Nephron-sparing percutaneous ablation of a 5 cm renal cell carcinoma by superselective embolization and percutaneous RF-ablation

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Nierenschonende perkutane Ablation eines 5 cm Nierenzellkarzinoms durch superselektive Embolisation und perkutane Radiofrequenzablation. **Ziel:** Bericht über eine nierenschonende, perkutane Ablation eines 5 cm großen Nierenzellkarzinoms durch kombinierte Transkatheterembolisation und perkutane Radiofrequenzablation. **Material und Methoden:** Ein 5 cm großes Nierenzellkarzinom eines 43 Jahre alten Drogenabhängigen mit serologisch nachgewiesener HIV, Hepatitis B- und C-Infektion, der eine operative Therapie ablehnte, wurde superselektiv durch Embosphären (Partikelgröße: 500 – 700 μm) und einer Platinspirale unter Lokalanästhesie embolisiert. Am Folgetag wurde eine perkutane Radiofrequenzablation mit einer 7F LeVeen-Sonde (Schirmdurchmesser: 40 mm) und einem 200 Watt Generator in Intubationsnarkose durchgeführt. **Ergebnisse:** Das kombinierte Vorgehen führte zu einer vollständigen Ablation des Tumors, ohne das umgebende gesunde Nierenparenchym zu schädigen. Der Patient wurde am Tag nach der Radiofrequenzablation entlassen. Der Eingriff verlief ohne Komplikationen, weder ein Urinom oder eine Urinfistel wurden beobachtet. Im Kontroll-CT am Tag nach der Intervention sowie nach 4 Wochen wurde weder ein Rest- noch ein Rezidivtumor nachgewiesen. **Schlussfolgerung:** Die kombinierte Transkatheterembolisation und perkutane Radiofrequenzablation von Nierenzellkarzinomen erwies sich bei diesem Patienten als technisch möglich, effektiv und sicher. Das Verfahren kann unter bestimmten Umständen als Alternative zur Nierenteilresektion oder radikalen Nephrektomie angeboten werden. **Abkürzungen:** RF = Radiofrequenzablation; CT = Computer-tomographie; HIV = human immunodfiency virus

Schlüsselwörter: Radiofrequenzablation (RF-Ablation) – Embolisation (arteriell) – Nierenzellkarzinom – Therapie

Abstract. **Purpose:** To report on the nephron-sparing, percutaneous ablation of a large renal cell carcinoma by combined superselective embolization and percutaneous radiofrequency ablation. **Materials and Methods:** A 5 cm renal cell carcinoma of a 43-year-old drug abusing male with serologically proven HIV, hepatitis B and C infection, who refused surgery, was superselectively embolized using microspheres (size: 500 – 700 μm) and a platinum coil under local anesthesia. Percutaneous radiofrequency ablation using a 7 F LeVeen probe (size of expanded probe tip: 40 mm) and a 200 Watt generator was performed one day after transcatheter embolization under general anesthesia. **Results:** The combined treatment resulted in complete destruction of the tumor without relevant damage of the surrounding healthy renal tissue. The patient was discharged 24 hours after RF ablation. No complications like urinary leaks or fistulas were observed and follow up CT one day and 4 weeks after the radiofrequency intervention revealed no signs of residual tumor growth. **Conclusion:** The combined transcatheter embolization and percutaneous radiofrequency ablation of renal cell carcinoma has proved technically feasible, effective, and safe in this patient. It may be offered as an alternative treatment to partial or radical nephrectomy under certain circumstances. **Abbreviations:** RF = radiofrequency ablation; CT = computed tomography; HIV = human immunodeficiency virus.

