Percutaneous cryoablation of renal masses

Poster No.: C-0700
Congress: ECR 2016
Type: Educational Exhibit
Authors: P. Coulson¹, J. Rogers², J. Kao¹; ¹Knoxville/US, ²Knoxville, TN/US
Keywords: Multidisciplinary cancer care, Metastases, Cancer, Education, Ablation procedures, Ultrasound, MR, CT, Kidney, Interventional non-vascular, Abdomen
DOI: 10.1594/ecr2016/C-0700
Learning objectives

- Describe indications for percutaneous cryoablation of renal masses and identify patients who may benefit.

- Discuss advantages of percutaneous cryoablation over radiofrequency ablation and more invasive treatments.

- Discuss common complications and postprocedural imaging findings.
Background

Recently, there has been a significant increase in the number of incidentally discovered renal masses identified during cross-sectional imaging [1]. Renal cancer now represents approximately 3-5% of malignancies in the United States, with an estimated 61,560 new cases occurring in 2015 [2]. Historically, treatment of renal tumors has consisted of total or partial nephrectomy. In poor surgical candidates or patients with decreased functional renal capacity, less invasive "nephron-sparing" treatments are desired.

Two increasingly prevalent treatment options are cryoablation (CA) and radiofrequency ablation (RFA). While CA and RFA have been performed using open and laparoscopic techniques, recent advances have allowed for ablation using a percutaneous approach. Percutaneous cryoablation (PCA) has been shown to offer several advantages over RFA and nephrectomy, providing an effective, nephron-sparing treatment for renal masses while reducing morbidity, post-procedure pain, and length of hospital stay [3-4].
Findings and procedure details

Indications and patient selection

The current gold standard for treatment of malignant renal tumors is surgical excision. At most institutions, patients who have no contraindications and are able to undergo nephrectomy are generally treated surgically. However in many cases this treatment is undesirable or contraindicated. Patients with many medical comorbidities may be unable to tolerate an invasive surgical procedure, and nephrectomy is undesirable in those who have a high likelihood of developing many tumors over their lifetime (such as those with von Hippel-Lindau syndrome) and would therefore require additional surgeries. Additionally, in patients with decreased renal functional capacity due to medical renal disease or prior nephrectomy, effective, nephron-sparing treatment is desirable in order to preserve renal function. In these situations, PCA may be offered as an alternative to traditional surgical treatment [3].

It is also important to consider tumor characteristics when selecting candidates for PCA. Candidates should have imaging performed to evaluate lesion size, location, and morphology. Favorable characteristics include posterior and inferior location, smaller size (<4cm), and exophytic morphology. Posterior and inferior location allows for easier isolation of the tumor with less risk of damaging adjacent critical structures, such as liver, bowel, diaphragm, and lung. Exophytic tumors have shown better long-term treatment response than centrally located lesions. Larger tumors, while exhibiting good initial treatment response, have been shown to have an increased post-procedural complication rate, most often hemorrhage [5]. Additionally, pre-procedural imaging should be used to evaluate for local tumor invasion, hilar and/or renal vein involvement, and metastasis, which may complicate or contraindicate treatment with PCA [3].

Candidates for PCA should have, at a minimum, relative contraindication to nephrectomy and tumor characteristics that predict a favorable response to therapy. Some authors also recommend first obtaining a biopsy-proven diagnosis of malignancy before proceeding with PCA. This remains somewhat controversial, however, due to the relatively large number of indeterminate or false negative biopsy results [6]. At our institution, a biopsy-proven diagnosis is not required before proceeding with PCA, but biopsy is typically obtained during the procedure. Patient and tumor characteristics that should prompt evaluation for potential therapy with PCA are summarized in Fig. 1 on page 7. When considering renal PCA, these factors should be considered and included in a discussion of risks and benefits among the patient, radiologist, and urologist.

Percutaneous cryoablation technique
Cryoablation takes advantage of the cytotoxic effects of rapid tissue cooling and thawing to cause cell death. The formation of intra- and extracellular ice crystals is directly cytotoxic, causing cellular rupture and dehydration. Upon thawing, microvascular stasis leads to endothelial damage, thrombosis and ischemic tissue injury [7].

