 ms. Proton density images and T2 weighted images were also obtained using the partial saturation method with a TR of 2,000 ms and a TE of 20 and 60 ms. In principle, axial sections were displayed as proton density images and T2 weighted images, and coronal or sagittal sections as T1 weighted images. The slice thickness used in axial scans was 5 mm, with a 10 mm gap, and the thickness in coronal or saggital scans was 10 mm, with a 15 mm gap. T1 and T2 weighted images and proton density images were performed as shown in Table 1.

All of the patients were examined simultaneously with CT, in 10 mm thickness at 5 mm intervals. Both plain and enhanced images were generated on third generation CT scanners (GE 8,800; General Electric CO. Milwaukee).

To examine the usefulness of MRI in differentiating renal cell carcinoma from other renal tumors, the density of the renal tumor and that of the psoas muscle were determined using a densitiometer (Sakura PDA65, Japan), and the % contrast value (the intensity of renal tumor/ that of the psoas muscle $\times 100$) was used as a comparison parameter.

RESULTS

1) Renal tumor depicted using MRI

In the T1 weighted images, the tumor signals were relatively homogeneous. The difference between the maximum and minimum % contrast values was 10 or less, in 24 of the 27 cases (88.9%). The intensity of the tumors was similar to that of the psoas muscles (% contrast $=100\pm30$) in 19 of the 27 cases (70.4%) (Fig. 1).

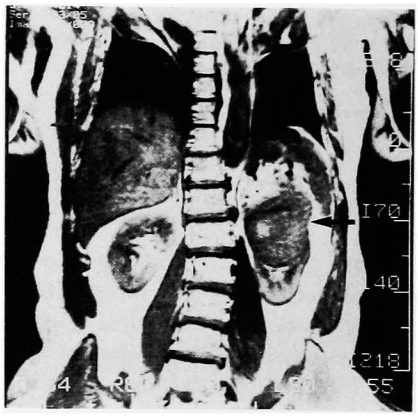

Fig. 1. A T1 weighted image of a left renal cell carcinoma. The tumor (arrow) appears as a nearly homogeneous body of medium intensity in the image.

In the proton density images, the tumors appeared homogeneous in 16 of the 28 patients (57.1%). The % contrast values,

however, were 100±30 in only 12 patients (42.9%) (Fig. 2), and between 20 to 30 in some patients. In the T2 weighted images, the tumor signal was often heterogenous, and the difference between the maximum and minimum values of the % contrast was 10 or more in 27 of the 29 patients (75.9%) and 20 or more in 13 patients (44.8%). The maximum value of the % contrast was 50 or less in 20 patients (69.0%) (Fig. 3). Pseudocapsules caused by the compression of the renal parenchyma by the tumor were clearly discernible as low intensity lines especially on the T2 weighted images (Fig. 4).

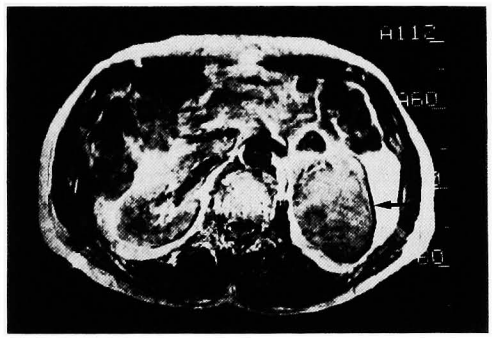

Fig. 2. A proton density image of Fig. 1. The tumor (arrow) is shown at medium to slightly high intensity.

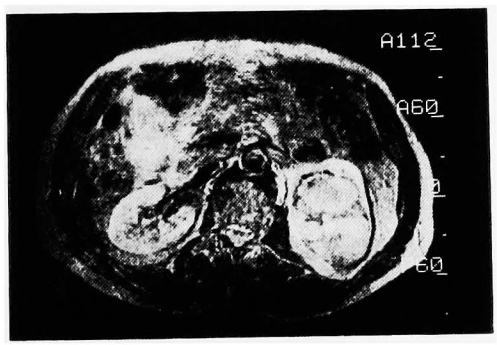

Fig. 3. A T2 weighted image of Fig. 1.

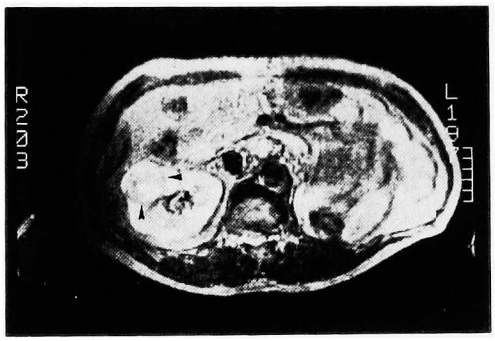

Fig. 4. A T2 weighted image of a right renal cell carcinoma. A pseudocapsule (arrow head) appears as a low intensity line. The tumor was easily enucleated.