Key words: Radiofrequency (RF) ablation – embolization (arterial) – renal neoplasm – therapy

Introduction

Renal cell carcinoma is the most common malignant tumor of the kidney. In the United States, approximately 30,000 new cases per year are reported [1]. Standard treatment is radical or partial nephrectomy [2], depending on tumor size and presence of local or distant metastases. Despite the development of modern, less invasive techniques like laparoscopic nephrectomy, there is still a demand for further reduction of therapy-related morbidity, especially in high-risk patients. Recent advances in percutaneous thermal ablation techniques like cryotherapy and radiofrequency ablation have opened new perspectives of non-surgical, percutaneous tumor ablation [3 – 6]. Whereas these techniques are popular in the management of liver malignancies, there are only reports on percutaneous treatment of small renal tumors [7 – 9]. We report our experience with a patient who refused surgery and whose medical problems precluded local surgical resection of a 5 cm renal cell carcinoma of the right kidney.

Subject and Methods

A 43-year-old male drug addict, suffering from serologically proven HIV, hepatits B and C, underwent a routine examination

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during a methadon drug program. Abdominal ultrasound examination revealed a large, organ exceeding tumor mass of the upper pole of the right kidney. He was referred to our hospital for tumor staging and therapy. A contrast enhanced multi-slice spiral CT (MSCT, Somatom Volume Zoom, Siemens, Germany, 4 × 2.5 mm collimation, increment of 4 mm, effective slice thickness 5 mm) of the chest and abdomen revealed a 5 × 4 × 4.5 cm renal tumor of the upper pole of the right kidney (Fig. **1 a**). The lesion exceeded the margin of the upper pole and was bulging towards the right liver lobe (Fig. **1 b**). Approximately 1/3 of the kidney was infiltrated by the tumor. Maximum intensity projections showed displacement, but no obstruction of the upper calices. No local or distant organ or lymph node metastases were observed, the renal vein was completely patent. As the patient refused any surgical procedure, he was referred for percutaneous radiofrequency ablation. Percutaneous treatment was performed based on a consensus discussion between referring urologists, oncologists and radiologists. Because of the large estimated tumor volume of more than 40 cc and high tumor vascularization, a superselective transcatheter embolization was performed prior to percutaneous hyperthermal radiofrequency ablation. Serum creatinine level, hemostatic parameters including platelets count and standard hematological tests revealed to be normal. Written informed consent was obtained for embolization and subsequent tumor ablation.

a, b

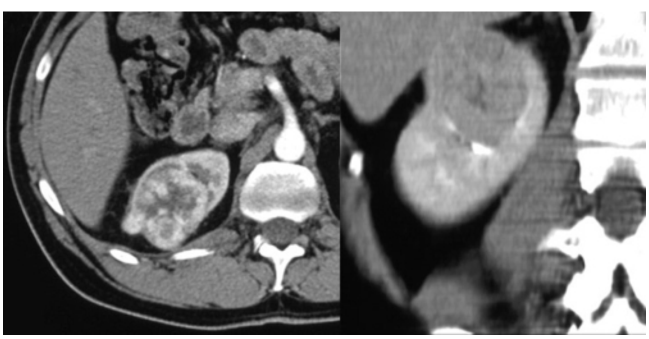
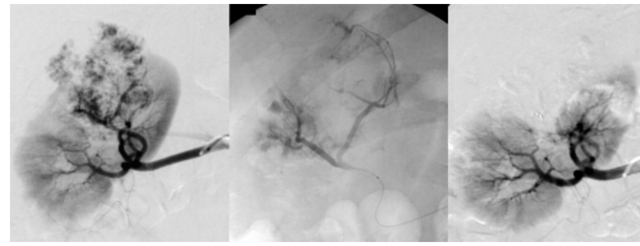


Fig. 1 (**a**) Contrast-enhanced MSCT, arterial phase (left). Exophytic tumor in the upper third of the right kidney. (**b**) Coronal multiplanar reformation (center). Bulging of the tumor towards the right liver lobe can be easily appreciated.

