Original Article
Özgün Araştırma

Endourol Bull 2020;12(3); 192-198 e-ISSN:2148-0532

Does preoperative enhanced computed tomography show the invasion to surrounding structures in renal cell carcinoma?

Preoperatif gelişmiş bilgisayarlı tomografi, renal hücreli karsinomda çevre dokulara invazyonu gösterir mi?

Burak Kopru[1], Turgay Ebiloglu[2], Sinan Akay[3], Selcuk Sarikaya[2], Murat Zor[2], Engin Kaya[2], Giray Ergin[1], Ibrahim Yavan[4], Mesut Gurdal[2]

1 Koru Ankara Hospital, Department of Urology, Ankara, Turkey
2 Gulhane Training and Research Hospital, Department of Urology, Ankara, Turkey
3 Gulhane Training and Research Hospital, Department of Radiology, Ankara, Turkey
4 Burdur Public Hospital, Department of Pathology, Ankara, Turkey

ÖZET

Amaç: Renal hücreli karsinomların cerrahi tedavilerinden önce preoperatif gelişmiş bilgisayarlı tomografinin komşu yapılara invazyonu hakkında yeterli bilgi verip vermediğini belirlemek.

Gereç ve Yöntemler: Ocak 2015 ile mart 2018 tarihleri arasında böbrek kitlesi nedeniyle açık radikal veya parsiyel nefrektomi yapılan toplam 50 hasta bu retrospektif çalışmaya dahil edildi. Radyolog tarafından preoperatif gelişmiş bilgisayarlı tomografi ile karaciğer, vena kava, aort, dalak, pankreas, iliopsoas kası, karın arka duvarındaki yağ düzlemleri ve sınırlarının düzenliliğini veya düzensizliğini özenle inceledi. Ürolog tarafından intraoperatif olarak aynı parametreleri kaydedildi ve intraoperatif bulgular kayıt altına alındı. İntraoperatif ortamda invazyon tanısı, söz konusu organın diseksiyonu sırasında elde edilen bulgulara göre değerlendirildi.

Bulgular: Çalışmada 16 (% 32) kadın ve 34 (% 68) erkek vardı. Ortalama hasta yaşı 60.14 ± 13.89 (26-88) idi. Etkilenen böbrek ünitesi 22 (% 44) hastada sağ böbrek, 28 (% 56) hastada sol böbrek idi. Preoperatif gelişmiş bilgisayarlı tomografi ile operasyon arası ortalama gecikme süresi 34.48 ± 12.07 (1-60) gün olarak tespit edildi.

Sonuç: Karaciğer, dalak, pankreas, iliopsoas kası ve abdominal arka duvar için preoperatif gelişmiş bilgisayarlı tomografinin ameliyatta tespit edilenden daha fazla yanlış pozitif yapışma veya düzensizlik sonuçları vermektedir. Vena kava ve aort için preoperatif gelişmiş bilgisayarlı tomografi cerrahide görülen doku yapışıklıkları veya düzensizliklerini yeterli düzeyde tespit edememiştir.

Anahtar Kelimeler: *Bilgisayarlı tomografi, renal hücreli karsinoma, invazyon*

ABSTRACT

Objective: To determine if preoperative enhanced computed tomography (PECT) yields enough information or not about the invasion to adherent structures before operations for renal cell carcinoma.

This study was approved by the local ethical committee (Approval number: 2018/002-5). All research was performed in accordance with relevant guidelines/regulations, and informed consent was obtained from all participants.

Corresponding Author : Burak Kopru, Kizilirmak District, 1450. St. No:13 06530, Çukurambar, Ankara, Turkey
Tel: +90 312 444 66 62 ***Fax:*** +90 312 304 44 75 ***e-mail:*** dr_burak83@yahoo.com
Received : June 22, 2020 - ***Accepted*** : December 25, 2020

ENDOÜROLOJİ BÜLTENİ ENDOUROLOGY BULLETIN

Material and Methods: A total of 50 patient who had open radical or partial nephrectomy due to renal mass between January 2015 and March 2018 enrolled in this retrospective study. The radiologist elaborately examined the fat planes, and regularity/irregularity of the border at liver, vena cava, aorta, spleen, pancreas, iliopsoas muscle and abdominal posterior wall. The urologist took part in the operations noted the same parameters while operations or extracted them from operational notes. The diagnosis of invasion in intraoperative setting was based on findings while dissection of mentioned organ.

