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CASE REPORT

Microwave Ablation of Renal Cell Carcinoma of the Transplanted Kidney: Two Cases

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Abstract Thermal ablative techniques have been increasingly recognized as a valuable alternative to graftectomy and nephron-sparing surgery for the treatment of small neoplasms arising in the transplanted kidney. However, long-term efficacy and safety data are still lacking. In particular, current experience with microwave ablation is limited to a very recent single-centre series of three cases. We herein report two microwave ablations of renal cell carcinoma of the kidney allograft. The procedures were successfully performed under ultrasound guidance with complete tumour necrosis, no peri-operative complications, and preserved renal function. No recurrences were observed after 3 years of follow-up.

Keywords Microwave ablation · Percutaneous thermal ablation · Kidney transplantation · Renal cell carcinoma · Neoplasm · Allograft

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Introduction

Due to the prolonged exposure to immunosuppression, kidney transplant (KTx) recipients have a greater risk of malignancy than the general population [1]. In particular, allograft neoplasms represent an exceptional challenge as the benefit of complete transplant removal must be weighed against the risk of death arising from chronic renal failure and return to dialysis [2, 3]. Until recently, transplantectomy was the gold standard treatment. Encouraging results from nephron-sparing surgery (NSS) and thermal ablation (TA) in native kidneys have led to their increasing application in renal allografts [4]. Advantages of TA over NSS are that it is less invasive, allows a better preservation of renal function, does not require vascular clamping, entails a lower risk of intra-operative bleeding, has lower complication rates, has shorter hospitalization, and avoids dialysis. Limitations include a lack of definitive histological diagnosis and difficult follow-up [4].

Data on long-term efficacy and safety of TA are limited. The only published experience of microwave ablation (MWA) comprises a single-centre series [5]. We herein describe 2 cases of MWA of renal cell carcinoma (RCC) in transplanted kidneys.

Case 1

A 73-year-old woman received a deceased-donor KTx in 1999. Medical history included end-stage renal disease (ESRD) secondary to polycystic kidneys and hypertension. Immunosuppression consisted of cyclosporine, mycophenolate mofetil, and steroid. Sixteen years post-transplant, a routine Doppler ultrasound revealed an exophytic

(≥ 50%), 2-cm-sized, hypo-echoic mass with intra-lesional vascularization in the anterior-lateral aspect of the lower pole of the allograft, over 4 mm from the collecting system (American Joint Committee on Cancer T1a and RENAL Nephrometry Score 5a) [6]. Contrast-enhanced computed tomography (ce-CT) confirmed a lesion suspicious for malignancy (Fig. 1). The case was discussed in a multidisciplinary meeting, and the decision was made to treat the tumour with MWA. We followed the ABLATE renal ablation planning algorithm [7]. The operation was carried out under general anaesthesia via an open retroperitoneal approach since the risk of colonic perforation was considered too high for a percutaneous route. We used the AMICA—Microwave Ablation System (Mermaid Medical A/S, Denmark). Intra-operative biopsy demonstrated a papillary type II RCC, Fuhrman grade 2. Ablation was performed with ultrasound guidance (Arietta V70, Hitachi Aloka Medical, Japan). The probe was placed perpendicular to the cortex, within the neoplasm (20 W for 3 min), above (20 W for 2 min), laterally (20 W for 2 min), and medially (20 W for 2 min). The procedure took 105 min without complications. Complete cancer necrosis was assessed immediately after the procedure by Doppler ultrasound and at 1 month of follow-up by ce-CT (Fig. 2). Renal function remained stable (pre- and post-operative serum creatinine 1.1 and 1.2 mg/dL, respectively) with no recurrence after 3 years of follow-up.

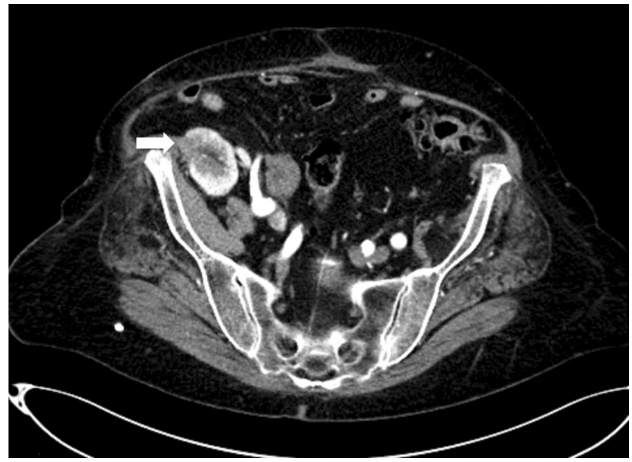

Fig. 2 Case 1: post-operative ce-CT scan demonstrating complete tumour ablation (white arrow)