Selective arteriogram of the right kidney (Fig. **2 a**) via a 5.2 F cobra guide catheter (Cordis, Miami, FL) revealed a hypervascularized tumor with two feeding segmental arteries in the upper half of the organ. A 3 F microcatheter (Tracker, Boston Scientific, Fremont, CA) was coaxially guided into both feeding arteries and 2 g embospheres (Contour, ITC, South San Francisco, CA) with a size ranging from 500 to 700 µm, mixed with nonionic contrast agent, were gently injected under fluoroscopic control until blood flow ceased in both arterial branches (Fig. **2 b**). Finally, a platinum microcoil (Cook, Bjaeverkov, Denmark, 25 mm in length and 3 mm in diameter) was placed in the lower of the segmental arteries. Postembolization arteriography revealed complete devascularization of the tumor (Fig. **2 c**). Only local anesthesia was administered and the procedure was well tolerated without any pain.

One day after embolization, percutaneous RF ablation was performed under CT control under general anesthesia. The



a – c

Fig. 2 (**a**). Selective arteriogram of the right kidney (left). Hypervascularized tumor with two feeding segmental arteries. (**b**) Angiography during superselective embolization with embospheres (center) demonstrates partly occluded tumor vessels. (**c**) Selective arteriogram after embolization (right) shows a completely devascularized tumor. No remaining arterial feeders are seen.

intubated patient was placed in prone position on the CT table and a contrast enhanced CT depicted the tumor as hypodense mass, indicating a successful embolization the day before. 4 grounding pads were placed on the patient's thighs and connected to an RF-generator (RF 3000 Generator, Radiotherapeutics, Mountain View, CA, USA). A 7 F LeVeen RF-probe (size of expanded probe tip: 40 mm) was placed percutaneously into the upper part of the tumor after removing the distal 5 mm of the electrical insulation in order to allow coagulation of the puncture channel while retracting the probe after the ablation. The correct placement of the probe was controlled by CT after releasing the prongs and connecting the probe cable to the generator. Then, RF energy was applied corresponding to the protocol of the manufacturer, starting with 80 Watts and subsequently rising up to 170 Watts. Seventeen minutes after starting the ablation, the initial electrical impedance of 40 Ω (Ohms) rose significantly and energy application was stopped automatically (roll-off). A small rim of liver tissue adjacent to the upper pole of the tumor was included into thermal ablation volme. A control scan revealed multiple gas bubbles within the tumor, indicating sufficient heating of the ablated part of the tumor (Fig. **3**). After retracting the prongs, the probe was removed stepwise during application of 30 Watts in order to coagulate the puncture channel. Subsequently, the RF probe was placed in the lower part of the tumor, respecting the contrast-filled calices of the renal pelvis. A second cycle of RF-ablation, ranging from 80 to 160 Watts, was performed. After 16 minutes, a second roll-off was observed and a CT scan revealed air bubbles within the whole tumor volume. Before the probe

Fig. 3 Control CT scan after first RF ablation cycle shows the LeVeen probe with released prongs (diameter 40 mm) in the center of the tumor. Note the gas bubbles within the tumor.

