Radiofrequency Ablation: An Alternative Treatment Method of Renal Cell Carcinoma

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Renal Cell Carcinoma (RCC) is a common renal parenchymal malignancy. Although complete or partial nephrectomy is still the gold standard of management, a lot of minimally invasive techniques are currently emerging into the field of treatment. Recently, image-guided radiofrequency (RF) ablation has received increasing attention and been proposed as an alternation to more invasive procedures such as partial or radical nephrectomy. For the RCC patients who are not amenable to surgery or have a single kidney, RF ablation is another feasible option of management. We present a 71-year-old patient who had right nephrectomy for RCC 10 years prior to admission, and hypertension and arrhythmia under regular treatment. He was noted to have two masses in the left kidney and right adrenal gland, respectively, on follow-up computed tomography images. Percutaneous biopsies of the left renal and right adrenal masses were proven to be renal cell carcinoma. After a right adrenalectomy was performed, this patient underwent two treatment sessions of percutaneous RF ablation to avoid a nephrectomy which would lead her on dialysis. Successful treatment was impressed after 1 year of follow-up. We report this case to emphasize the potential role of percutaneous RF ablation on the treatment of RCC. *(Chang Gung Med J 2004; 27:618-23)*

Key words: kidney, interventional procedures, kidney neoplasm, radiofrequency (RF) ablation.

There has been an increasing tendency to use minimally invasive techniques in the management of renal cell carcinoma (RCC), from complete to partial nephrectomy or laparoscopic nephrectomy, and to thermotherapeutic procedure recently.[1,2] In the past, those patients who were not candidates for surgery only had systemic therapies such as chemotherapy or immunotherapy as the only choices of treatment. Previous reviews have shown that RCC is resistant to chemotherapy.[3,4] Immunotherapy had response rates from 10% to 20%.[5,6] Recently, percutaneous radiofrequency (RF) ablation has become another option modality for treatment of RCC due to its less invasive nature, lower morbidity rate, and feasibility.

CASE REPORT

A 71-year-old woman had received right nephrectomy for RCC 10 years prior to this admission. She had hypertension and complete heart block, and received medial therapy. On physical examination, the patient appeared healthy. The results of hematological and biochemical profiles revealed coagulopathy. Serum creatinine level was 1.1 mg/dL. Follow up computed tomography images showed two masses in the left kidney and right adrenal gland area, respectively. Biopsies of right adrenal and left renal masses proved renal cell carcinoma metastases.

After a right adrenalectomy was performed, this

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patient received follow-up computed tomography study (Fig. 1) and CT-guided RF ablation of the left RCC. The RF ablation was scheduled as an outpatient procedure and was performed with intravenous sedation that consisted of midazolam (2-5 mg) and fentanyl (100-300 mg). RF ablation was performed using a Radionic RF generator (Cosman Coagulator CC-1, Radionics, Burlington, Mass, USA) with a single internally cooled radiofrequency electrode with 3-cm active tip. Generator output was adjusted automatically to supply maximal pulsing RF current without causing impedance rise of more than 10 Ω. Cooling of the electrode tip was achieved using a pump to infuse iced water into the lumen of the elec-

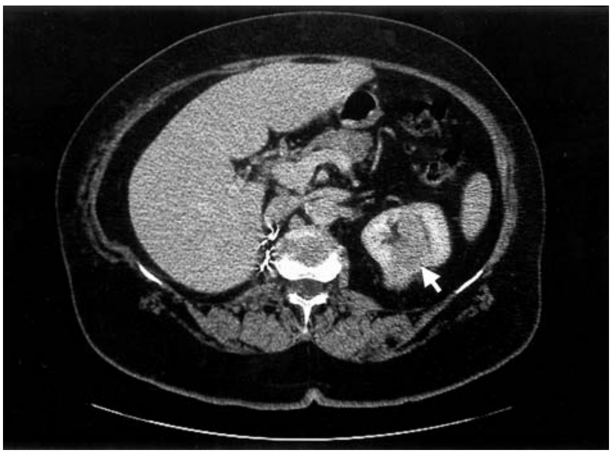

Fig. 1 Contrast-enhanced CT Scan obtained before RF ablation. An enhancing renal cell carcinoma (arrow) of the left kidney involves from the middle pole into the renal sinus, measuring 5.3×3.6×4 cm in size. This mass has an attenuation value of 23 HU before contrast injection. Renal function of left kidney is intact without obstructive uropathy. The left renal vein is not involved.

