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Original article

The correlation between preoperative renal scintigraphy and postoperative renal function in upper urinary tract urothelial carcinoma patients following radical nephroureterectomy

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ABSTRACT

Objective: To predict the renal function after nephroureterectomy (NUR) for upper urinary tract urothelial cancer (UTUC) based on preoperative technetium-99m mercaptoacetyltriglycine (99mTc-MAG3) renal scintigraphy.

Subjects and methods: We retrospectively reviewed 238 patients who originally underwent nephroureterectomy for UTUC between 2007 and 2010. Of these patients, 129 underwent MAG3 renal scintigraphy before unilateral NUR. Serum creatinine was measured in all of the patients before surgery, and renal function was monitored for one year after surgery. Preoperative and postoperative eGFRs were compared and analyzed based on the preoperative MAG3 renal scintigraphy.

Results: A total of 129 patients, including 62 men (48%) and 67 women (52%) with an average age at surgery of 69.0 years (range from 48 to 87) were included in this study. The mean preoperative creatinine level was 1.42 mg/dL, and the baseline eGFR was 54.76 ml/min/1.73 m^2. One year after NUR, the mean creatinine level was 1.89 mg/dL, and the eGFR was 44.44 ml/min/1.73 m^2, a mean decrease of 18.73%. The preoperative effective renal plasma flow (ERPF) of the operated kidney was 91.65 ml/min/1.73 m^2, and that of the remaining kidney 158.30 ml/ min/1.73 m^2. The average preoperative ERPF of the resected kidney accounted for 34% of total preoperative ERPF, which was statistically significant in its relation to the decrease in eGFR. The decrease in eGFR ratio was also significantly correlated with the calculated decrease in ERPF ratio ($R^2 = 0.279$, $p < 0.001$). The predictive equation of renal function one year after NUR was established as following: eGFR decreased ratio $= -0.80 \times$ predictive ERPF decreased ratio +0.72.

Conclusion: We developed an equation to predict postnephroureterectomy 1 year eGFR before surgery based on preoperative MAG3 renal scintigraphy results and preoperative eGFR. The equation could be more accurate in the situation if the diseased kidney is not hydronephrotic.

1. Introduction

Upper urinary tract urothelial cancer (UTUC) accounts for < 5% of all urothelial cancers (UC).[1] The incidence of UC in the area endemic for "Blackfoot disease" in southern Taiwan has been reported to be significantly higher than anywhere else in the world.[2,3] In Taiwan, UC of the renal pelvis accounts for 10.7% of all urothelial cancer, and for ~40% of all renal carcinomas.[3] Ipsilateral radical nephroureterectomy (NUR) and bladder cuff resection (BCR) is currently the standard treatment for UTUC. Possible renal function deterioration after surgery remains an important patient concern, however, studies concerning changes in renal function after radical nephroureterectomy and bladder cuff resection are limited. Deterioration of renal function may influence the use of perioperative chemotherapy. Recently, two studies have demonstrated a decline in renal function following radical NUR,[4,5] with a reported decrease in estimated glomerular filtration rate (eGFR) of 21% and 32%, respectively. Preoperative hypertension, older age, and preoperative eGFR < 60 mL/min/1.73 m^2 have been reported to be predictive factors for impaired renal function after radical NUR. However, preoperative predictive tools are still under investigation. Dimercaptosuccinic acid renal scintigraphy has been used as a potentially predictive exam used to identify patients with preoperative absolute uptake of < 11% in the remaining kidney who are at risk of

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postoperative chronic renal failure or insufficiency.[6] Technetium (Tc)-99m mercaptoacetyltriglycine (MAG3) renal scintigraphy has also been found to be useful in predicting renal insufficiency after nephrectomy.[7] However, both of these previously published series were both limited in their relatively small sample size. Thus, we performed a retrospective review of a large single institutional database to survey the renal function outcomes in patients with UTUCs following unilateral radical NUR. MAG3 renal scintigraphy was used in all of these patients to evaluate the renal function before radical NUR. The aims of this study were to report the change of renal function following radical NUR for UTUC and to develop an equation for predicting the renal function (eGFR) 1 year after NUR based on preoperative 99mTc-MAG3 renal scintigraphy.

2. Materials and methods

We retrospectively reviewed the medical records of 238 patients who underwent unilateral NUR and BCR for UTUC between 2007 and 2010 in the National Cheng Kung University Hospital, a tertiary medical center in Southern Taiwan. The patients with end-stage-renal disease, and those who underwent a second operation or received bilateral nephroureterectomy were excluded. In total, 129 patients underwent MAG3 renal scintigraphy before unilateral NUR and BCR. The serum creatinine levels were measured in all patients before surgery, and renal functions were monitored for 1 year after surgery. We used revised equations for estimated GFR from serum creatinine.[8] For men, the equation is:

$$\text{eGFR (mL/min/ 1.73 m}^2) = 194 \times (\text{Serum creatinine})^{1.094} \times (\text{age})^{0.287}, \quad (1)$$

and for women Eq. (1) is multiplied by 0.739.