a – c

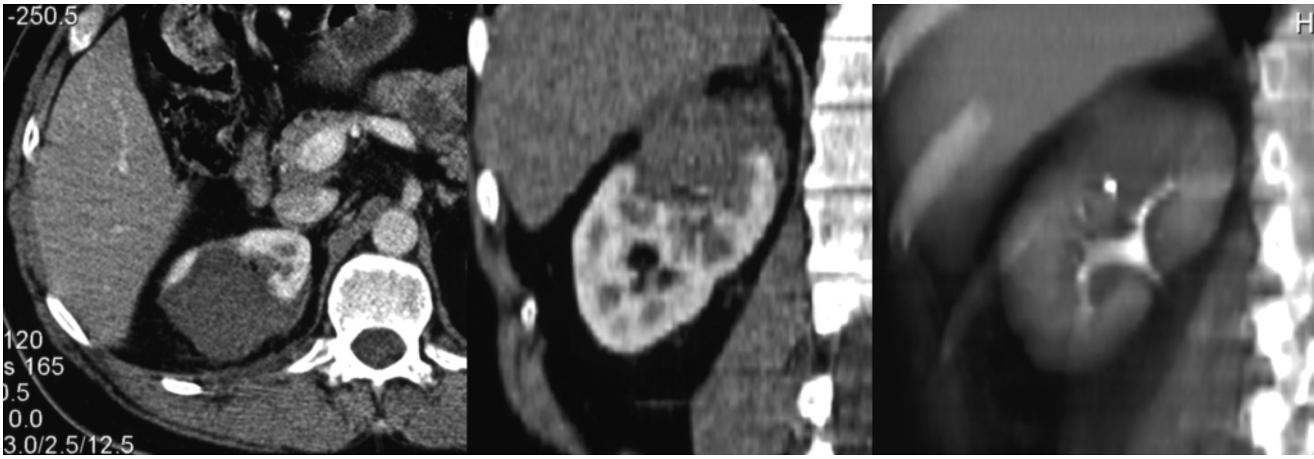


Fig. 4 (**a**) Contrast-enhanced MSCT 4 weeks after RF ablation, arterial phase (left). Regular contrast enhancement of normal and unaffected renal parenchyma. No enhancement of the previously treated tumor is seen proving tumor necrosis. (**b**) Coronal multiplanar reformation of A (center) allows clear delineation of nonperfused tumor and viable, contrast enhancing renal parenchyma (compare to Fig. **1 b**). Note the hypodense rim at adjacent liver which obviously was included in the hyperthermal ablation. (**c**) Urographic phase (maximum intensity projection) of A. No damage of the adjacent calices or urine leakage was detected. Platinum coil within the necrosis.

was removed, a contrast-enhanced CT scan revealed no residual contrast-enhancing tumor. The patient's recovery was uneventful and after a contrast-enhanced MSCT, he was discharged the day after RF ablation. CT revealed complete tumor necrosis including a 10 mm rim of adjacent liver tissue. No damage of the renal pelvis was seen. 4 weeks later, the previously viable tumor had decreased in size and no residual or recurrent enhancing tumor tissue was detected on contrast-enhanced MSCT (Fig. **4 a, b**).

Discussion

Hyperthermal tumor ablation by radiofrequency induced heat is a relatively new technique. It is based on a radiofrequent current (460 kHz) that passes through the target tissue from an active electrode (probe) towards dispersive electrodes (grounding pads) and leads to ion agitation, which is converted by means of friction into heat. Depending on the system, active eletrodes can be a single or clustered needles, which may be internally cooled by saline in order to increase the heating capacity. Other systems are based on expandable probes with a various number of prongs that are released in the target tissue and vary in diameter between 2 cm and 5 cm. Depending on different factors like RF generator capacity, needle design, electrical conductivity and perfusion of the target organ, thermal lesions of up to 5 cm in diameter are possible with a single probe.

First described by LeVeen and co-workers [10], this technique took a long time being accepted as a clinical treatment modality. With the beginning 1990's, several working groups reported on successful experimental and clinical RF ablation of the liver [5,6]. Based on the experiences with large patient studies in the second half of the 1990's [5] percutaneous RF-ablation is now a clinically established method of percutaneous treatment of primary and secondary liver tumors. However, it is not only restricted to the liver. In few and foremost preliminary reports the feasibility of percutaneous RF ablation of the bone, lung, brain, spleen and parathyroids was shown [5].

The technical feasibility of RF ablation of the kidney has already been demonstrated in an experimental set up during open surgery [11], during laparoscopy [12], percutaneously under ultrasound control [13], CT-guidance [9], or MR-guidance [14]. Although these studies differ significantly in number of animals, treatment protocols and follow-up periods and, thus, are hardly comparable, no relevant complications were reported. Hilar occlusion during RF ablation was reported to yield no significant increase in the extension of thermal necrosis [12].

