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### Function-preserving high-dose adaptive radiotherapy for renal pelvic cancer in a solitary functioning kidney with severe dysfunction: A case report

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**Abstract.** *It is challenging to treat renal pelvic cancer in a solitary functioning kidney and severe kidney dysfunction while preserving renal function. A 78-year-old man with renal pelvic cancer and G4 chronic kidney disease was treated with high-dose adaptive radiotherapy using helical tomotherapy with a total dose of 74 Gy in 37 fractions. His serum creatinine level before radiotherapy was 190.1  $\mu\text{mol/L}$ , which temporarily increased to 442.1  $\mu\text{mol/L}$  at 9 months after radiotherapy, but gradually decreased to 181.3  $\mu\text{mol/L}$  2 years later with medical treatment. Follow-up MRI showed complete tumor regression 5.5 years after radiotherapy, and dialysis was avoided. High-dose adaptive radiotherapy may be a viable option for a solitary functioning kidney and severe renal dysfunction complicated by renal pelvic cancer.*

**Keywords:** kidney neoplasms, chronic kidney disease, intensity-modulated radiotherapy, transitional cell carcinoma.

**Conflict of interest.** The authors declare no conflict of interest.

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## Функціонально-зберігаюча високодозова адаптивна променева терапія раку ниркової миски у пацієнта з хронічною хворобою єдиної функціонуючої нирки: клінічний випадок

Відділення радіаційної онкології, медичний центр Едогава, Токіо, Японія

**Резюме.** Адаптивна променева терапія раку ниркової миски має суттєві обмеження у пацієнтів з нирковою недостатністю. Цей клінічний випадок демонструє успішне лікування 78-річного чоловіка із раком ниркової миски та хронічною хворобою нирок IV стадії, який отримував високодозову адаптивну променеву терапію із застосуванням спіральної томотерапії із загальною дозою 74 Гр за 37 фракцій. Рівень креатиніну сироватки до променевої терапії становив 190,1 мкмоль/л, який тимчасово підвищився до 442,1 мкмоль/л через 9 місяців після променевої терапії, але поступово знизився до 181,3 мкмоль/л через 2 роки після променевої терапії без лікування гемодіалізом. Контрольна МРТ показала повну регресію пухлини через 5,5 років після променевої терапії, а діалізу вдалося уникнути. Адаптивна променева терапія у високих дозах може бути життєздатним варіантом для пацієнтів з раком ниркової миски єдиної функціонуючої нирки та нирковою недостатністю.

**Ключові слова:** новоутворення нирок, хронічна хвороба нирок, високодозова променева терапія, перехідно-клітинний рак.

**Introduction.** Most people live normal lives with only one kidney, either due to congenital agenesis or secondary causes such as injury, resection, or dysfunctional disease [1]. However, if the only remaining kidney is affected by cancer, surgical resection may cure the cancer, but dialysis or kidney transplantation will be required [2]. In general, radiotherapy for renal pelvic cancer is given at a total dose of 35 to 55 Gy in standard fractionated doses of 1.8 to 2.0 Gy per fraction over 4 to 6 weeks [3]. Here we report a case of successful high-dose adaptive radiotherapy with helical tomotherapy for renal pelvic cancer in a solitary functioning kidney with severe renal dysfunction.

**Case Report.** A 78-year-old man presented with macroscopic hematuria. Ultrasonography showed left-sided hydronephrosis and a renal pelvic tumor in the left renal pelvis. The right kidney was atrophied and not functioning. After a biopsy of the left renal pelvic tumor, he was diagnosed with moderately differentiated urothelial carcinoma of the renal pelvis and a double J ureteral stent was placed to relieve the hydronephrosis (Fig. 1a and 1b).

His kidney function was severely impaired and surgery was not indicated, so he was referred to our department for radiotherapy. On admission, he was diagnosed with G4 chronic kidney disease with a serum creatinine level of 2.15 mg/dl and an estimated glomerular filtration rate (eGFR) of 24.0 mL/min/m<sup>2</sup> (Table 1).