All these patients had received preoperative image evaluation, including computed tomography, magnetic resonance imaging, or renal sonography. According to the latest image, we divided all these patients into hydronephrosis group and nonhydronephrosis group. The diagnosis of hydronephrosis was determined by the radiologists or the urologist. It was defined as urinary obstruction and dilatation of the collecting system in ipsilateral upper urinary tract with urothelial cancer.

2.1. MAG3 renal scintigraphy

The renal radionuclide scans were carried out using MAG3.One hundred and eleven milliliters of MBq (3 mCi) MAG_3 (INER MERTIARISW kit, INER, Taoyuan, Taiwan) was injected into the vein of the forearm and serial scintiphotos were taken using a gamma camera. Blood samples were taken at 44 minutes postinjection from the contralateral forearm. Effective renal plasma flow (ERPF), normalized to body surface area of 1.73 m^2, was determined by the procedure developed by Russell et al.[9,10] Split renal function was determined by the 1- to 2-minute postinjection images.

2.2. Statistical analysis

We used the paired t test to compare pre- and postoperative eGFR and serum creatinine. The predicted decreased in ERPF ratio was compared with a decrease in eGFR using a paired t test. Values are expressed as the mean and 95% confidence interval (CI). Pearson's correlation analysis was performed to evaluate the correlations between the decreases in preoperative ERPF and eGFR ratios for all patients, hydronephrosis group, and nonhydronephrosis group. All statistical analyses were performed using SPSS version 20 (SPSS Inc., Chicago, IL, USA) for Microsoft Windows. Statistical significance was defined as $p < 0.05$.

3. Results

A total of 129 patients, including 62 men (48%) and 67 women (52%) with an average age of 69.0 years at surgery (range, 48–87 years) in this study. The preoperative characteristics of the 129 patients, all of whom had at least 1 year of postoperative follow-up are listed in Table 1. The mean preoperative creatinine level was 1.42 mg/dL (95% CI 1.31–1.53), and the baseline eGFR was 54.76 mL/min/1.73 m^2 (95% CI 50.68–58.85). Baseline renal function was comparable in hydronephrosis and nonhydronephrosis groups with respect to serum creatinine (1.49 ± 0.70 mg/dL vs. 1.3 ± 0.54 mg/dL, $p = 0.11$), eGFR (54.02 ± 24.31 mL/min/1.73 m^2 vs. 56.10 ± 21.51 mL/min/1.73 m^2, $p = 0.63$), and total ERPF (235.24 ± 150.32 mL/min/1.73 m^2 vs. 276.51 ± 157.67 mL/min/1.73 m^2, $p = 0.15$). The average preoperative ERPF of the resected kidney in hydronephrosis group was 81.37 mL/ min/1.73 m^2 (95% CI 63.37–99.38), which was lower than the nonhydronephrosis group (110.20 mL/ min/1.73 m^2, 95% CI 88.35–132.06; $p = 0.05$). The renal function was comparable in hydronephrosis and nonhydronephrosis groups 1 year after NUR with respect to serum creatinine (1.96 ± 1.320 mg/dL vs. 1.77 ± 1.34 mg/dL, $p = 0.48$), and eGFR (44.28 ± 21.15 mL/min/1.73 m^2 vs. 44.74 ± 19.66 mL/min/1.73 m^2, $p = 0.91$). One year after NUR, the mean creatinine level was 1.92 mg/dL (95% CI 1.68–2.16, $p < 0.001$) and eGFR was 44.44 mL/min/1.73 m^2 (95% CI 40.72–48.17, $p < 0.001$), which represented a decrease of 18.73% with comparison to preoperative data. The preoperative ERPF of the operated kidney was 91.65 mL/min/1.73 m^2, and that of the remaining kidney 158.30 mL/ min/1.73 m^2 (Table 2). The average preoperative ERPF of the resected kidney accounted for 34% of the total preoperative ERPF.

The decrease in eGFR ratio was defined as the change in eGFR (preoperative eGFR subtracted by the postoperative eGFR) divided by preoperative eGFR. The predicted decrease in ERPF ratio was defined as the ERPF of the operated kidney divided by total ERPF. The decrease in eGFR ratio was significantly correlated with the calculated decrease in ERPF ratio ($R = 0.279$, $p < 0.001$; Fig. 1). Based on the patients' preoperative imaging results, the patients were divided into two groups: with hydronephrosis ($n = 46$) or without hydronephrosis ($n = 83$). In linear regression analysis, the nonhydronephrosis group had a higher correlation between the decreases in ERPF ratio and eGFR ratio ($R^2 = 0.362$, Fig. 2) than the hydronephrosis group ($R^2 = 0.248$, Fig. 3). Based on the Pearson's

Table 1
Baseline characteristics of 129 patients.

Patient characteristics ($n = 129$)	
Gender	
Male	62 (48)
Female	67 (52)
Age at surgery, y	
Mean (range)	69 (46–87)
Tumor location	
Left	60 (47)
Right	69 (53)
Age ≥ 70 y	66 (51)
Pathological stage	
≤ pT1	50 (39)
pT2	22 (17)
pT3	46 (36)
pT4	9 (7)
Other	2 (1)
pN+	10 (8)
Hydronephrosis	
Hydronephrosis	46 (36)
Nonhydronephrosis	83 (64)

Data are presented as n (%).

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