

The new approach to prognostication of development of the renal impairment in patients with the renal-cell carcinoma of T₁ stage: role of the MRI

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Abstract

The incidence of the renal-cell carcinoma (RCC) is 5% and 3% among all malignant neoplasms in adult men and women respectively. In recent years, MRI has increasingly attracted the attention of clinicians as a method for diagnosing and staging of RCC, since it has a number of advantages. Clinical application of one of the functional techniques of MRI – diffusion-weighted imaging (DWI) allows the quantitative measurement of the thermoelectric motion of water molecules in health and pathologic tissues of the kidney in vivo. The apparent diffusion coefficient (ADC) is a quantitative parameter of DWI, which reflects the degree of diffusion in the tissues of the body. The aim of the study was to investigate the efficiency of DWI of the MRI in prognostication of the renal impairment development in patients with RCC. The study involved 37 patients. All patients were divided into two groups. The first (main) group consisted of 17 patients who were diagnosed with the RCC of T₁N₀M₀ stage. The velocity of glomerular filtration rate (GFR) in all cases was ≥ 90 ml/min/1.73 m². The second (control) group

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consisted of 20 patients, without evidence of RCC, and without evidence of anatomical or functional renal impairment. In the course of the correlation analysis, there was a direct connection between the GFR of patients with RCC 12 months after the surgery, and the preoperative values of the ADC of diffusion-weighted MRI images: the Pearson correlation coefficient was $r = 0.750$ ($p < 0.05$). As it follows from the data obtained, in patients with a decrease in GFR of the affected by the tumor kidney, 12 months after its resection, the preoperative value of the ADC of diffuse-weighted MRI images significantly differed from this indicator of the control group by an average of 35.3% ($p < 0.05$). At the same time, this difference was not observed in subgroups with an increase and no change in GFR ($p > 0.05$). Conclusion. The use of ADC of the diffusion-weighted MRI allows predicting a decrease in the functional capacity of the affected by tumor kidney in patients with RCC (T1 stage of the disease) after its resection, which is important for the meta-prevention of the development of CKD in this category of patients.

Introduction

The incidence of the renal-cell carcinoma (RCC) is 5% and 3% among all malignant neoplasms in adult men and women respectively, thus representing the 7th the most common cancer in men and 10th in women [1]. In economically developed countries, CT is a routine method for diagnosing and staging of RCC in the context of choosing surgical approaches, such as laparoscopic and nephron-sparing surgical interventions. However, on the other hand, the significant risk of CT-induced oncogenesis results in increased interest of scientists to alternative methods of diagnostics of this pathology [2].

In recent years, MRI has increasingly attracted the attention of clinicians as a method for diagnosing and staging of RCC, since it has a number of advantages: excellent image quality, highly informative, no radiation load on the patient and staff, the possibility of obtaining a three-dimensional image, assessing the function of the kidneys by means of contrast-ing, etc. Clinical application of one of the functional techniques of MRI – diffusion-weighted imaging (DWI) allows the quantitative measurement of the thermoelectric motion of water molecules in health and pathologic tissues of the kidney in vivo [3]. The apparent diffusion coefficient (ADC) is a quantitative parameter of DWI, which reflects the degree of diffusion in the tissues of the body. Most of the contemporary clinical MRI systems (1.5 T and 3T), with the availability of the appropriate software, are

capable of performing the modality of the DWI in addition to the general morphological and anatomical visualization [4,5]. In one of our previous works, the existence of pathomorphological changes of the intact renal parenchyma of the affected by tumor kidney of the patients with RCC was exposed. Such changes in the tissues of the kidney can be treated as the early precursors of the development of the renal impairment and CKD and were observed in the absence of abnormalities in the biochemical indicators of the kidneys function (creatinine, urea) [6,7]. Taking into account the foregoing, it can be assumed that the use of MRI with the DWI modality can be used for prediction of the development of the chronic kidney disease (CKD) in patients with RCC at the T1 stage, in the absence of radiation burden on the patient.

Goal

The aim of the study was to investigate the efficiency of DWI of the MRI in prognostication of the renal impairment development in patients with RCC.

Materials and methods of research

The study was allowed by the Ethics Committee of the Lviv National Medical University. The study involved

37 patients. All patients were divided into two groups. The first (main) group consisted of 17 patients who were diagnosed with the RCC of T1N0M0 stage. The velocity of glomerular filtration rate (GFR) in all cases was ≥ 90 ml/min/1.73 m². All patients of the first group showed symptoms of urinary tract syndrome. The second (control) group consisted of 20 patients, without evidence of RCC, and without evidence of anatomical or functional renal impairment. The average age of patients varied from 45 to 69 years (57.3 ± 2.1 years). No additional risk factors of CKD (arterial hypertension, diabetes mellitus, etc.) were registered in both group.