Contrast-enhanced CT in the excretory phase showed contrast excretion in the left kidney (Fig. 1c). However, the right kidney was atrophic with little or no contrast excretion, indicating that the kidney was not functioning. Since the stent was placed prior to referral, his hydronephrosis had resolved. MRI revealed a heterogeneous isointensity mass on T2-weighted and short tau inversion recovery (STIR) images (Fig. 1d). The tumor in the left renal pelvis showed a high signal on diffusion-weighted imaging (DWI) (Fig. 1e) and low signal on apparent diffusion coefficient (ADC) map (Fig. 1f) without direct invasion into the renal parenchyma. An arteriovenous fistula was surgically created in the left arm to provide long-term vascular access for hemodialysis, but blood flow through the arteriovenous shunt was insufficient for dialysis at the time of referral. High-dose adaptive radiotherapy with helical tomotherapy was used to control the tumor while avoiding immediate hemodialysis.

The patient underwent CT and MRI simulation, and fusion images of non-contrast CT and STIR images were generated using Monaco 5.0 treatment planning software (Elekta AB, Stockholm, Sweden). Gross tumor volume (GTV) was defined on STIR images, and planning target volume (PTV) was defined as 0.5-1 mm margin expansion from GTV. The prescribed dose to the D95% of the PTV (the dose covering 95% of the PTV) was 74 Gy in 37 fractions over 7.5 weeks (Fig. 2a-c).

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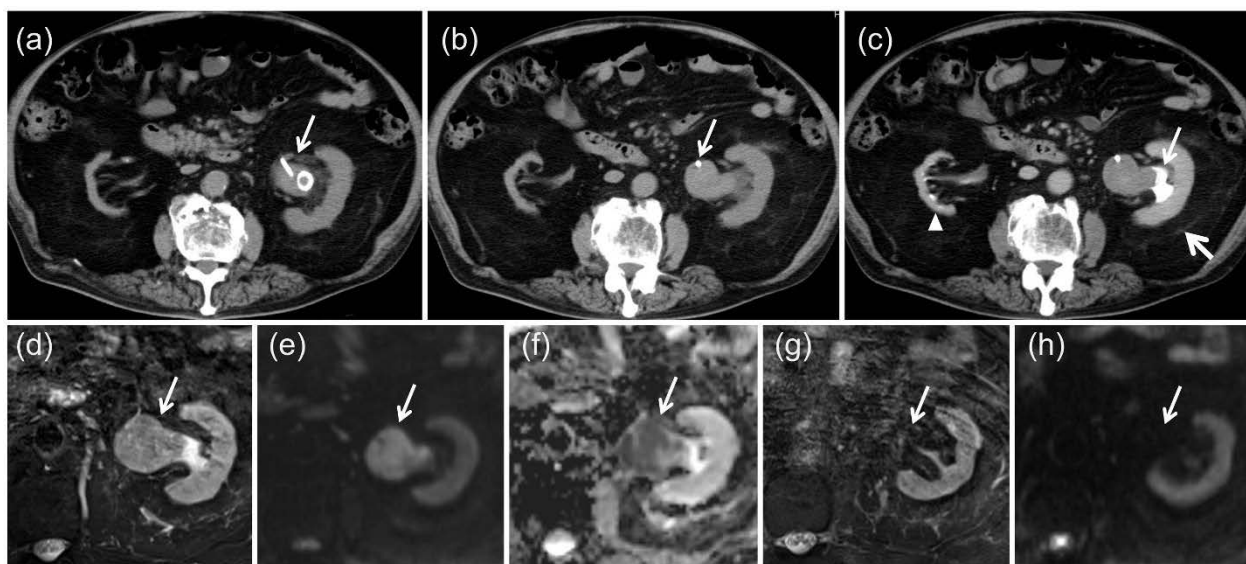


Fig. 1. A 78-year-old man with renal pelvic cancer and severe kidney dysfunction of a solitary functioning kidney. (a) The J stent is visible in the left renal pelvis on non-contrast CT (arrow); (b) The J stent is surrounded by a tumor in the left renal pelvis (arrow); (c) Contrast-enhanced CT in the excretory phase showed contrast excretion (small arrow) in the left kidney. Perinephric inflammation or edema is noted (large arrow), suggesting post-renal pyelonephritis. the right kidney was atrophic with little or no contrast excretion, indicating that the kidney was not functioning (arrowhead); (d) Transverse short tau inversion recovery image shows a mass with heterogeneous isointense signal in the left renal pelvis (arrow); (e) The tumor showed high signal on diffusion-weighted imaging (arrow); (f) Apparent diffusion coefficient map generated from diffusion-weighted imaging showed a heterogeneous hypointense mass (arrow); (g) Transverse short tau inversion recovery image shows complete disappearance of the tumor in the left renal pelvis (arrow) 5.5 years after radiotherapy; (h) There was no hyperintense lesion in the left renal pelvis on diffusion-weighted imaging (arrow) 5.5 years after radiotherapy.