Fig. 2 Radiofrequency tumor ablation. A 3 cm internally cooled radiofrequency electrode was advanced into the caudal aspect of left renal cell carcinoma and a 12 minute RF treatment was performed in this region.

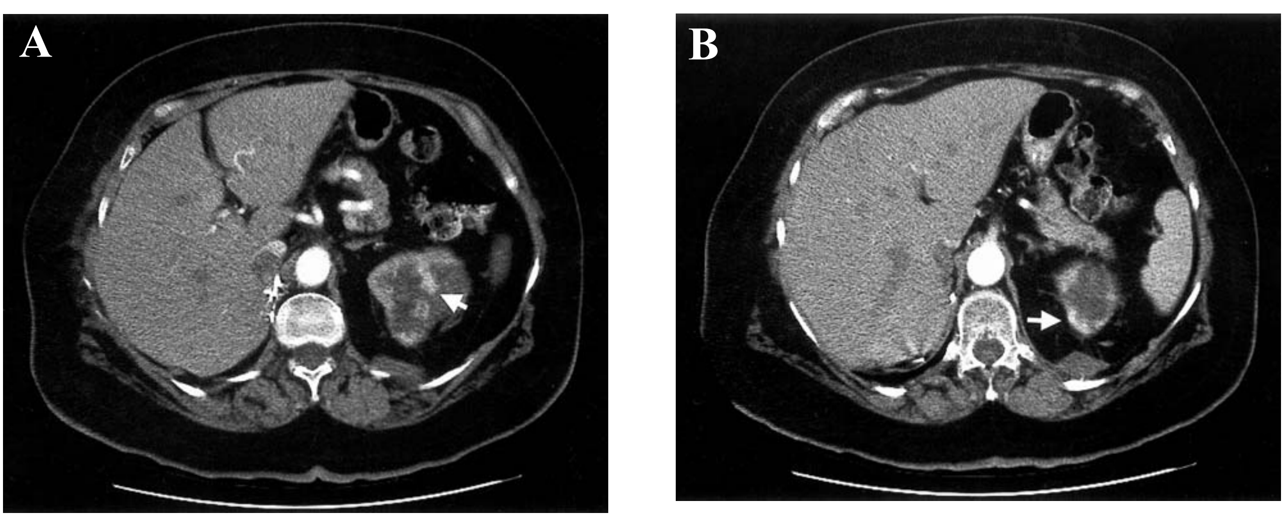

Fig. 3 Contrast-enhanced CT scan obtained after first radiofrequency ablation session. The left renal tumor reveals residual enhancement (arrow) in the central (A) and peripheral (B) areas. Necrosis from the prior RF treatment extends medially and laterally. There is a post treatment hematoma in left posterior pararenal space.

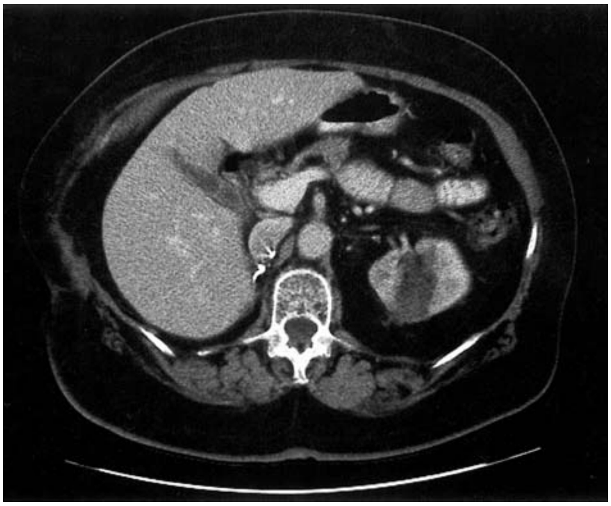

Fig. 4 Contrast-enhanced CT scan obtained after second radio frequency ablation session. An unenhancing area of coagulation necrosis replaces the left renal tumor. The residual tumor is no longer enhancing.