2) Staging (Table 2)

2-1; Perinephric extension

As a whole, the findings observed using MRI were not greatly superior to the findings observed using CT. However, as long as a chemical shift—an artifact displayed on the borderline between water and fat—was present, no extracapsular invasion was clearly discernible (Figs. 5 and 6). Hepatic invasion was more clearly demonstrated using MRI than CT (Figs. 7 and 8). Differentiation between pT2 and pT3 seemed to be difficult using either procedure.

2-2; Lymph node metastasis.

Lymph node metastases were shown more clearly by MRI as medium intensity signals on the T1 weighted images and as

Table 2. Specificity, sensitivity and accuracy of imaging examinations for staging of renal cell carcinomas.

	MRI			CT		
	sensitivity	specificity	accuracy	sensitivity	specificity	accuracy
Perinephric extension	50% (4/8)	76.2% (16/21)	69.0% (20/29)	62.5% (5/8)	76.2% (16/21)	72.4% (21/29)
Venous invasion	100% (4/4)	96% (24/25)	96.6% (28/29)	50% (2/4)	92% (23/25)	86.2% (25/29)
Metastatic adenopathy	80% (4/5)	91.7% (22/24)	89.7% (26/29)	80% (4/5)	83.3% (20/24)	82.8% (24/29)
Adjacent organ invasion	100% (1/1)	100% (28/28)	100% (29/29)	100% (1/1)	96.4% (27/28)	96.6% (28/29)

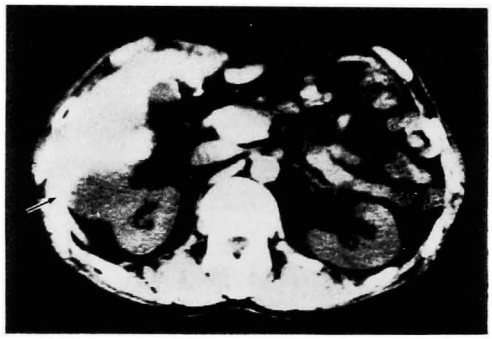

Fig. 5. A CT scan of a right renal tumor. Though the radiologist found no tumor invasion into the liver (arrow), the border between the tumor and the liver is unclear in the image.

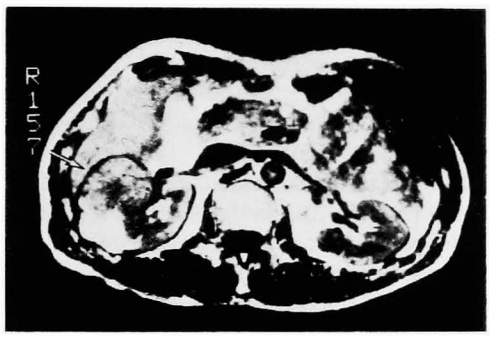

Fig. 6. A Proton density image of Fig. 5. The chemical shift artifact (arrow) suggests no tumor invasion into the liver.

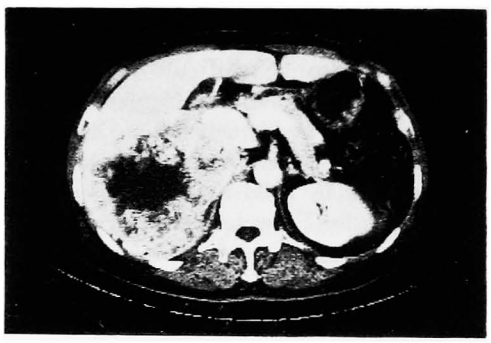

Fig. 7. A CT scan of a right renal cell carcinoma. Tumor invasion into the liver is not discernible.

high intensity signals on the T2 weighted images than by CT.

Two patients whose lymph nodes were interpreted as metastases, were overstaged using both MRI and CT. Malignant and benign lesions might have been indistinguishable in MR images, and metastasis was assessed based only on the size of the lymph node. Two patients were overstaged

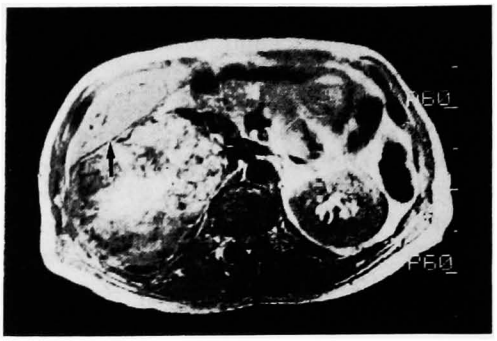

Fig. 8. A Proton density image of Fig. 7. The border (arrow) between the tumor and the liver is clear.