Table 1

**Peripheral blood laboratory parameters before radiotherapy, at 9 months after radiotherapy, and at 2 years after radiotherapy**

	Unit	Before radiotherapy	9 mo. after radiotherapy	2 yrs. after radiotherapy
White blood cell	x10 <sup>12</sup> /L	6.5	5.6	5.1
Red blood cell	x10 <sup>12</sup> /L	3.34	3.76	3.58
Hemoglobin	g/L	102	117	111
Platelet	x10 <sup>9</sup> /L	287	202	208
Blood urea nitrogen	mg/dl (mmol/L)	54 (19.3)	99 (35.4)	44 (15.7)
Creatinine	mg/dl (mmol/L)	2.15 (190.1)	5.00 (442.1)	2.05 (181.3)
Calcium	mg/dl (mmol/L)	9.0 (2.25)	8.4 (2.10)	8.3 (2.07)
Phosphate	mg/dl (mmol/L)	3.7 (1.19)	5.3 (1.71)	2.5 (0.81)
C-reactive protein	mg/dl	2.61	1.17	1.12



Fig. 2. Radiotherapy isodose line distribution. Isodose lines are displayed on (a) transverse, (b) coronal, and (c) sagittal CT imaging. Isodose lines with corresponding actual radiation doses were given over 37 fractions.

The treatment plan was carried out using intensity-modulated radiation therapy (TomoTherapy, Accuray, Madison, WI, USA), and the maximum dose within PTV was not constrained. We tried to keep his D1cc of the small bowel and colon to less than 56 Gy and the average dose to the left kidney to less than 10 Gy. To reduce the dose to the left kidney, adaptive radiotherapy planning was performed in the same manner as the initial planning when 46 Gy and 66 Gy were delivered. Radiotherapy was administered as planned and there were no adverse events. At the end of all radiotherapy sessions, the average renal dose was 10 Gy, with 27% of the left kidney volume receiving 16 Gy. His serum creatinine level temporarily increased to 5.00 mg/dl 9 months after radiotherapy, but gradually decreased to 2.05 mg/dl 2 years after radiotherapy (see Table 1) with antihypertensive medication and diuretics, and did not require dialysis. Follow-up MRI showed complete tumor regression (Fig. 1g and h) 5.5 years after radiotherapy, and dialysis was avoided.

**Discussion.** As far as we know, there is no positive result of primary radiotherapy without surgical resection or chemotherapy. Adjuvant radiotherapy alone or as an adjunct to chemotherapy may improve outcomes in high-risk patients, while primary radiotherapy may be an option in inoperable patients [3]. However, the role of definitive radiotherapy has yet to be determined. It is generally difficult to treat renal pelvic cancer in a solitary functioning kidney while preserving renal function. Furthermore, it becomes even more difficult in cases of severe renal dysfunction. In this case of a solitary functioning kidney, we successfully avoided dialysis with high-dose adaptive radiotherapy for renal pelvic cancer complicated by stage 4 (G4) chronic kidney disease [2]. It has been recommended that a mean kidney dose of less than 10 Gy is considered optimal for renal preservation during radiotherapy, and the volume of the kidney receiving 16 Gy should be kept below 35% to minimize nephrotoxicity [4]. In this case, the average kidney dose was limited to 10 Gy, and the volume of the left kidney receiving 16 Gy was 27%, within the ideal dose constraint [4]. The reason for the transient decline in renal function 9 months after radiotherapy is thought to be due to radiation-induced kidney damage [5]. In the case of a solitary functioning kidney with stage 4 chronic kidney disease, radiation-induced kidney damage may still occur even when dose constraints are followed, so care should be taken to minimize radiation-induced kidney damage.

