

# CRYOSURGICAL ABLATION OF RENAL TUMORS USING 1.5-MILLIMETER, ULTRATHIN CRYOPROBES

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## ABSTRACT

**Introduction.** To describe an open technique for the cryosurgical ablation of small renal tumors using multiple ultrathin cryoprobos. Renal cryosurgery is an evolving surgical technique, and uncertainties exist regarding the ideal approach to freezing renal tumors.

**Technical Considerations.** Using an open surgical approach, a 3-cm upper pole renal mass was ablated using five, state-of-the-art, 1.5-mm cryoprobos simultaneously under real-time ultrasound guidance. The technique is described and demonstrated in a multisegment, Internet-based video tutorial. The blood loss was minimal, and no intraoperative or postoperative complications were experienced. Follow-up imaging at 3 months suggested shrunken, nonviable tumor.

**Conclusion.** Cryosurgical ablation of renal tumors using multiple 1.5-mm cryoprobos is a safe, feasible approach that may be associated with a decreased risk of bleeding. *UROLOGY* 59: 130–133, 2002. © 2002, Elsevier Science Inc.

The increase in the routine use of computed tomography and abdominal ultrasonography has resulted in a marked increase in the number of incidentally discovered, small, renal masses. The optimal management of these tumors remains controversial, as they tend to be of a lower grade and biologically less aggressive than tumors presenting with symptoms.<sup>1,2</sup> Nephron-sparing surgery has been shown to be equal to radical nephrectomy in long-term survival and local tumor recurrence rates in this setting.<sup>3,4</sup> Recently, newer forms of renal ablative surgical technologies, which promise to reduce the morbidity of open partial nephrectomy, have been advocated as viable alternatives to standard renal surgery. For patients with a hereditary or sporadic predisposition to form multiple renal tumors, those with impaired renal func-

tion, or for the elderly patient with significant comorbidities, renal tumoral ablation may be an attractive option. Cryosurgical ablation has been the most studied of the new ablative modalities. Multiple animal models have shown the feasibility of cryosurgical ablation of renal tissue and its ability to produce a zone of completely nonviable renal tissue within the area of the generated iceball.<sup>5,6</sup> Furthermore, these studies confirm the accuracy of real-time, intraoperative ultrasonography to monitor the generation and development of the frozen area. Although the long-term efficacy of renal cryoablation has not been established, several small pilot studies involving open,<sup>7–9</sup> laparoscopic,<sup>10</sup> and percutaneous<sup>11</sup> renal cryoablation have shown it to be a safe technique that is capable of locally controlling small, peripherally located, renal tumors.

One potential area of concern and morbidity revolves around the use of standard 3 to 8-mm cryoprobos, which have been noted to cause renal capsular and parenchymal fractures, resulting in significant bleeding. In this report, accompanied by an Internet-based video tutorial, we demonstrate our technique for the cryosurgical ablation of renal tumors using ultrathin, 1.5-mm cryoprobos. We believe that these 17-gauge cryoprobos, each of which can be operated independently, allow for greater control of the iceball formation and have a reduced potential to damage

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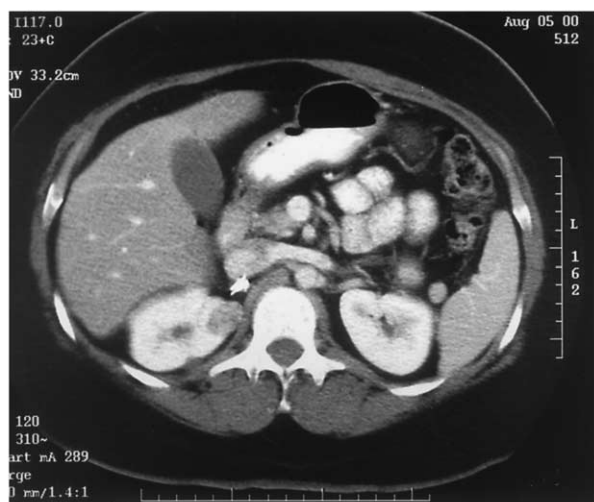


FIGURE 1. *Computed tomography scan of kidneys showing a 3-cm, enhancing, right upper pole renal mass and a more posteriorly located 1-cm cyst. Note metallic clips from previous adrenalectomy.*

the kidney tissue in this evolving surgical modality.