Due to the minimally invasive nature of the percutaneous approach, the procedure can usually be performed under local anesthesia with conscious sedation. The patient is typically placed in the prone position to allow posterior approach, and after routine skin preparation one or more cryoprobes are placed into the target tissue under CT guidance. A liquid gas, typically argon, is used to rapidly cool the probe tip to temperatures as low as -190°C, forming an ice ball around the probe and causing target tissue ablation by the mechanisms described above.

Cell death is time and temperature dependent, with the threshold for cell death estimated at -20°C. Different cryoprobes produce a variety of ice ball sizes and shapes, and depending on the size and shape of the mass multiple probes may be required to achieve cytotoxic temperatures throughout the lesion (Fig. 2 on page 7 Fig. 3 on page 7 Fig. 4 on page 8). To ensure adequate ablation of malignant tissue, it is recommended that the ice ball extend beyond the mass by a margin of at least 6 mm [8]. This can be easily monitored with intermittent CT imaging, which allows for direct visualization of the ice ball due to the decreased attenuation of frozen tissue (Fig. 5 on page 9). Studies have shown that performing multiple freeze-thaw cycles increases efficacy, and generally at least two cycles are performed [7]. Typically first and second last between 8-15 minutes and 5-20 minutes, respectively, with a passive or active thaw of 5-8 minutes [3].

Achieving adequate ablation margins can be problematic if the target lesion is in close proximity to adjacent critical structures. For example, studies have shown that superior pole lesion location is a significant predictor of procedural complications due to lesion proximity to the diaphragm and bowel [5]. In order to avoid injury saline, carbon dioxide/air, or balloons can be used to displace critical structures (Fig. 6 on page 10).

Another notable nephron-sparing treatment for renal masses is RFA. In contrast to PCA, RFA utilizes high-frequency electrical currents to generate heat within an electrode, causing direct thermal injury to target cells. While RFA can also be performed using a minimally invasive approach, PCA has been shown to offer several advantages. Direct visualization of ablation margins and ability to use multiple cryoprobes allows PCA for real-time determination of treatment adequacy. PCA has been shown to have more favorable outcomes than RFA, requiring fewer retreatments and less risk of local and metastatic disease progression [9]. PCA is also less painful than RFA, with patients undergoing PCA requiring significantly less post-procedure analgesia [10].
Follow up and potential complications

Imaging follow up after renal PCA consists of contrast-enhanced CT or MRI at increasing intervals. Initial imaging is performed at one day to one week after the procedure to document treatment success, assess for immediate complications, and establish a baseline for future imaging. Further imaging is performed at increasing intervals of months to years to monitor for disease recurrence, metastasis, and late complications.

Immediately following the procedure, normal CT findings include a hypodense ablation zone, which will be larger than the tumor due to the intended marginal ablation of normal tissue. In the acute phase, soft tissue stranding and peripheral enhancement surrounding the ablation zone is not unexpected. As the ablated tissue involutes size of the ablation zone and any enhancement should decrease over time (Fig. 7 on page 10 Fig. 8 on page 11). Increasing ablation zone size or enhancement on subsequent imaging should raise concern for disease recurrence or inadequate treatment (Fig. 9 on page 12 Fig. 10 on page 13) [11].

At some centers, MRI is the preferred postprocedural imaging modality. The ablation zone has a variable appearance on T1- and T2-weighted images, however it usually appears T1-isointense and T2-hypointense compared to normal renal parenchyma [3]. Typical postprocedural MRI appearance is shown in Fig. 11 on page 14. As with CT, subsequent MR imaging should be compared with preprocedural and acute phase images to assess for residual enhancement or lack of ablation zone involution to suggest recurrence.