This case report has several strengths. First, this is the first demonstration that high-dose adaptive radiotherapy can preserve renal function and avoid dialysis even in a solitary functioning kidney complicated by severe renal dysfunction. If renal pelvic cancer can be

cured while preserving kidney function, even if the cancer is in a solitary functioning kidney, it may not only improve the patient's quality of life but also prolong survival. It has been reported that the typical median survival rate for advanced kidney disease patients on dialysis was 6 to 22 months [6]. Second, the use of adaptive radiotherapy techniques can reduce PTV during the course of radiotherapy [7], ultimately reducing the dose to the renal parenchyma and minimizing radiation-induced kidney damage.

There are several limitations to this case report. First, the treatment period is as long as 7.5 weeks. The long treatment time allowed the tumor to shrink throughout treatment, which in turn allowed for the effective implementation of adaptive radiotherapy. Second, a single case report cannot be generalized to other cases of patients with solitary-functioning kidneys complicated by cancer. Given the rarity of patients with solitary functioning kidney in a state of severely impaired renal function who develop malignancies, it is currently difficult to establish a generalized treatment for patients with similar conditions. Further research will ensure the feasibility and efficacy of high-dose adaptive radiotherapy for renal pelvic cancer in a solitary functioning kidney complicated by severe renal dysfunction.

**Conclusions.** In conclusion, a single case report cannot be generalized to others without further scientific verification, but high-dose adaptive radiotherapy may be an alternative treatment for the solitary functioning kidney with severe renal failure complicated by malignancy.

**Ethics statement.** All procedures were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Institutional review board approval was waived because every treatment was approved by the national health insurance. Written informed consent was obtained from the patient for the use of clinical data.

**Competing interests.** The authors have no conflicts of interest to declare.

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**Authors' contributions.** Yukihiro Hama and Etsuko Tate were equally involved in the data collection, interpretation, and analysis, wrote the paper. Both authors critically revised the report, commented on drafts of the manuscript, and approved the final report.

**Data availability statement.** The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

**References:**

1. Kim S, Chang Y, Lee YR, Jung HS, Hyun YY, Lee KB, et al. Solitary kidney and risk of chronic kidney disease. *Eur J Epidemiol*. 2019 Sep;34(9):879-888. doi: 10.1007/s10654-019-00520-7.
2. Stevens PE, Levin A, Kidney Disease: Improving Global Outcomes Chronic Kidney Disease Guideline Development Work Group Members. Evaluation and management of chronic kidney disease: synopsis of the kidney disease: improving global outcomes 2012 clinical practice guideline. *Ann Intern Med*. 2013 Jun 4;158(11):825-30. doi: 10.7326/0003-4819-158-11-201306040-00007.
3. Zalay O, Yan M, Sigurdson S, Malone S, Vera-Badillo FE, Mahmud A. Adjuvant Radiotherapy for Upper Tract Urothelial Carcinoma: Systematic Review and Meta-Analysis. *Curr Oncol*. 2022 Dec 20;30(1):19-36. doi: 10.3390/curroncol30010002.
4. Kunogi H, Yamaguchi N, Terao Y, Sasai K. Dosimetric predictors of nephrotoxicity in patients receiving extended-field radiation therapy for gynecologic cancer. *Radiat Oncol*. 2021 Feb 4;16(1):25. doi: 10.1186/s13014-021-01755-z.
5. Ali M, Koo K, Chang D, Chan P, Oon SF, Moon D, et al. Low rate of severe-end-stage kidney disease after SABR for localised primary kidney cancer. *Radiat Oncol*. 2024 Feb 15;19(1):23. doi: 10.1186/s13014-024-02413-w.
6. Wong SPY, Rubenzik T, Zelnick L, Davison SN, Loudon D, Oestreich T, et al. Long-term Outcomes Among Patients With Advanced Kidney Disease Who Forgo Maintenance Dialysis: A Systematic Review. *JAMA Netw Open*. 2022 Mar 1;5(3):e222255. doi: 10.1001/jamanetworkopen.2022.2255.
7. Price AT, Schiff JP, Laugeman E, Maraghechi B, Schmidt M, Zhu T, et al. Initial clinical experience building a dual CT- and MR-guided adaptive radiotherapy program. *Clin Transl Radiat Oncol*. 2023 Jul 22;42:100661. doi: 10.1016/j.ctro.2023.100661.