MRI of the abdominal region was performed using the SignaHDxt 1.5T (GeneralElectric®, USA) and eight-channel coil. A standard scanning protocol was used, which included, in addition to the T-1 and T-2 sequences, an axial DWI with b-values of 0 and 800 s/mm². DWI was performed prior to the introduction of contrast agents, using a one-time echo-planar sequence with parallel imaging and fat saturation techniques during one breath delay; additional study time was 18 seconds. ADC was measured using the ADC-color maps, which were generated on the workstation based on DWI. For its calculation, the region of interest (ROI) on the ADC map was placed over the cortex of the kidney, in the zone of maximal distance from the tumor (intact parenchyma and cortex), and then measurements were made. Additionally, measurements of the ADC of normal renal cortex in healthy volunteers were performed by placing ROI over the renal cortex. The software packages Functool 4.5 and RadiAnt DICOM Viewer 4.2 were used for the MRI data analysis.

All patients with RCC were followed after the operative treatment and on average 12 months afterwards, a dynamic renoscintigraphy using Infinity-Hawkeye Gamma Camera (GeneralElectric®, USA) and ^{99m}Tc-DTPA with activity of 200 MBq (effective dose – 1.3 mSv) was performed in the position lying down. Based on the obtained data, GFR was determined for the right and left kidneys separately. The Xeleris software package was used to process the scintigraphic data. The evaluation of the results was carried out 12 months after the beginning of the

treatment. The processing of statistical data executed Microsoft Excel 2016 software package.

Results

All patients with RCC, before the resection of the kidney according to the scintigraphy had the GFR within 90-95 ml /min /1.73 m², the mean GFR was 92 ml/min/1.73 m². 12 months after the treatment, 5 (29.41%) patients had a significant decrease in the mean GFR to 81 ml/min/1.73 m² ($p < 0.05$), in 1 (5.88%) patients it was observed the increase of GFR to 98 ml/min/1.73 m² ($p < 0.05$), and in the remaining 11 (64.71%) patients, the mean GFR value was not significantly different from the baseline ($p > 0.05$).

In accordance with the obtained differences in the GFR after the resection of the kidneys, the patients were divided into subgroups in which a retrospective analysis of the ADC of diffusion-weighted images was performed (Table 1).