Results: There were 16 (32%) female and 34 (68%) males. The mean patient age was 60.14±13.89 (26-88). The effected renal unit was right kidney in 22 (44%) and left kidney in 28 (56%) patients. The mean time lag from PECT and operations was 34.48±12.07 (1-60) days.

Conclusion: For liver, spleen, pancreas, iliopsoas muscle, and abdominal posterior wall, PECT yielded some false positive results of adherence or irregularity than detected in surgery. For vena cava and aorta, PECT could not detect the adherence or irregularity that was seen in surgery.

Keywords: *Computed tomography, renal cell ca, invasion*

INTRODUCTION

According to 2017 Cancer Facts and Figures report, kidney, renal pelvis cancers accounts 5% and 3% of yearly new diagnosed cancers in males and females in Unites States (USA) and the mortality rate of kidney, renal pelvis cancers is reported < 3 % for all gender types (1). The renal cell carcinoma (RCC) is reported to be the most common primary malignant tumor of kidney (2). The development of invasive and metastatic cancer of RCC is 2.1% and 1.2% in males and females (1, 2). So, it is especially important do diagnose and treat an RCC in the early stages. Moreover, nearly 15%-60% of RCC cases were detected incidentally while investigation of renal or non-renal symptoms. These tumors are generally small and being at early stage (2).

Despite developments in minimally invasive techniques such as radiofrequency ablation, or cryotherapy, surgery like partial nephrectomy, laparoscopic partial or radical nephrectomy are still accounts the most curative treatment modality in RCC. Therefore, it is essential to make an appropriate preoperative staging, including tumor size, extent to neighboring organs, metastases, or lymph node involvement, for an accurate surgical planning (3). Preoperative enhanced computed tomography (PECT) is the imaging of choice for characterization and staging of RCC. It is reported to be 90% sensitive for detecting renal masses. With PECT, images can be formatted in coronal, sagittal or multiplanar fashion to examine the organs in detail (4). However, in our daily practice, we sometimes have difficulty deciding about the invasion to adjacent organs by examining the PECT and hesitate for applying minimally invasive techniques.

In this study, we aimed to evaluate if PECT yielded enough information about the invasion to adherent structures or not before operations for RCC.

MATERIAL AND METHODS

Our Institute's Local Ethical Committee approved the ethical acceptance of this study (2018/002-5) and the study is followed by ethical standards described in Helsinki Declaration Statement.

A total of 70 patients who had open radical or partial nephrectomy due to renal mass between January 2015 and March 2018 enrolled in this retrospective study. The indications for partial nephrectomy were contrasted renal mass at kidney <10 cm diameter with favorable tumor location. The indications for open radical nephrectomy were the patients not suitable for partial nephrectomy such as <10 cm tumor with unfavorable location, tumor seemed to be locally advanced, tumor making significant deterioration in patient health, and tumor with >10cm diameter. A senior radiologist interpreted the PECT results without having any knowledge about the patients' intraoperative status. The operations were applied in our urology department. The radiologist elaborately examined the fat planes, and regularity/irregularity of the border at liver, vena cava, aorta, spleen, pancreas, iliopsoas muscle, and abdominal posterior wall. The urologist took part in these operations noted the same parameters while operations or extracted them from operational notes. The diagnosis of invasion in intraoperative setting was based on findings while dissection of men-

tioned adjunct organ.

The fat plane in PECT was defined as adherent or non-adherent, regularity was defined as seeing the smooth contour between the organs, and irregularity was defined for all other situation. The same parameters were examined in intraoperative settings.

Twenty patients were excluded from study due to excessive missing information used for the formation of study. The radiologic and operational results were matched.

Pathology results were also examined for same parameters and compared with PECT and intraoperative findings.

Preoperative Enhanced Computed Tomography Imaging Protocol

CT examinations were performed prior to the surgical resection with 64- and 320-rowdetector systems belonging to the same brand (Aquilion; Toshiba Medical Systems, Ottawara, Japan) using dynamic enhanced (oral + intravenous) abdomino-pelvic CT imaging protocol. Dynamic CT images were acquired in the axial plane as followed: Non-contrast, 40, 90 and 420 seconds after the intravenous contrast agent injection. Then, multi-planar reformatted images (sagittal and coronal) were created from the initial scan. The fat planes and the border regularity/irregularity between RCC lesions and liver, vena cava, aorta, spleen, pancreas, iliopsoas muscle, and abdominal posterior wall were evaluated.