### SURGICAL TECHNIQUE

The patient was a 37-year-old woman with type IIB von Hippel–Lindau disease, who had undergone right adrenalectomy 3 years earlier for a pheochromocytoma. Interval computed tomography scans of the abdomen had revealed four bilateral renal lesions that were too small to characterize, as well as an enlarging, enhancing, right upper pole renal mass (Fig. 1). Anticipation of numerous future renal operations suggested a nephron-sparing approach be undertaken. The patient was positioned in a full flank position, and the right kidney was exposed using a supra-11th, extrapleural, extraperitoneal incision. The ureter, artery, and vein were dissected and isolated, and the perirenal fat was removed to inspect the surface of the renal parenchyma and to expose the tumor. Fat overlying the tumor was sent for pathologic examination (Video Clip 1, Tumor exposure and vascular control). An intraoperative frozen needle biopsy of the tumor mass was obtained and revealed clear cell renal cell carcinoma. The retroperitoneal space was filled with water to create an acoustic window to facilitate ultrasound imaging by eliminating any air-tissue interfaces. Real-time, B-mode ultrasonography was performed using a 7.5-MHz linear array probe with color flow Doppler. Transverse and longitudinal scanning were performed and freeze-frame images were obtained to assess the tumor size, depth of parenchymal extension, and the relationship of the mass to the collecting sys-

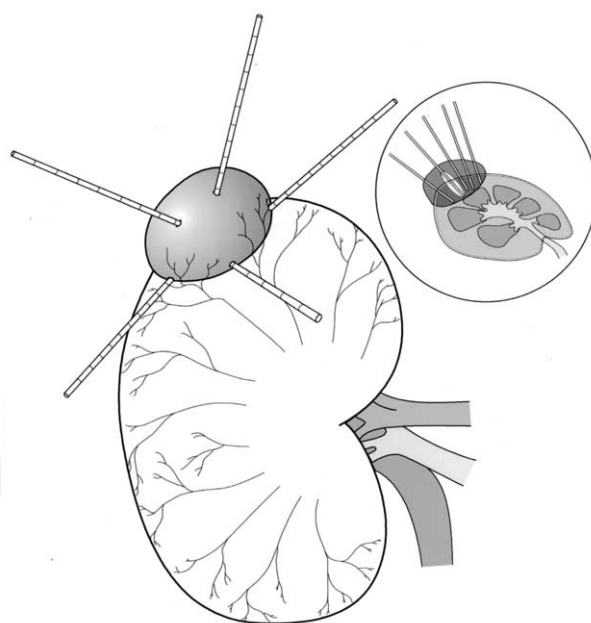


FIGURE 2. *Planning of probe placement. Probe tips are positioned at the deep border of the tumor (inset). Three probes are placed along the medial border of the tumor, because this was where the blood supply to the tumor entered.*

tem and major vessels. Using color Doppler, the blood supply to the mass was visualized. In this patient, a 1-cm renal cyst with a complex nature not appreciated on preoperative computed tomography and the 3-cm upper pole mass were identified (Video Clip 2, Intraoperative ultrasonography).

Because cyst puncture with a cryoprobe could risk tumor spillage, it was elected to perform a partial nephrectomy of the complex cyst. After administration of 12.5 g of intravenous mannitol, a Kaufman clamp was applied for hemostatic control, and the cyst removed with a 5-mm margin of normal renal tissue (Video Clip 3, Partial nephrectomy). The total warm ischemia time to the portion of the kidney affected by the Kaufman clamp was 13 minutes. After hemostasis was complete, cryosurgery was performed on the 3-cm upper pole mass using an argon gas-based machine and five, 1.5-mm diameter, cryoprobes simultaneously (Galil Medical, Yokneam, Israel). The cryo-manifold permits independent control of each cryoprobe. The anticipated depth of probe placement is marked off on each probe to guide insertion. Three probes were placed at 1-cm intervals along the periphery and the base of the tumor, since this was where the blood supply to the tumor came from, and an additional two probes were placed in the center of the tumor (Fig. 2). Using ultrasound monitoring, the position of each probe tip was ver-