Discussion

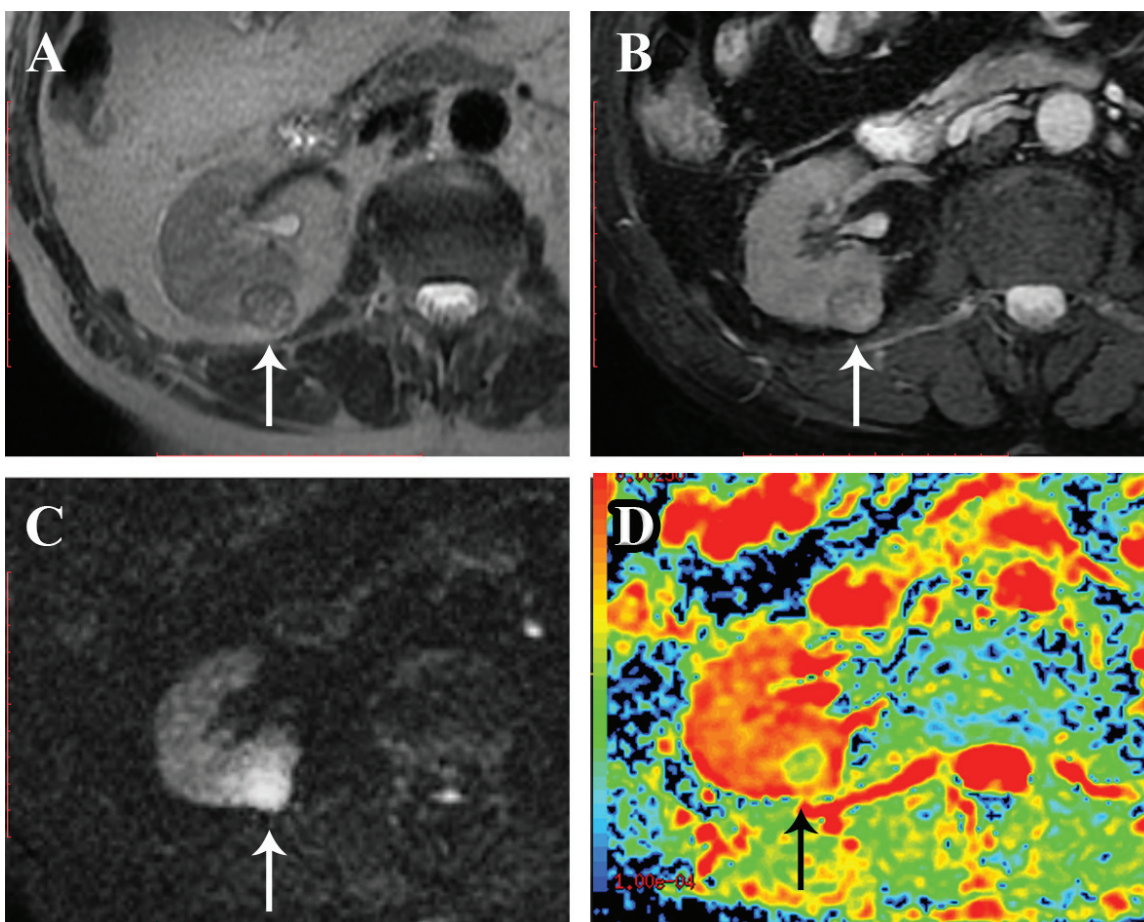
In the course of the correlation analysis, there was a direct connection between the GFR of patients with RCC 12 months after the surgery, and the preoperative values of the ADC of diffusion-weighted MRI images: the Pearson correlation coefficient was $r = 0.750$ ($p < 0.05$). As it follows from the data obtained, in patients with a decrease in GFR of the affected by the tumor kidney, 12 months after its resection, the preoperative value of the ADC of diffuse-weighted MRI images significantly differed from this indicator of the control group by an average of 35.3% ($p < 0.05$). At the same time, this difference was not observed in subgroups with an increase and no change in GFR ($p > 0.05$). Thus, the reduction of the ADC of the intact area of the affected by the tumor kidney in comparison with the values of the normal renal cortex was a prognostic marker for reducing the GFR from the ipsilateral side, which can be considered as a prerequisite for the development of CKD (Fig. 1). Further research is required to study the correlations between ADC and GFR in patients with RCC.

Table 1.

ADC of the cortex of the kidney in patients with RCC prior to resection of the kidney, in relation to the GFR (of the affected by tumor kidney) 12 months after treatment and in the control group

Subgroup of patients with RCC	ADC of the intact by RCC renal cortex before resection \pm SD, $\times 10^{-3} \text{ mm}^2 / \text{sec}$	ADC of normal renal cortex \pm SD, control group (n-20), $\times 10^{-3} \text{ mm}^2 / \text{sec}$	p
Reduction of GFR (n-5)	1,7 \pm 0,3	2,3 \pm 0,3	(p<0,05)
Unchanged GFR (n-11)	2,2 \pm 0,4	2,3 \pm 0,3	(p>0,05)
Increase of GFR (n-1)	2,4 \pm 0,2	2,3 \pm 0,3	(p>0,05)
$p_{1,2}$	p<0,05	-	-
$p_{1,3}$	p<0,05	-	-
$p_{2,3}$	p>0,05	-	-

Legend: SD – standard deviation, ADC – apparent diffusion coefficient, GFR – glomerular filtration rate

**Fig. 1.**

MRI of the patient L., 64 years, RCC of the posterior segment of the right kidney, T1N0M0 (arrows). A: axial T2 SSFSE; B: axial 2D FIESTA FATSAT; C: axial diffusion-weighted image (DWI); D: ADC map, ADC of the cortex of the right kidney = $1.6 \times 10^{-3} \text{ mm}^2 / \text{sec}$, ADC over the area of the cortex of the contralateral healthy kidney = $2.2 \times 10^{-3} \text{ mm}^2 / \text{sec}$. The patient has the resection of the kidney affected with tumor. 12 months after the operation, the GFR on tumor side was 80 ml/min/ 1.73 m^2 , on the side of healthy kidney – 92 ml/min/ 1.73 m^2 .

Conclusions

According to the obtained data, the use of resection of the kidney of patients with RCC in the stage T1, during 12 months of follow-up in 29.41% of cases led to the progression of CKD. An analysis of the data of the conducted research indicates a direct correlation between GFR and ADC in 12 months of observation. The use of ADC of the diffusion-weighted MRI allows predicting a decrease in the functional capacity of the affected by tumor kidney in patients with RCC (T1 stage of the disease) after its resection, which is important for the meta-prevention of the development of CKD in this category of patients.

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