Open Radical or Partial Nephrectomy Technique

After general anesthesia, a urethral catheter was inserted through urethra. Patient was positioned at mid-flank position. A mid-chevron incision was made at the related side of body. Ever anatomic layer was passed with excessive attention. Peritoneum incised, and colon and small bowels were exposed. For right kidney, liver was dissected from anterior surface of kidney and the invasion or irregularity between kidney and liver were determined and noted. Then, colon and duodenum were dissected medially. Renal artery and vein were found, and if the procedure was partial nephrectomy they were reversibly clamped, but if the procedure was radical nephrectomy they were irreversibly clamped. Two Urologists evaluated and noted invasion or irregularity between the kidney and vena cava, aorta, duodenum and pancreas during surgery. Ureter was found and dissected if necessary. Then, the posterior region of kidney was dissected. İnvasion or irregularity between kidney and iliopsoas muscle or posterior abdomen was determined and noted. At last, procedure was accomplished by applying the partial or radical nephrectomy.

The same procedure was applied for the left kidney. The difference was: firstly, the spleen was dissected from the anterior surface of kidney, and invasion to spleen was determined and noted. Secondly, the colon and pancreas were dissected medially. Invasion or irregularity between kidney and pancreas was determined and noted. Thirdly, after clamping the artery and vein, we examined or dissected the medial border of kidney to find out the invasion or irregularity in aorta, or vena cava.

Statistical Analysis

Statistical analysis was done using Statistical Package for Social Sciences 20.0 software (SPSS 20.0 for MAC). Descriptive statistics of nominal samples were expressed with numbers and percentiles. Descriptive statistics of scale samples were expressed as mean ± standard deviation (minimum-maximum). Shapiro-Wilk, Kurtosis, and Skewness Tests were used to assess the variables' normalization. Chi Square Test was used to compare the independent nominal parameters. Probability of $p<0.05$ was accepted as statistically significant. Sensitivity, specificity, positive likelihood ratio (+LHR), and negative likelihood ration (-LHR) was calculated.

RESULTS

Finally, a total of 50 patients were included in this study. There were 16(32%) female and 34(68%) males. The mean patient age was 60.14±13.89(26-88). The effected renal unit was right kidney in 22(44%) and left kidney in 28(56%) patients. There were 37(74%) radical, 13(26%) partial nephrectomies. The mean time lag from PCCN and operations was 34.48±12.07(1-60) days.

The mean diameter of tumor was 64.11±33.42(12-145) * 55.01±27.01(16-119) * 45.07±22.09(14-91) and 62.17±32.55(10-140) * 53.89±26.06(15-110) * 44.27±21.95(10-90) in PECT and pathology specimens, respectively (p=0.03).

The comparison of findings in PECT, operations, and pathology reports were expressed in table 1 (Table 1). For liver, spleen, pancreas, iliopsoas muscle, and abdominal posterior wall, PECT yielded some false positive results of adherence or irregularity than detected in surgery and pathology. For vena cava and aorta, PECT could not detect the adherence or irregularity that was seen in surgery.

Table 1. Comparison of PECT, intraoperative, and pathology findings.