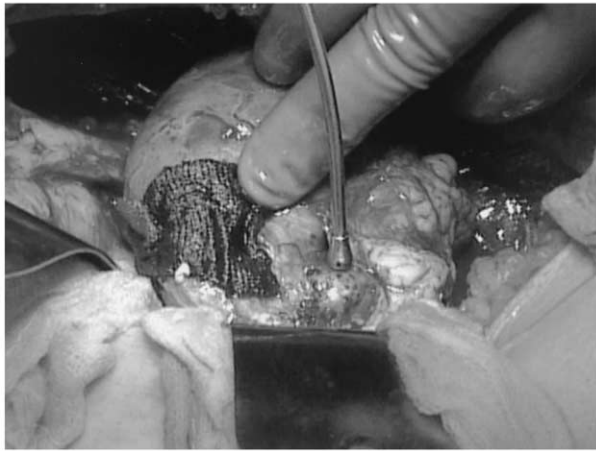


FIGURE 3. No evidence of bleeding after tumor thawing and probe removal.

ified to be just beyond the deep border of the tumor. Each probe was inserted at an angle so that the cryo-defect created by the probes formed a wedge-shaped area encompassing the tumor. Cryoablation was then initiated beginning with the most posterior probes, and a double freeze-thaw cycle with tip temperatures of  $-180^{\circ}\text{C}$  was performed under real-time ultrasound monitoring. Freezing was continued until the hyperechoic leading edge of the iceball was advanced 10 mm beyond the edge of the tumor. Obliteration of blood flow to the posteriorly shadowed iceball indicating tumor ischemia and normal blood flow to the surrounding kidney were confirmed using color Doppler imaging. After the conclusion of the second active thaw cycle, the probes were carefully removed without the need for hemostatic measures (Video Clip 4, Cryosurgical ablation). The total cryosurgical time was 29 minutes, including two freeze cycles lasting 10 and 9 minutes and two active thaw cycles lasting 5 minutes each. Inspection of the kidney at the end of the procedure demonstrated no bleeding from the probe tracts and healthy, viable renal tissue beyond the margin of the ablated lesion (Fig. 3). Pathologic examination revealed clear cell renal cell carcinoma in the wall of the cyst. Magnetic resonance imaging of the kidneys at 3 months showed a 2-cm shrunken, non-enhancing mass in the upper pole of the right kidney that was approximately 30% smaller than it had been on the preoperative scans.

#### COMMENT

Cryoablative technology has improved, with better ultrasound monitoring and advanced delivery systems. The availability of reliable intraoperative ultrasonography that can provide precise positioning of the cryoprobe and allow for the necessary

visualization of the tumor margin and the advancing edge of the evolving iceball as it freezes the tumor has made cryotherapy a viable alternative.<sup>12,13</sup> However, operative, as well as postoperative, hemorrhage associated with the use of larger cryoprobes remains a concern.<sup>14</sup>

In this report, we simultaneously used five 1.5-mm cryoprobes, which are the same size as 17-gauge needles. This approach is based on an iceball geometry in which a 9-mm radius is achieved at 5 minutes and 13 mm at 10 minutes of continuous freezing, with the lethal  $-20^{\circ}\text{C}$  isotherm located at a radius of 7 mm and 10 mm, respectively. The 1.5-mm probe creates an iceball with a length of 27 mm that begins 5 mm distal to the tip of the probe. The leading edge of the iceball that is seen on ultrasonography, which achieves a freezing temperature of only  $0^{\circ}\text{C}$ , is only 2 to 3 mm beyond the  $-20^{\circ}\text{C}$  zone, allowing a comfortable margin of error if one freezes 5 to 10 mm beyond the tumor margin on ultrasonography. The placement of each probe and the necessity of performing a “pull back” maneuver are estimated on the basis of these characteristics, and spacing the probes at 10-mm intervals generates one large iceball created by the confluence of each individual, overlapping iceball. Although no case of tumor spillage and subsequent dissemination has been reported after tumor puncture by a cryoprobe, it is unclear whether the use of multiple, small probes would increase or decrease the risk of this occurring.