Case 2

A 56-year-old man received a deceased-donor KTx in 1985. Medical history included ESRD of unknown origin, hypertension, and chronic cardiac failure. Immunosuppression consisted of cyclosporine and steroid. Twenty-nine years after transplant, a surveillance Doppler ultrasound detected a mostly endophytic (> 50%), 3-cm-sized, vascular, hypo-echoic mass localized between the polar lines, in the central aspect of the allograft, less than 4 mm from the sinus (American Joint Committee on Cancer T1a and RENAL Nephrometry Score 9×). Magnetic resonance imaging (MRI) confirmed a mass suspicious for malignancy (Fig. 3). Pre-operative histology demonstrated a clear-cell RCC, Fuhrman grade 1. NSS was deemed impossible due to the close proximity of the neoplasm to

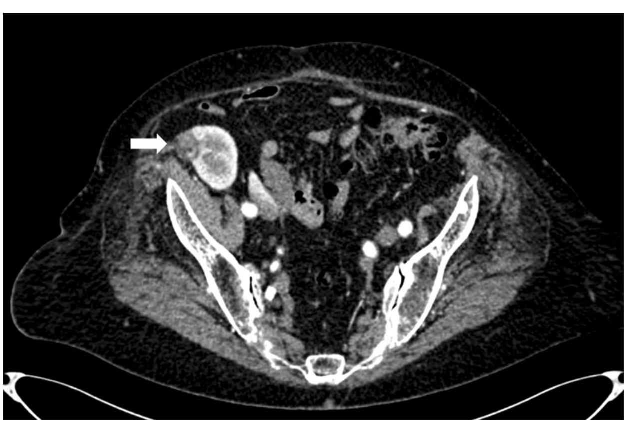

Fig. 1 Case 1: pre-operative ce-CT scan demonstrating an exophytic (≥ 50%), 2-cm-sized, vascularized, solid mass (white arrow) in the anterior-lateral aspect of the lower pole of the renal allograft, over 4 mm from the collecting system (papillary type II RCC, American Joint Committee on Cancer T1a, Fuhrman grade 2, RENAL Nephrometry Score 5a)

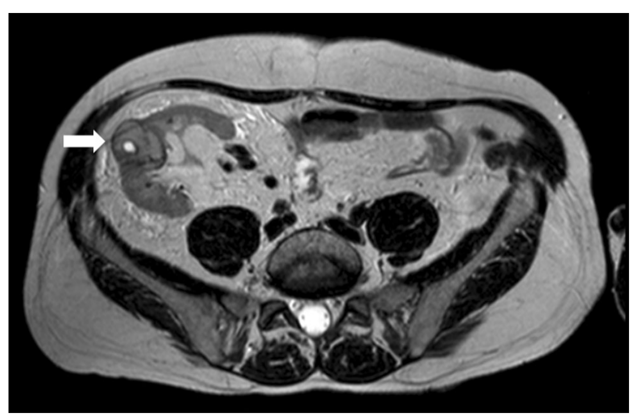

Fig. 3 Case 2: pre-operative MRI demonstrating an endophytic (> 50%), 3-cm-sized, vascularized, solid mass (white arrow) with a small intra-lesional cyst localized between the polar lines, in the central aspect of the allograft, distant less than 4 mm from the sinus (clear cell RCC, American Joint Committee on Cancer T1a, Fuhrman grade 1, RENAL Nephrometry Score 9×)

the renal sinus. Following multidisciplinary discussion, the patient was offered MWA. We followed the ABLATE renal ablation planning algorithm. The procedure was carried out percutaneously under local anaesthesia with ultrasound guidance. Ablation was performed by placing the probe perpendicular to the renal pelvis, inside the lesion (40 W for 5 min). The operation took 25 min without complications. Complete tumour necrosis was assessed immediately after the procedure by Doppler ultrasound and at 1 month of follow-up by ce-CT (Fig. 4). Renal function remained stable (pre- and post-operative serum creatinine 1.5 and 1.3 mg/dL, respectively) with no recurrence after 5 years of follow-up.

Discussion

Incidence and prevalence of kidney transplant neoplasms are 0.19% and 0.5%, respectively [8]. However, considering current donor and recipient characteristics rates are likely to rise in the future [8]. Risk factors remain poorly understood, but chronic renal failure and immunosuppression seem to play a role [8]. Time intervals between transplant and diagnosis are extremely variable [9] and most tumours are diagnosed incidentally [10]. Transplantectomy is now indicated only for advanced diseases, lesions exceeding 7 cm (T2 or above), sarcomatoid, or infiltrating the hilum. For the remainder, NSS is most commonly used for treatment. Adhesions from previous surgery, short vascular pedicles, and increased tissue fragility represent surgical challenges that complicate organ mobilization, vascular control, and adequate tumour resection. For non-transplant patients with contraindications to general anaesthesia, high surgical risk, or for maximal renal function preservation, TA has been increasingly recognized as a valuable alternative to NSS.