Clinical experiences using RF ablation are still rare. To the best of our knowlegde, only four reports on renal RF ablation exist. Zlotta and co-workers [11] reported on a successful, percutaneously performed RF ablation using a bipolar system of a 2 cm upper-pole tumor 1 week prior to surgery, and on ablations of two 3 cm and 5 cm large tumors during surgery before resection. The resulting necrosis per ablation was 2.2 × 3 × 2.5 cm in diameter. McGovern and co-workers [13] reported on a case of a 3 cm renal cell carcinoma that was treated successfully with an internally cooled RF needle without relapse within a 3 month period. Gervais and co-workers [9] reported on 24 CT and/or ultrasound-guided percutaneous RF ablations of 9 tumors in 8 patients using an internally cooled single- and cluster-needle system (Radionics, Burlington, Mass). Whereas small (< 3 cm in diameter) exophytically and centrally located tumors (n = 6) were treated successfully during one or two interventions (mean follow-up period 10.3 months), the treatment of large tumors (4.1 to 5 cm in diameter, n = 3) required up to eight interventions and resulted in incomplete tumor ablation in two and complete ablation in only one case. An embolization prior to the treatment or resection after ablation was not performed. Hall and co-workers [8] reported on a case of combined transcatheter embolization and percutaneous RF ablation of an exophytic 2.5 × 3 cm renal tumor using a LeVeen probe and an RF 2000 generator (RadioTherapeutics, Mountain View, CA). Within a follow-up period of 3 months no evidence of recurrence was observed. Although this tumor had an estimated volume of less than 12 cc, the combined strategy of embolization and RF ablation seemed to be neccessary due to the generator capacity which was limited to 90 Watts. Furthermore, the maximum diameter of the expanded LeVeen probes that were available at the time of Hall's intervention were limited to 3.5 cm. However, this data was not given in his paper.

In the presented case, we used the latest generator (RF 3000, RadioTherapeutics, Mountain View, CA) with an energy capacity of 200 Watts and a LeVeen probe with 4 cm in diameter. From our own experiences in liver tumor ablation, this set-up results in a maximal thermal necrosis between 4 cm and 5 cm in diameter for a single probe position, depending on tissue perfusion. However, because of the estimated tumor volume of approximately 45 cc and the proximity of the central tumor parts to the renal pelvis (Fig. **1 b**), we decided to combine RF ablation with transcatheter embolization. One can only hypothesize if repetitive RF ablation alone would have resulted in a sufficient tumor ablation. We believe that the additional devascularization by previous tumor embolization allowed a better distribution of the RF-generated conductive heat and, thus, resulted in a complete ablation of the previsously hypervascularized tumor. As shown by Gervais and co-workers [9], the control of tumors exceeding 3 cm in diameter by pure RF ablation seems to be difficult. Interestingly, in none of the reported studies including our experience were urinary leaks or severe damage of the renal pelvis observed. Although every interventionalist plans the procedure with maximum care and presumably reduces completeness of the ablation in favour of safety, there is no explanation for this observation and thus, should be a subject of further experimental investigations.

It is a known advantage of all percutaneous therapies that hospitalization and recovery time is significantly shorter compared to surgical treatment. In good accordance with the other reports, our patient was discharged within 24 hours after the RF procedure. Due to the short duration of hospitalization and subsequent reduced time of recovery, economic aspects seem to be another advantage of this procedure. As known from the study by Shetty and co-workers [6], percutaneous RF ablation is very cost-effective. Although they analyzed the treatment costs of hepatocellular cancer and liver metastases, and no comparable data for renal cell carcinoma exist, it can be assumed that percutaneous procedures in general are less expensive than surgical procedures including partial or radical nephrectomy.

Data from the literature suggest that the 5-year cancer-specific survival of partial nephrectomy corresponds well to the results of radical nephrectomy for unilateral tumors of 5 cm and less [15]. The number of all known cases of percutaneous RF ablation is too small and follow-up period too short to compare the percutaneous versus surgical treatment, but the preliminary results including ours are encouraging to warrant further clinical studies.

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