Currently, investigators are exploring several approaches, including the use of cryotherapy during open surgery and laparoscopic surgery and as a percutaneous technique.<sup>11</sup> Delworth *et al.*<sup>7</sup> investigated the feasibility of open renal cryotherapy on 2 patients with tumors involving solitary kidneys. Both patients tolerated renal cryotherapy well, with no change in renal function, but with a blood loss of 200 and 700 mL, respectively. Rodriguez *et al.*<sup>8</sup> reported on three laparoscopic cryosurgeries, as well as on an additional 4 patients treated by way of an open approach, using 3-mm cryoprobes. The average blood loss was 111 mL, and hemostasis was obtained by packing the probe sites with microfibrillar collagen, manual pressure, and the argon beam coagulator when necessary. Rukstalis *et al.*<sup>9</sup> expanded the open cryosurgical experience with a report on an additional 29 patients treated with 3 or 8-mm cryoprobes. Only 1 patient in that series experienced a biopsy-proven recurrence, and 93% of patients demonstrated a complete radiographic response. The median blood loss was 200 mL (range 50 to 3000), and 5 patients experienced renal capsular fractures, one of whom required transfusion after the use of multiple probes. After cryoprobe removal, thrombin-soaked Gelfoam was used to occlude the probe tract.

Gill and Novick<sup>10</sup> recently reviewed the worldwide experience of laparoscopic renal cryotherapy comprising approximately 50 cases, of which 32 were performed at the Cleveland Clinic using 4.8-mm cryoprobes. The initial review of their first 10 cases, which were performed on patients with an average tumor size of 2.3 cm, showed minimal blood loss and a mean cryoablative time of less than 13 minutes.<sup>15</sup> Hemostatic pressure on the probe sites was maintained using Surgicel for 15 minutes, followed by lowering the intra-abdominal pressure by partially evacuating the pneumoperitoneum and visual inspection for an additional 5 minutes. More recently, the use of the argon beam coagulator in the laparoscopic setting has also been described by that group.<sup>14</sup> Of 22 patients undergoing biopsy 6 months after laparoscopic renal cryosurgery, persistent renal cell carcinoma was detected in only 1 patient.<sup>16</sup>

Since the first description of percutaneous renal cryotherapy performed in 2 patients with symptomatic metastatic RCC by Uchida *et al.*,<sup>17</sup> an additional series of 20 patients was reported using single 2 to 3-mm cryoprobes requiring access sheaths under magnetic resonance imaging guidance.<sup>11</sup> Depending on the size of the tumor, a variable number of consecutively performed probe repositions and freeze cycles was required. After cryotherapy, the access sheath was packed with absorbable knitted fabric or gelatin sponge pledgets to facilitate hemostasis. Although no patient experienced significant, symptomatic hemorrhage, 20% of patients developed small perinephric hematomas preventing complete visualization of the cryoablated area on follow-up imaging in the short term and 1 patient had evidence of persistent tumor that required repeated treatment.

## CONCLUSIONS

The feasibility and technique for open cryosurgical ablation of the kidney using ultrathin, 1.5-mm cryoprobes are described. This approach, whether performed open or laparoscopically, permits histologic examination of the peritumoral fat, facilitates intraoperative ultrasound imaging and exploration of the surrounding kidney and enables the simultaneous use of multiple probes without the necessity for probe repositioning or post-probe-removal hemostatic measures. Renal cryoablation is a minimally invasive alternative for the treatment of small renal tumors that is currently under clinical investigation at a number of centers. Currently, only four large series have been presented to date involving fewer than 100 patients. The long-term

efficacy of this approach must still be assessed, and it is unclear as of yet whether early reports of local recurrence reflect inadequate oncologic control or the learning curve inherent in a new surgical approach. This modality should be considered as an investigational but promising form of tumor ablation for select patients.

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A video clip of this procedure can be viewed on the Internet at: <http://www.elsevier.com/locate/urologyonline>.