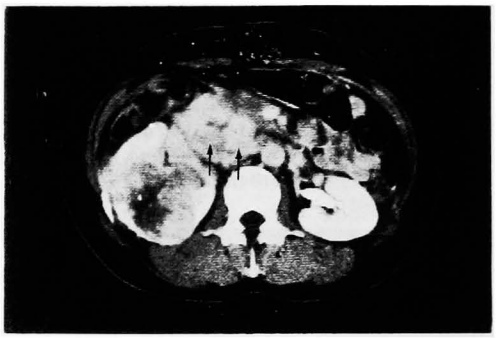

Fig. 9. A CT scan of a right renal cell carcinoma. Lymph node metastasis is suspected (arrow).

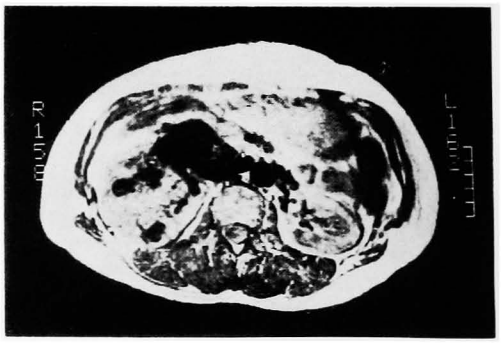

Fig. 10. A proton density image of Fig. 9. The mass, suspected to be lymph node metastasis in the CT image, shows no signal in the image, and would be diagnosed as aggregate blood vessels at the renal hilum (eg. an enlarged and / or damaged vena cava due to tumor thrombus).

using CT, but were correctly staged using MRI. The gonadal vein was mistaken for lymph nodes in one patient, andaggregate blood vessels at the renal hilum (eg. an enlarged and/or affected vena cava with tumor thrombi) were mistaken for lymph nodes in the other patient when using CT (Figs. 9 and 10). Blood vessels were readily differentiated from lymph nodes using MRI, since they did not register a signal.

2-3; Venous invasion.

Only a minor difference was observed in the rate of correct diagnoses of venous invasion between the two imaging techniques, since the invasion was infrequently seen. Using MRI, a tumor thrombus in a blood vessel, and adhesion of a tumor to the vascular wall were easily discernible. In addition, the upper margin of the tumor thrombus was depicted precisely using MRI (Figs. 11 and 12).

A tumor thrombus in the renal vein (V1) was incorrectly diagnosed using MRI since the tumor markedly displaced displaced the renal vein, resulting in a deformation of the vein.

3) Differential diagnosis

As mentioned above, the % contrast value in the T1 weighted images of the patients with clear cell renal carcinoma, was about 100. Only 4 patients (14.8%) had a value of 50 or less. Of 3 of the above 4 patients who also were tested using T2 weighted images, 2 had a maximum value of less than 50, and the other showed a low value of 17-62.

In one patient with spindle cell type (sarcomatoid type) carcinoma, the % contrast value was 109 for the T1 weighted image and 88 for the proton density image, but was a high value of 65-85 for the T2 weighted image (Figs. 13 and 14). In one patient with papillary renal cell carcinoma, the % contrast value was 60.6 for the T1 weighted image and 88 for the proton density image, but was a high value of 33-104 for the T2 weighted images.

The highest contrast value of the T2 weighted images of the other 27 patients with renal cancer which occurred in a patient whose cancer was shown as a heterogenous mass was 54-79.

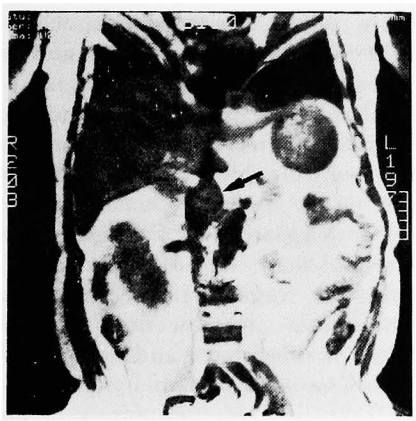

Fig. 11. A T1 weighted image of a tumor thrombus. The tumor thrombus (arrow) from the left renal vein extends into the vena cava.

