

ENHANCED RENAL PARENCHYMAL CRYOABLATION WITH NOVEL 17-GAUGE CRYOPROBES

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ABSTRACT

Objectives. To evaluate novel, 17-gauge cryoprobes with a modified heat exchange mechanism to evaluate the area of ablation that could be achieved with 17-gauge (1.47-mm) cryoprobes.

Methods. Eleven pigs were divided into four groups. Each animal underwent laparoscopic creation of three cryolesions with an elliptical iceball-generating 17-gauge cryoprobe (group 1), one that generates a teardrop-shaped iceball (group 2), a template of three standard 17-gauge cryoprobes (group 3), or a single, standard, large-caliber (3.4-mm) cryoprobe (group 4). Each cryolesion was created with a standard double-freeze cycle. Intraoperative ultrasonography was used to measure the maximal iceball dimensions, and the renal temperatures were measured with a thermocouple. The animals were killed after 14 days. The gross lesion size and histopathologic area of necrosis were documented.

Results. The mean temperature for the surrounding renal parenchyma was not significantly different among the groups. No statistically significant difference was noted in the size of the gross or histopathologic lesions created among the four groups. The gross lesion size correlated statistically significantly with the histologic area of necrosis ($P < 0.01$).

Conclusions. Despite the diminutive size of the 17-gauge cryoprobes tested, the probes ablated tissue volumes equivalent to that ablated using the larger, standard 3.4-mm cryoprobe or a configuration of three standard 17-gauge cryoprobes. These novel 17-gauge cryoprobes may facilitate ablation of small and medium-size renal tumors and may have expanded application for percutaneous ablation owing to the decreased risk of hemorrhage. *UROLOGY* 64: 173–175, 2004. © 2004 Elsevier Inc.

The growing and widespread application of ultrasonography and computed tomography has resulted in the increased recognition of small renal tumors. Once considered only for patients with renal insufficiency or other comorbidities, nephron-sparing surgery is quickly becoming the standard of care for small renal tumors. Renal tumors less than 3 cm in diameter are potential candidates for renal cryoablation. Renal cryoablation is especially useful for those patients with comorbidities who may not tolerate the longer operative times or increased blood loss associated with

laparoscopic partial nephrectomy. Cryoablation is also an important modality for patients with familial renal tumor patterns such as von Hippel–Lindau syndrome or tuberous sclerosis, who are at greater risk of developing multiple renal tumors during their lifetime.

Cryotherapy for renal masses may be performed through an open incision, laparoscopically, or percutaneously with real-time ultrasound, computed tomography, or magnetic resonance imaging (MRI) guidance. Renal cryoablation technology currently relies on the application of a relatively large (3 to 5-mm) cryoprobe for “one stick” ablation or the application of multiple 17-gauge (1.47-mm) cryoprobes in a template configuration. Larger cryoprobes may increase the risk of hemorrhage, and multiple small diameter cryoprobes are occasionally difficult to target properly, especially when using a minimally invasive approach.

We evaluated novel, small-caliber cryoablation probes (Oncura, Plymouth Meeting, Pa) with a

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TABLE I. Local temperature measured by thermocouple probe and lesion kill zone size

	n	Lesion Size (cm)		
		Mean Temperature (°C)	Gross	Microscopic
Group 1 (novel 17-gauge elliptical cryoprobe)	7	-41.5	2.3	1.9
Group 2 (novel 17-gauge teardrop cryoprobe)	7	-30.9	2.1	1.9
Group 3 (template of 3 standard 17-gauge cryoprobes)	7	-39.2	3.1	1.6
Group 4 (large-caliber [3.4-mm] cryoprobe)	4	-47.4	2.7	1.8

modified heat exchange mechanism that allow for larger iceballs of different shapes to be formed even with small (1.43-mm) probes.

MATERIAL AND METHODS

Eleven domestic farm pigs were divided into four groups. Each animal underwent laparoscopic creation of three cryolesions, two on one kidney and one on the other kidney. The four groups were divided as follows: group 1, 17-gauge elliptical cryoprobe; group 2, 17-gauge teardrop cryoprobe; group 3, template of three standard 17-gauge cryoprobes; and group 4, control group with a single, large-caliber (3.4-mm) cryoprobe.

Each cryolesion was created in either the upper or lower pole of the kidney with an 8-minute double-freeze cycle, with a target temperature of -150°C . An active thaw was applied between freeze cycles. Intraoperative ultrasonography was used to measure the maximal iceball dimensions, and renal temperatures were measured with a local thermocouple placed 1 cm from the center of the iceball. The pigs were killed after 14 days. The specimens were preserved in 5% formalin and were stained with hematoxylin-eosin. All specimens were examined by an experienced histopathologist (P.A.H.). The gross lesion size and histopathologic area of necrosis were documented. The results were analyzed by nonparametric comparisons and by the Spearman correlation test.

RESULTS

All procedures were successfully accomplished laparoscopically. After cryoablation, excellent hemostasis was achieved with each probe in all groups. At organ harvest, gross examination revealed minimal adhesions within the peritoneal cavity and around the kidney in each animal. No evidence of urinoma was found in any case.