trodes. The electrode was placed in different locations to treat the entire volume of the tumor with six 12-minute RF treatments (Fig. 2). The patient tolerated the procedure well and no immediate complications were noted.

Two weeks after the procedure, follow-up CT images showed enhancement in the central portion of left renal mass, consistent with residual tumor (Fig. 3). RF ablation treatment was arranged again. During the second session of RF ablation, the entire volume of residual tumor was treated with six 12-minute RF treatments.

Follow-up imaging at 1 month (Fig. 4) and 1 year after the second procedure revealed no enhancement in the left renal area or peripheral region, thus, reflecting no residual viable tumor. Serum creatinine level at 2 months after the ablation was 1.3 mg/dL which was within the reference range.

DISCUSSION

Since the percutaneous RF ablation first showed successful treatment of hepatic neoplasm in animal models, this technique has inspired early clinical trials for the management of tumors, including benign bone tumors, hepatocellular carcinoma, hepatic and cerebral metastases, and retroperitoneal tumors.[7-15] Percutaneous RF ablation is a minimally invasive method that can be done under local and intravenous sedation, and may be performed as an outpatient procedure. Current indications for RCC include (a) elderly patients, (b) patients have one kidney, and (c) patients have other malignancies or metastatic diseases. Patients with predisposition to RCC such as Von Hippel-Lindau disease may also be considered as candidates for RF ablation due to the high likelihood of renal tumors developing in contralateral kidney. In many of these patients, RF ablations will allow the patients to avoid dialysis. Because this is a minimally invasive procedure, treatment can be done more than once if new lesions or residual tumors are noted, just as in our case. Patients with sepsis, severe debilitation and uncorrectable coagulopathies are absolutely contraindicated for this procedure.[10,16]

There are three RF ablation systems in the commercial market today, including a pronged umbrella needle system (RITA Medical Systems), a 12-hook array system (Radiotherapeutic), and a single or cluster cooled-tip electrode system (Radionics). Each device consists of an electric generator, needle electrode, and ground pad. To date, there have been no published studies that document the definite advantages of one needle design over the others. The basic principles in all three systems are the same. Heat is produced by ionic agitation around the electrode when alternating electric current is passing the needle, resulting in a focal thermal injury in the tissue.[16,17] The coagulation area is determined by RF current density. The greater the current density surrounding the electrode, the more heat is deposited in the tissue. Goldberg et al.[16] found that irreversible damage occurred in the ablated tumor when temperature was increased to 46˚C for 60 minutes. Raising the ablation temperature to 50 to 52˚C markedly shortened the time to induce cytotoxicity, and only 4 to 6 minutes were needed. If the temperature reaches 105˚C, gas production, tissue charring, and carbonization were produced, thereby resulting in increased impedance and limited current flow. A key aim for ablative therapies is achieving and maintaining a 50 to 100˚C temperature range throughout the entire target volume.[16]

Generally, there are several approaches to maximize energy deposition, including intraparenchymal injection of saline prior to and/or during RF application, the development of algorithms for pulsed energy delivery, and the use of hooked-electrodes, multiprobe arrays, clustered needle electrodes and internally cooled electrodes.[14,17] With the use of these methods, coagulation diameters of 3.5-5.5 cm have been reported, but reproducible ablation of larger than 5 cm diameter is still not permitted.[17,18] In addition, pharmacological modulations of blood flow and antiangiogenesis therapy is theoretically possible to improve the effects of ablation treatment.[19]

Size and location of the renal tumor are the critical factors of successful RF ablation. Gervais et al found RF treatment was more likely to be successful in patients with small (≤ 3 cm) and exophytic renal cell carcinoma.[14] The kidney is usually surrounded by perirenal fat which is an insulator and thus increases the thermal effect in the tumor, the so called oven effect, that allows exophytic renal tumors to have good responses to RF ablation.[10,13] In contrast, a tumor within the renal parenchyma, a highly vascular structure, will constantly replace the heating blood with cooler flowing blood in the adjacent vessels, this "heat sink" effect results in limiting the efficacy of RF ablation.