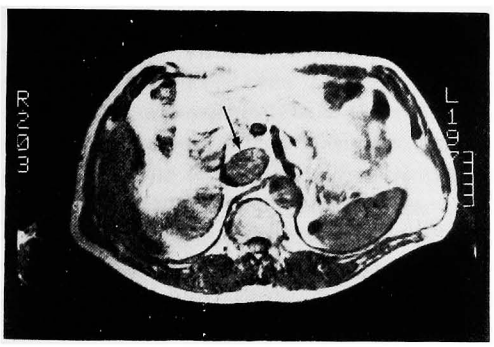

Fig. 12. A proton density image of Fig. 11. The tumor thrombus (arrow) in the vena cava is clear.

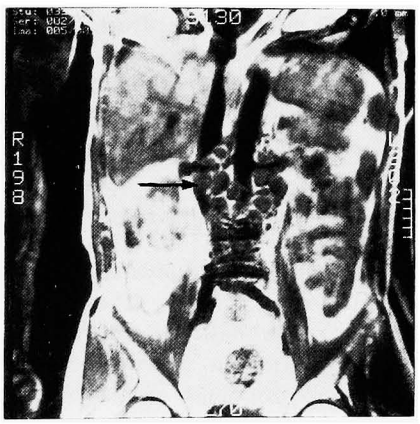

Fig. 13. A T1 weighted image of multiple lymph node metastasis. The lymph node (arrow) is shown at medium intensity on the T1 and proton density images.

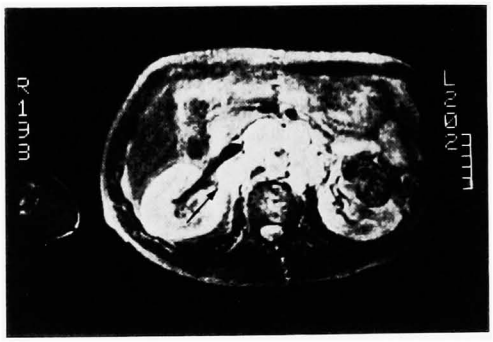

Fig. 14. A T2 weighted image of Fig. 13. The lymph node (arrow) shows up at high intensity on the T2 weighted image. The tumor does not show up at high intensity and was diagnosed as a spindle cell type, renal cell carcinoma, pathologically.

On patients with renal angiomyolipomas, the % contrast values were measured after excluding the portion believed to be fatty tissue. The % contrast value in the T1 weighted images was 50 or less in all 3 patients. The % contrast values in the T2 weighted images was 50 or more for 2 patients and 21–38 for the other. In renal angiomyolipomas, portions consisting of only high-volume fat are registered as fat signals, but other parts of the tissue which do not register as fat signals also contain large amounts of fat. This may be the cause of the low values in the T1 weighted images and the high values in the T2 weighted images in angiomyolipoma cases.

In cases of renal pelvic cancer that were difficult to differentiate from renal cell carcinoma, the % contrast value was 61 in the T1 weighted images and 40–47 in the T2 weighted images, thus demonstrating the difficulty in discerning one from the other.

DISCUSSION

Thorough diagnostic evaluation of patients with renal masses is essential for determining the most appropriate treatment procedure. In patients with renal cysts, angiomyolipomas, and oncocytomas, conservative treatment will usually be chosen first. In patients with renal cell carcinoma, however, multiple imaging procedures such as urography, ultrasonography, angiography, and CT have been used in preoperative staging. The principal parameters that should be considered in the preoperative staging of renal neoplasms are: (1) perinephric extension, (2) retroperitoneal lymphadenopathy, (3) renal vein involvement, (4) inferior vena caval involvement[11].

Ultrasonography is an operator dependent technique. Technically poor scans are often obtained in patients with inappropriate body habitus. It has been shown to be less sensitive than CT in demonstrating perinephric extension[12]

Angiography is frequently used, but it is an invasive procedure. As suggested by Mauro et al.[13], CT staging of renal cell carcinoma cases has been more widely accepted, and has reduced the use of routine preoperative angiography.

Before MRI was available, CT was thought to be the most reliable and accurate means of preoperatively staging cases of renal cell carcinoma. The findings of this study confirm the results of other studies regarding the diagnostic accuracy of CT[10,14–16]. Although renal lesions are much more apparent on contrast-enhanced CT scans than on MR images[10], CT scanning for staging renal cell carcinoma has limitations in detecting perinephric invasion of the tumor, and venous extension[10] The results of this study indicate that CT staging has limitations in determining the presence or absence of hepatic or splenic invasion due to the "partial volume effect," invasion in the renal veins and the vena cava, the upper margin of the tumor thrombus, and the presence or absence of adhesion of the tumor thrombus to the vena cava. The findings suggest that MRI is slightly superior in diagnosing venous extension, metastatic adenopathy, and adjacent organ invasion. With MRI the involvement of perinephric fat is difficult to determine. Lang[15] compared conventional CT, dynamic CT, arteriography, ultrasonography and radionuclide scanning, and concluded that dynamic CT was the most accurate technique for staging renal cell carcinoma. He recommended dynamic CT to overcome the