The mean temperature for the surrounding renal parenchyma was not significantly different among the groups ($P = 0.81$; Table I). No statistically significant difference was found in the size of the gross ($P = 0.14$) or histopathologic ($P = 0.91$) lesions created in the four groups. The gross lesion size (at organ harvest) correlated significantly with the histologic area of necrosis ($P < 0.01$). All cryoa-

blation lesions showed a peripheral rim of fibrosis with chronic inflammation, calcification, and foreign body-type giant cells surrounding the central complete coagulative necrosis (Fig. 1).

COMMENT

Open renal cryotherapy was first reported in 1996 by Delworth and colleagues¹ using multiple 3-mm cryoprobes through an open flank incision. Laparoscopic cryotherapy was introduced to the urologic clinical armamentarium by Gill and associates² who, in 1998, published the first clinical experience with laparoscopic cryoablation of 11 solid renal tumors in 10 patients. All tumors were small (average size 2.3 cm), solid, and exophytic. Each cryoablation was performed using a single 4.8-mm probe under ultrasound guidance by way of retroperitoneoscopy. The mean follow-up was 5.5 months. Follow-up MRI on postoperative day 1 showed a nonenhancing lesion in all patients.²

Bishoff and associates³ reported their results with laparoscopic cryotherapy in a porcine model using a 4.8-mm cryoprobe, and, after encouraging histologic results, they applied the technique to a human model. In the initial series of 8 patients, they used a 4.8-mm cryoablation probe for tumors greater than 2 cm and a 3-mm probe for tumors less than 2 cm.

Shingleton and Sewell⁴ have reported percutaneous cryoablation of renal masses under MRI guidance. They reported percutaneous ablation of 14 renal masses in patients with solitary kidneys under MRI guidance using one to four 3-mm cryoprobes.⁴

As cryoablation continues to prove itself within the urologic community as an acceptable option for nephron-sparing surgery for patients with small renal masses, clinicians should continue to search for improvements in techniques to make

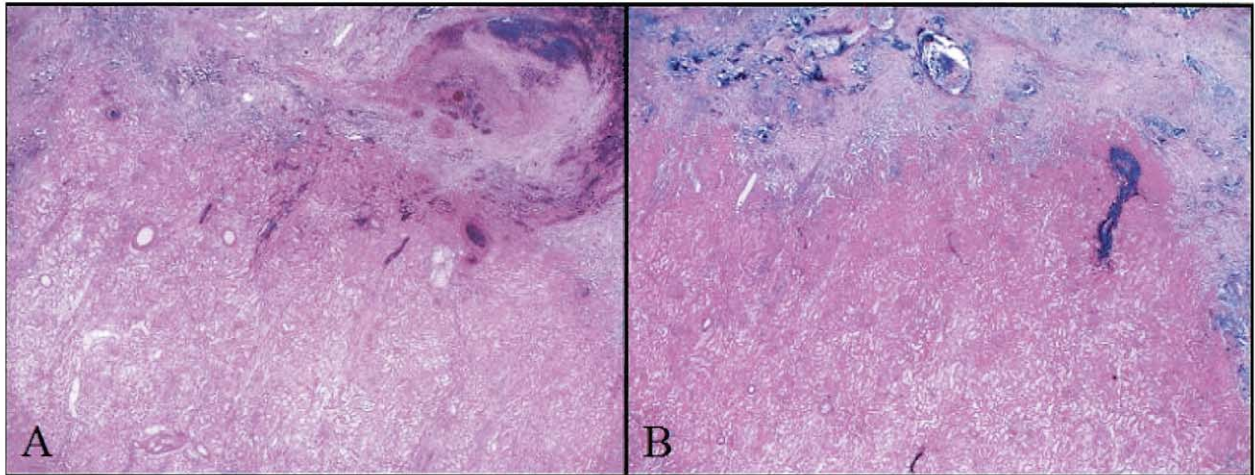


FIGURE 1. All cryoablation lesions showed the same peripheral rim of fibrosis with chronic inflammation, calcification, and foreign body-type giant cells surrounding central complete coagulative necrosis. (A) Novel cryoprobe. (B) Standard probe.

renal cryotherapy a safer and more precise operation. The probes we evaluated allowed for ablation of a larger tissue volume with small caliber tissue penetration. The probes consist of a titanium closed tip, thin-walled needle containing a 0.4-mm heat exchanger and a copper/nickel cryogenic Joule Thompson assembly. According to the Joule Thompson coefficient of argon, the innate property of this gas causes it to cool on expansion. Conversely, helium warms on expansion. The gas travels through a high-pressure system within the cryoablation needle and then causes an acute temperature shift as it exits the probe and expands.

The clinical application of 17-gauge cryoprobes that can ablate a larger volume of tissue will help facilitate improved treatment of renal masses, including complete ablation of the target lesion and a margin of surrounding normal tissue. Clinical application of the novel 17-gauge cryoprobes tested may reduce the risk of bleeding and will facilitate laparoscopic and percutaneous ablation of renal lesions with fewer and smaller probes.

CONCLUSIONS

Despite the diminutive size of the novel 17-gauge cryoprobes tested, the probes ablated normal renal tissue volumes equivalent to that with a standard 3.4-mm cryoprobe or a configuration of three standard 17-gauge cryoprobes. The novel 17-gauge cryoprobes may allow ablation of small and medium-size renal tumors while offering a decreased risk of hemorrhagic complications.

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