	Preoperative enhanced computed tomography findings		Intraoperative findings		P* value
	Yes	No	Yes	No	
Liver adherence	15(30%)	35(70%)	8(16%)	42(84%)	0.029
Irregularity of tissues between kidney and liver	13(26%)	37(74%)	8(16%)	42(84%)	0.010
Vena cava adherence	6(12%)	44(88%)	11(22%)	39(78%)	0.078
Irregularity of tissues between kidney and vena cava	6(12%)	44(88%)	11(22%)	39(78%)	0.078
Aorta adherence	1(2%)	49(98%)	5(10%)	45(90%)	0.00
Irregularity of tissues between kidney and aorta	0(0%)	50(100%)	5(10%)	45(90%)	0.001
Spleen adherence	11(22%)	39(78%)	3(6%)	47(94%)	0.001
Irregularity of tissues between kidney and spleen	8(16%)	42(84%)	3(6%)	47(94%)	0.001
Pancreas adherence	8(16%)	42(84%)	0(0%)	50(100%)	0.001
Irregularity of tissues between kidney and pancreas	7(14%)	43(86%)	0(0%)	50(100%)	0.001
Iliopsopas muscle adherence	13(26%)	37(74%)	8(16%)	42(84%)	0.010
Irregularity of tissues between kidney and iliopsoas muscle	9(18%)	41(82%)	8(16%)	42(84%)	0.001
Abdominal posterior wall adherence	10(20%)	40(80%)	9(18%)	41(82%)	0.001
Irregularity of tissues between kidney and abdominal posterior wall	7(14%)	43(86%)	9(18%)	41(82%)	0.001
	Intraoperative findings		Pathologic findings (2 missing)		P* value
	Yes	No	Yes	No	
Liver adherence	8(16%)	42(84%)	1(2%)	47(94%)	0.001
Irregularity of tissues between kidney and liver	8(16%)	42(84%)	1(2%)	47(94%)	0.005
Vena cava adherence	11(22%)	39(78%)	1(2%)	47(94%)	0.001
Irregularity of tissues between kidney and vena cava	11(22%)	39(78%)	1(2%)	47(94%)	0.001
Aorta adherence	5(10%)	45(90%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and aorta	5(10%)	45(90%)	0(0%)	48(96%)	0.001
Spleen adherence	3(6%)	47(94%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and spleen	3(6%)	47(94%)	0(0%)	48(96%)	0.001
Pancreas adherence	0(0%)	50(100%)	0(0%)	48(96%)	0.9
Irregularity of tissues between kidney and pancreas	0(0%)	50(100%)	0(0%)	48(96%)	0.9
Iliopsopas muscle adherence	8(16%)	42(84%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and iliopsoas muscle	8(16%)	42(84%)	1(2%)	47(94%)	0.001
Abdominal posterior wall adherence	9(18%)	41(82%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and abdominal posterior wall	9(18%)	41(82%)	1(2%)	47(94%)	0.001

	Preoperative enhanced computed tomography findings		Pathologic findings (2 missing)		P* value
	Yes	No	Yes	No	
Liver adherence	15(30%)	35(70%)	1(2%)	47(94%)	0.001
Irregularity of tissues between kidney and liver	13(26%)	37(74%)	1(2%)	47(94%)	0.001
Vena cava adherence	6(12%)	44(88%)	1(2%)	47(94%)	0.001
Irregularity of tissues between kidney and vena cava	6(12%)	44(88%)	1(2%)	47(94%)	0.001
Aorta adherence	1(2%)	49(98%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and aorta	0(0%)	50(100%)	0(0%)	48(96%)	0.001
Spleen adherence	11(22%)	39(78%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and spleen	8(16%)	42(84%)	0(0%)	48(96%)	0.001
Pancreas adherence	8(16%)	42(84%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and pancreas	7(14%)	43(86%)	0(0%)	48(96%)	0.001
Iliopsopas muscle adherence	13(26%)	37(74%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and iliopsoas muscle	9(18%)	41(82%)	1(2%)	47(94%)	0.001
Abdominal posterior wall adherence	10(20%)	40(80%)	0(0%)	48(96%)	0.001
Irregularity of tissues between kidney and abdominal posterior wall	7(14%)	43(86%)	1(2%)	47(94%)	0.001

There were 32(64%) patients with renal cell cancer classified as clear cell variant, 4(8%) as papillary variant, 7(14%) as chromophobe variant, 1(2%) as primitive neuroectodermal tumor, 1(2%) as adrenocortical carcinoma, and 3(6%) as oncocytoma (2 missing). The Fuhrman grade of tumor was 4 in 5(10%), 3 in 15(30%), 2 in 14(28%), and 1 in 2(4%) of patients (for other 14(28%) patients, there was no need for Fuhrman Grading System). The perirenal fat tissue was normal in 32(64%), had congestion in 15(30%), included liver tissue in 1(2%), and had tumor infiltration in 1(2%) of patients. Eight (16%) patients had extension of tumor through renal capsule. There was only 1(2%) lymph node involvement. Lymph vascular invasion and tumor necrosis was seen in 2(4%) and 6(12%) patients, respectively. There was only 1 patient with tumor involving sarcomatous component.

Table 2. The sensitivity and specificity of preoperative contrasted computerized tomography findings compared to intraoperative findings.