Although complications of PCA are rare (1.8% and 9.2% for major and minor complications, respectively), several been described. Major complications include significant hemorrhage, ureteral stricture, urine leak, pneumothorax, and bowel injury. These complications are readily identified on routine follow up imaging. As discussed previously, many of these complications can be avoided by carefully selecting candidates, avoiding unfavorably located lesions, and utilizing various dissection techniques to separate ablation targets from adjacent critical structures. Minor complications are more common and include wound infection, minor hemorrhage, decreased renal function, and postprocedural pain [7].
Images for this section:

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Tumor Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Poor surgical candidate</td>
<td>• Smaller size (&lt;4cm)</td>
</tr>
<tr>
<td>• Limited renal function</td>
<td>• Exophytic morphology</td>
</tr>
<tr>
<td>• Likely to develop additional tumors</td>
<td>• Posterior, inferior location</td>
</tr>
<tr>
<td>• Biopsy-proven malignancy</td>
<td>• No nearby critical structures</td>
</tr>
</tbody>
</table>

Figure 1 – Patient and tumor characteristics which should prompt evaluation for treatment with PCA.

Fig. 1
© - Knoxville/US

![IceSeed™, IceRod™, IceBulb™](image)

Figure 2 – Examples of cryoprobes producing different ice ball shapes and sizes

Fig. 2
© - Knoxville/US
Figure 3 – Typical posterior approach for cryoablation. Preprocedure (A), cryoprobe placement (B), ice ball formation (C), and immediate postprocedure (D) images shown.

**Fig. 3**

© - Knoxville/US
Figure 4 – Utilizing multiple cryoprobes to achieve adequate ablation

Fig. 4

© - Knoxville/US

Figure 5 – CT images demonstrating tumor (arrow) before (A) and during (B) ablation with hypodense ice ball formation (arrowhead). Note the extension of the ice ball beyond the tumor margin.
Figure 6 – Displacing critical structures during PCA. A) Utilizing saline hydrodissection to displace the colon from the ablation zone. The hydrodissection catheter (arrowhead) and cryoprobe (arrow) are shown. B) Instillation of air to isolate the ablation zone.
Figure 7 – Typical postablation appearance. Right renal tumor shown immediately after ablation (A) and at 6 week (B), 1 year (C), and 18 month (D) Follow up. Note the ablated tissue decreases in size at each follow up, indicating adequate treatment.
Figure 8 – Post ablation follow up in a patient with polycystic kidney disease. Right renal tumor (arrows) immediately after ablation (A) and at 4 months (B), 1 year (C), and 16 months (D).

Fig. 8

© - Knoxville/US
Figure 9 – Left renal tumor shown during ablation (A). 5 Month follow up image (B) demonstrates nodular enhancement (arrow), concerning for disease recurrence. Repeat ablation was performed 1 year after the initial treatment (C). Imaging performed 1 month after repeat ablation (D) demonstrates no enhancement at the ablation site (arrow).

**Fig. 9**

© - Knoxville/US
Figure 10 – An additional example of tumor recurrence. Despite normal immediate postprocedural appearance (A), left renal tumor (arrows) demonstrates nodular enhancement on 18 month follow up (B)

Fig. 10

© - Knoxville/US
Figure 11 – T1-weighted image (A) demonstrates a T1 hypointense, heterogeneously enhancing left renal mass, concerning for renal cell carcinoma (arrows). PCA was performed (B). Biopsy performed during the procedure confirmed the diagnosis. 8 month follow up images show typical T1-isointense (C) and T2-hypointense (D) appearance of the ablation site.

Fig. 11

© - Knoxville/US
Conclusion

Percutaneous cryoablation has been shown to be an effective, nephron-sparing treatment for renal cancer. While maintaining treatment outcomes comparable to surgical excision, it offers the advantages of minimal invasiveness, rapid recovery, and low complication rate. In carefully selected patients, percutaneous cryoablation should be considered as an alternative to nephrectomy and other ablation techniques.
References


9. Kunkle DA, Uzzo RG. Cryoablation or Radiofrequency Ablation of the Small Renal Mass. Cancer 2008; 113

11. Atwell TD et al. Percutaneous Ablation of Renal Masses Measuring 3.0 cm and Smaller: Comparative Local Control and Complications After Radiofrequency Ablation and Cryoablation. AJR 2013; 200:461-466