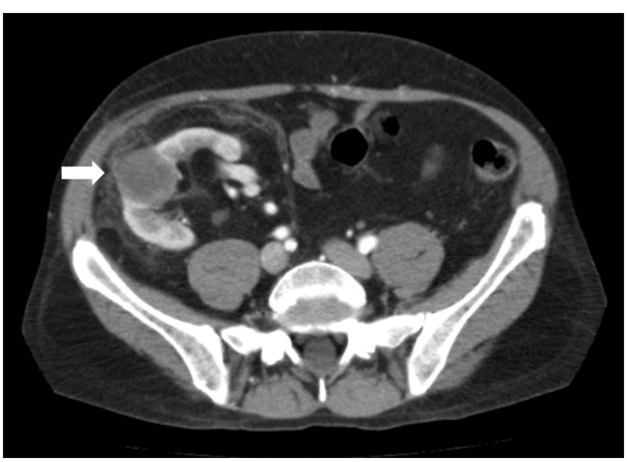

Fig. 4 Case 2: post-operative ce-CT scan demonstrating complete tumour ablation (white arrow)

These encouraging results have led to the acceptance of TA in the transplant community. Unique characteristics of the renal allograft, such as a superficial location and greater susceptibility to ischaemia–reperfusion injury, make it even more suitable for ablation than the native kidney. Indications for TA are currently limited to T1a or T1b lesions.

Our recipients presented with small asymptomatic RCC detected during surveillance ultrasound. The main indication for TA was the need to preserve as much transplant parenchyma as possible. At that time, radiofrequency ablation (RFA) and MWA were the only TA techniques available at our institution. Considering our previous experience with RFA and MWA for the treatment of solid masses of the liver and the native kidney, we opted for the latter as it provided a better oncological outcome with a similar safety profile. Most data on TA of renal allograft tumours refer to RFA. Results are satisfactory, but primary treatment failures and local recurrences have been reported. To date, only a few cases of cryoablation have been described whereas the total experience with MWA in KTx consists of a single small series [5]. MWA uses microwaves to oscillate polar molecules within target tissues leading to frictional heating and coagulative necrosis [11]. Compared to other ablative modalities, MWA provides higher intra-tumour temperatures, is less dependent on electrical conductivity, has an energy delivery that is only marginally limited by the exponential rising electrical impedances of heated tissues, and requires shorter ablation times [12, 13]. Cryoablation is considered the safest ablative technique for centrally located lesions since it has been shown to have a lower risk of thermal damage than RFA and MWA. Nevertheless, modern MWA systems and probes (with constant monitoring of microwave delivery and internal water cooling) may offer better safety profiles, and updated analyses are required to compare cryoablation and MWA in current clinical practice. Furthermore, cryoablation entails higher risks of bleeding than MWA [14]. Blood transfusions can be very detrimental for KTx recipients since they significantly increase the risk of sensitization, thus leading to antibody-mediated rejection and premature transplant loss. It is accepted that for lesions greater than 1.5 cm in maximal diameter cryoablation requires an overlapping ablation strategy, whereas MWA can destroy tumours up to 3 cm using a single probe. Due to complex and extensive comorbidities, most KTx recipients are considered poor surgical candidates. In such a context, short operative times are particularly desirable as they may reduce the risk of anaesthetic-related and infectious complications. Compared to cryoablation, MWA also offers the possibility to treat the puncture tracts reducing the risk of cancer seeding during the procedure. Results of MWA of T1a RCC in native kidneys have been recently published by Shakeri et al. [15]. The authors demonstrated excellent primary (92.8%) and secondary (100%) treatment efficacies with an overall complication rate of 5.8%.

Renal allograft tumours have specific anatomical characteristics that may limit the use of standard assessment tools such as the American Joint Committee on Cancer staging and the RENAL Nephrometry scoring systems. In particular, KTx are placed in the iliac fossa, anastomosed to the iliac vessels, and not surrounded by fatty tissue. A modified TNM staging system has been proposed by Tillou and co-workers in 2012, but it is not routinely used in clinical practice [8]. To the best of our knowledge, there is only one study using the RENAL Nephrometry scoring in the setting of RCC of the transplanted kidney [16]. The procedures reported in our series were fully described using American Joint Committee on Cancer staging, Fuhrman grading, and RENAL Nephrometry scoring in order to allow future inclusion in systematic reviews and meta-analysis. They were also performed following the ABLATE planning algorithm [7]. This algorithm provides a systematic method for reviewing imaging of renal masses for ablation treatment purpose. It considers axial tumour diameter (A), bowel proximity (B), location within kidney (L), adjacency to the ureter (A), touching renal sinus fat (T), and endo- or exophytic lesion (E).