Currently, ultrasound-guidance is commonly used in the probe placement for their real time imaging capacities, low cost and flexibility.[17] During the US guided ablation, intense hyperechogenicity is seen surrounding the electrode due to the microbubbles of gas formation, and disappears within minutes to 1 hour after ablation.[10,17,19] In fact, this artifact does not correlate with the distribution of these echoes and the exact ablated area, calamitously, it precludes the visualization of the deeper portion of the tumor, thereby increasing the difficulty of repositioning for further treatment.[19] Although CT guidance can provide a good visualization of needle placement and early detection of complications, the static nature of this modality limits its feasibility. The recent development of CT fluoroscopic systems may enhance the role of CT in future.[17]

To date, neither CT nor US findings during or immediately post RF ablation can reliably predict the results of treatment. Due to the presence of a thin rim of contrast material corresponding to hyperemic inflammatory reaction to the damage cells on the immediate post-ablation enhanced CT images, underestimation of residual disease may result.[10] Follow-up timing is acceptable in 1 month after the procedure. Generally, CT scan or MRI is used for follow-up study rather than biopsy.[13,14,20] On follow-up images, any lesion that is enhanced more than 10 HU on CT scan imaging or increases signal intensity on MR imaging after contrast administration is considered to be untreated renal cell carcinoma and further treatment is needed.[13, 14,] Complete ablation is fulfilled when there is no tumor enhancement on contrast-enhanced imaging initially or on follow-up imaging at 12 to 24 months after completing the procedure.

RF ablation for the treatment of renal tumor is very safe and has an extremely low complication rate. There is only one report showing severe complication, a paranephric hematoma, directly related to the procedure was occulded.[10] The collecting system of the kidney, and resolved by cystoscopic ureteral stent placement. Microscopic hematuria is common but no treatment is needed.[10] To prevent massive bleeding, Hall et al.[15] advocated transarterial embolization prior to percutaneous RF ablation. Heating of the track has been proposed to ablate any potentially remaining tumor cells. No tumor seeding along the needle track or renal function deterioration has been reported yet.

In conclusion, percutaneous RF ablation is an alternative to more invasive treatment methods of RCC, especially for patients with only one kidney or patients with bilateral renal tumors, this modality can help patients preserve the renal function and avoid dialysis.

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腎細胞癌之另類治療方式：射頻燒灼術

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腎細胞癌是一種常見的腎臟腫瘤。雖然全或部份腎臟切除術仍是目前的標準治療方式，但很多學者已利用各種微創技術來治療腎細胞癌。最近，射頻燒灼術漸漸被重視和被建議可替代具有危險性之部分或全切除術。對於不適合外科手術或只有一顆腎臟的病人，射頻燒灼術是另一有效之治療方法。本文報告一位71歲，有高血壓及完全心傳導阻滯的病患，於10年前因右腎細胞癌切除右腎，電腦斷層追蹤發現右腎上腺及左腎各有一實質塊狀物。經影像指引切片檢查，証實爲腎細胞癌。爲維持患者左腎功能，避免終身洗腎，故先行右腎上腺切除術，再接受電腦斷層指引射頻燒灼術來治療左腎細胞癌。經兩次燒灼術治療及經過一年的影像追蹤檢查，電腦斷層檢查顯示無任何活存腫瘤。此乃吾報告之成功案例之一。(長庚醫誌 2004;27:618-23)

關鍵字：腎臟，介入性治療，腎臟腫瘤，射頻燒灼術。

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