	The sensitivity	The specificity	Positive likelihood ratio	Negative likelihood ratio
Liver adherence	62.5%	76.2%	2.58	0.5
Irregularity of tissues between kidney and liver	38.5%	91.9%	4.22	0.68
Vena cava adherence	27.3%	92.3%	3.37	0.79
Irregularity of tissues between kidney and vena cava	27.3%	92.3%	3.37	0.79
Aorta adherence	0%	97.8%	0	1
Irregularity of tissues between kidney and aorta	0%	100%	0	1
Spleen adherence	100%	84.8%	6.25	0
Irregularity of tissues between kidney and spleen	100%	89.1%	9.09	0
Pancreas adherence	0%	84%	0	1
Irregularity of tissues between kidney and pancreas	0%	86%	0	1
Iliopsopas muscle adherence	62.6%	81%	3.26	0.46
Irregularity of tissues between kidney and iliopsoas muscle	50%	88.1%	4.16	0.56
Abdominal posterior wall adherence	66.7%	92.5%	8.25	0.36
Irregularity of tissues between kidney and abdominal posterior wall	44.4%	92.5%	5.5	0.6

The sensitivity, specificity, +LHR, and -LHR of PECT were expressed in table 2 by comparing the PECT and intraoperative findings (Table 2). For detection of adherence or irregularity with/into liver, spleen, iliopsoas muscle, and abdominal posterior wall, PECT yielded enough information before operations. For detection of invasion to vena cava, aorta, and spleen, PECT was detected not to be a good diagnostic test.

For exclusion of any invasion, PECT had 76.2-100% true exclusion rate for all anatomical sites.

DISCUSSION

Rarely, it is extremely difficult to decide on a minimally invasive technique for an RCC operation. In our daily practice, we examine all the patients' preoperative images and decide the best technique for treatment. Mostly, we realized that we usually misinterpreted the adherent structures when compared with operative findings: we said the tumors had cohesion to neighboring structures, however there were not in many cases. To better understand this situation, we planned this retrospective study to find the reliability of PECT for RCC invasion into adjacent organs.

Preoperative enhanced computed tomography is the choice of technique to identify a renal mass. In the protocol of a PECT, a non-contrast image was produced, and after injection of the contrast agent, multiple acquisitions were taken at 40 seconds for corticomedullary phase, 90 seconds for nephrographic phase, 7 minutes for delayed phase. Images at 90 seconds are usually enough to determine a renal lesion. The other phases were used to determine extra information for enhancement, collecting system and its invasion. Enhancement is the comparison of lesion density before and after the injection of contrast agent using the Hounsfield unit (HU). An increase of 15-20 HU identifies the lesion uptake of contrast medium (4).

Most of the studies of PECT are usually about the comparison of lesion sizes in pre-operative images and pathologic examination. Cathalano et al. reported that PECT identify the renal lesion size and enhancement correctly when 1 mm images were taken while procedure (5). Yaycioglu et al. examined the 291 patients' preoperative PECT and gross pathologic findings and reported that clinical and pathologic findings were significantly correlated between each other. They also mentioned that there was no difference between clinical and pathologic tumor size (6). Kurta et al. reported an overestimation of 1 mm tumor size with PECT in a large series of 521 patients (7). Jorns et al. reported a significant correlation of tumor volume between PECT and pathology especially in large tumors. They concluded that the overestimation was higher especially when tumor was smaller (8). In our research, we found the similar results with most of the literature. The tumor size was smaller in pathology examination than in PECT.

Other important factors of PECT yield before a surgery are perirenal adipose tissue condition and involvement of the renal vein or vena cava. Cathalona et al reported the sensitivity and specificity of PECT for detecting perirenal fat tissue involvement was 96% and 93%, respectively (5). Hallsheit et al. reported the accuracy of PECT as being 72%-78% for detecting tumor thrombus in patients who had tumor thrombus at operations (9). Lawrentschunk et al. reported 100% detection rates of the level of thrombus with PECT (10). Our study is different from the other studies in many features. We examined the adhesions of surrounding organs by perirenal fat status between these neighboring organs and kidney and/or tumor in PECT, and intraoperative or pathological findings. We evaluated if there was an adherence or irregularity with/into liver, vena cava, aorta, spleen, pancreas, iliopsoas muscle and abdominal posterior wall. Although, we found some false positive results of adherence or irregularity between kidney and liver, spleen, pancreas, iliopsoas muscle, and abdominal posterior wall, PECT yielded enough sensitivity with 38.5%-100% rate for detection of adherence or irregularity with/into these neighboring organs when compared to intraoperative findings. On the other aspect, the specificity was also enough to exclude the invasion with for these regions with 84.5%-92.5% rate. However, for invasion to vena cava, aorta, and spleen, PECT couldn't yield enough information with 0%-23.7% sensitivity rate indicating that someone could not say there was no invasion to vena cava, aorta, and spleen by examining PECT.