As previously mentioned, current experience of MWA of renal allograft neoplasms is limited to three cases: two percutaneous and one transosseous [5]. The authors used the NeuWave Microwave Ablation System (NeuWave Medical Inc., WI). Percutaneous procedures were performed using a single probe at 65 W for 1 min, 65 W for 2 min, and 50 W for 3 min. Transosseous ablation was performed at 90 W for 1 min, 65 W for 2 min, and 50 W for 3 min. The tumour described in Case 1 was 20 mm in maximal diameter. We used the AMICA Microwave Ablation System. This device has an internal water cooling system combined with a special miniaturized trap for reflected waves which yields quasi-spherical and perfectly controllable ablation volumes. The procedure was performed via an open access under ultrasound guidance. We used a 4-point ablation technique with a 16-gauge interstitial probe placed within the lesion, above, medially, and laterally to it. According to manufacturer's instructions, a single probe application at 20 W for 3 min is able to cover an estimated length of 23 mm and an estimated depth of 17 mm with 2 mm of thermal dispersion. Technical success and primary treatment efficacy were assessed during and immediately after the procedure by Doppler ultrasound so as to promptly detect suboptimal outcomes. Greater energy outputs would have been used during the same treatment session in case of primary failure. A ce-CT scan was also performed at 1 month of follow-up. Further ablative treatments would have been considered in case of primary treatment failure. It may be argued that 20 W for 3 min is a relatively low power output. Use of 50–65 W for 5 to 10 min has been suggested in native kidneys [17]. However, experience in renal allografts remains anecdotal [5]. We opted for a 4-point overlapping ablation with complete tumour coverage. Using a single probe at 60 W for 3 min as previously reported by Gul et al. [5] would have covered an estimated length of 35 mm and an estimated depth of 26 mm with 4 mm of thermal dispersion. In our opinion, such high-energy delivery would have increased the risk of thermal injury to the surrounding parenchyma and structures without any clear benefits. As pointed out by Lubner et al. [18], for MWA procedure using multiple probe placements, the power should be decreased in order to obtain an overall energy output concordant with the tumour volume. The neoplasm treated in Case 2 was 30 mm in maximal diameter and close to the sinus. The procedure was performed percutaneously under ultrasound guidance using a single probe placed inside the tumour at 40 W for 5 min. According to manufacturer's instructions, a single probe application at 40 W for 5 min is able to cover an estimated length of 36 mm and an estimated depth of 29 mm with 5 mm of thermal dispersion. As described above, technical success and primary treatment efficacy were assessed during and immediately after the procedure by Doppler ultrasound and at 1 month of follow-up by ce-CT scan. Using a single probe at 60 W for 3 min as per Gul et al. [5], we would have covered an estimated length of 36 mm and an estimated depth of 26 mm with 4 mm of thermal dispersion. Such an energy output is overall comparable to the one we actually delivered. According to Moore et al. [19], energy outputs exceeding 45 W should be avoided when treating lesions close to the collecting system. Considering tumour characteristics and given the fact that intra-operative and post-operative assessments could not detect any signs of persisting tumour, we decided not to proceed with further ablation avoiding unnecessary manipulation of the graft [20, 21].

In our series, there were no primary treatment failures, no peri-operative complications, and no episodes of recurrence. Allograft function remained stable over time. In both cases, we used intra-operative Doppler ultrasound to monitor ablation volume progression and completion. Technical success was defined as the ability to perform the intended ablation therapy with complete coverage of the tumour by the echogenic ablation margin on Doppler ultrasound. Primary treatment efficacy was assessed immediately after the procedure by Doppler ultrasound and after 1 month of follow-up by ce-CT scan. Primary treatment efficacy was defined as complete coverage of the lesion by the ablation coagulation zone without any signs of vascularization (Doppler signal and contrast enhancement) to suggest residual viable tumour. Further cross-sectional imaging was scheduled at 6, 12, 24, 36, and 48 months of follow-up. Local recurrence was defined as new enhancement on CT scan within a previously successfully treated lesion.

In conclusion, MWA is a valuable option for small localized neoplasms of the renal allograft. Multi-centre studies are needed to better define efficacy, safety, and specific role of such a promising technique.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and Animal Rights Treatments and procedures described in this study were in accordance with the ethical standards of the institutional committee at which it was conducted (Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Consent for Publication Consent for publication was obtained from all individual participants included in the study.

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