disadvantage of conventional CT mentioned above. A successful bolus injection CT study, however, requires the patient's co-operation and normal renal function[10]. Fein[10] reported findings similar to ours. He recommended MRI only for patients with a known contraindication to iodinated contrast medium, patients with prior suboptimal bolus-contrast CT studies, or patients in whom the CT findings are equivocal.

MRI seems to be more useful than CT in differentiating between renal cell carcinoma and other mass lesions. It is easy to differentiate solid masses from cystic lesions, and even hemorrhagic cysts can be differentiated from simple cysts[6–8]. Using MRI, almost all angiomyolipomas can be differentiated from renal cell carcinoma[7–9,17], because of their abundant fat component. It is also easy to differentiate such angiomyolipomas from renal cell carcinoma using either by CT or ultrasonography[18–22]. In those angiomyolipomas composed primarily of smooth muscle or those in which hemorrhaging in the tumor has obscured the fatty portion, it is difficult to distinguish the angiomyolipomas from other solid renal tumors using CT[21]. Therefore, there seemed to be no sure way of differentiating angiomyolipoma from adenocarcinoma[23]. The findings of this study, however, show that it may be possible to differentiate angiomyolipoma from renal cell carcinoma by calculating the % contrast value. The % contrast value for angiomyolipomas in the T1 weighted images was 50 or less for all 3 patients, and in the T2 weighted images it was 50 or more for 2 patients, and 21–38 for the other. Although the % contrast value for almost all clear cell carcinomas and mixed clear cell carcinomas in the T1 weighted images was about 100 (70.4%), only 4 patients (14.8%) with clear cell carcinomas or mixed clear cell carcinomas had a value of 50 or less, although their % contrast value in the T2 weighted images was less than 50. In cases of renal angiomyolipomas, portions consisting of only high-volume fat are registered as fat signals, but other parts of the tissues can also contain large amounts of fat. This may result in low T1 weighted image values, and high T2 weighted image values.

In one patient with spindle cell type carcinoma (sarcomatoid type), the % contrast was 109 in the T1 weighted image and 88 in the proton density image, but a high value of 65–85 was recorded in the T2 weighted image. The highest contrast value of the T2 weighted images obtained on the 27 patients with clear cell carcinoma or mixed clear cell carcinoma was 54–79, which occurred in a patient whose cancer was shown as a heterogenous mass.

Herman et al.[23] suggested that papillary renal cell carcinomas were visible as high signal masses with low signal rims in the T1 weighted images. In this study, however, the case of papillary renal cell carcinoma could not be differentiated from clear cell carcinoma by the % contrast alue (the % contrast in the T1 weighted image was 60.6, the % contrast in the T2 weighted image was 33–104).

Although we have no experience using MRI on patients with oncocytoma, calculation of % contrast values may make it possible to differentiate between various types of renal cell carcinoma and other renal masses.

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和文抄録

MRIによる腎癌におけるStagingおよび鑑別診断：特にCTとの比較について

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西　村　一　雄

33例の腎腫瘍に対しMRI，CTを施行し，stagingおよび鑑別診断における意義について検討した．33例の内訳は腎癌29例，腎血管筋脂肪腫3例，腎癌と鑑別の難しかった腎盂癌1例である．stagingの正診率は両者にあまり差は認めなかった．静脈浸潤，リンパ節転移，隣接臓器への浸潤に関してはMRIの方がやや正確な傾向があったが，腎周囲脂肪織への浸潤に関してはMRIはごくわずかに正確であったに過ぎなかった．

また，鑑別診断の目的で，MRIで%コントラスト（腎腫瘍のintensity/腸腰筋のintensity ×100）を計算した．clear cell typeの腎癌ではT1強調画像における%コントラストは，100前後，T2強調画像では大部分の症例で50以下を示したのに対し，spindle cell typeの腎癌ではT1画像では109であったが，T2画像では65～85と高値を示した．腎血管筋脂肪腫では明らかに脂肪成分と思われる部分以外の部位で%コントラストを計算したところ，T1画像では3例とも50以下，T2画像では2例で50以上，他の1例は21～38の値を示した．このように症例は少ないが，%コントラストを計算することによってある程度鑑別診断が可能であると予想された．

（泌尿紀要　**34**：1323-1331，1988）