The comparison intraoperative findings and pathologic examination of the excised material also showed that despite our thought of positive adherence and irregularity with/into neighboring organs intraoperatively, there was mostly no invasion in pathologic examination. This could be the tissue reaction of the perirenal structures due to tumor in related kidney. However, the evaluation of adherence and irregularity in intraoperative settings while dissection could reflect difficulties that someone could encounter while surgery. According to our study, an urologist could easily conclude if he/she would face to a dissec-

tion difficulty between kidney and liver, pancreas, iliopsoas muscle, and abdominal posterior wall. However, for vena cava, aorta, and spleen, it is difficult to conclude to face a dissection difficulty or not.

In urology literature, there is no study examining the PECT and intraoperative findings of RCC and the surrounding organs. So, our study is unique for being the first study about this subject. Tusuburaya et al. conducted a similar study about adjacent organ invasion in stomach carcinoma. They reported that the regular structure of the fat tissue between stomach and adjacent organ was fully deteriorated if there had been an invasion, and also, the same deterioration was seen in 42%-77% of patients if there had been no invasion. They concluded that PECT was not sufficient to determine and exclude the invasion between stomach and adjacent organs (11). In our study, the adherence or irregularity was lower than the stomach carcinoma. This was the different nature of organs and cancers.

Limitations

The patient sample size and retrospective design of study were the two limitations of our study. More patients and prospective double-blinded trials will reveal better results.

CONCLUSION

PECT is a useful imaging modality to determine or exclude the adherence or irregularity between RCC mass and liver, pancreas, iliopsoas muscle, and abdominal posterior wall. However, it is not useful for vena cava, aorta, and spleen invasion of RCC.

Disclosure

Authors have nothing to disclose.

Ethics Committee

Permission was granted by the local ethic committee. Decision no: 2018-002-5.

REFERENCES

1. Society, A.C., in Cancer Facts and Figures 2017. 2017: America. p. 4-5.
2. Spero M, Brkljacic B, Kolaric B, Marotti M. Preoperative staging of renal cell carcinoma using magnetic resonance imaging: comparison with pathological staging. Clin Imaging, 2010; 34: 441-447.
3. Mueller-Lisse UG, Mueller-Lisse UL, Meindl T, Coppenrath E, Degenhart C, Graser A, et al. Staging of renal cell carcinoma. Eur Radiol 200717:2268-2277.
4. Kang, S.K. and H. Chandarana, Contemporary imaging of the renal mass. Urol Clin North Am 2012;39:161-170.
5. Catalano C, Fraioli F, Laghi A, Napoli A, Pediconi F, Danti M, et al., High-resolution multidetector CT in the preoperative evaluation of patients with renal cell carcinoma. AJR Am J Roentgenol 2003;180:1271-1277.
6. Yaycioglu O, Rutman MP, Balasubramaniam M, Peters KM, Gonzalez JA. Clinical and pathologic tumor size in renal cell carcinoma; difference, correlation, and analysis of the influencing factors. Urology 2002;60:33-38.
7. Kurta JM, Thompson RH, Kundu S, Kaag M, Manion MT, Herr HW, et al., Contemporary imaging of patients with a renal mass: does size on computed tomography equal pathological size? BJU Int 2009;103:24-27.
8. Jorns J, Thiel DD, Arnold ML, Diehl N, Cernigliaro JC, Wu KJ, et al. Correlation of radiographic renal cell carcinoma tumor volume utilizing computed tomography and magnetic resonance imaging compared with pathological tumor volume. Scand J Urol 2014; 48:453-459.
9. Hallscheidt PJ, Fink C, Haferkamp A, Bock M, Luburic A, Zuna I, et al., Preoperative staging of renal cell carcinoma with inferior vena cava thrombus using multidetector CT and MRI: prospective study with histopathological correlation. J Comput Assist Tomogr 2005;29:64-68.
10. Lawrentschuk N, Gani J, Riordan R, Esler S, Bolton DM. Multidetector computed tomography vs magnetic resonance imaging for defining the upper limit of tumour thrombus in renal cell carcinoma: a study and review. BJU Int 2005;96:291-295.
11. Tsuburaya A, Noguchi Y, Matsumoto A, Kobayashi S, Masukawa K, Horiguchi K. A preoperative assessment of adjacent organ invasion by stomach carcinoma with high resolution computed tomography. Surg Today 1994;24:299-304.