Role of Combined Embolization and Ablation in Management of Renal Masses

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Abstract

Keywords

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Combination of minimally invasive treatment modalities is being increasingly utilized to improve local tumor control and overall survival. In the liver, the combination of embolization and ablation results in equivalent overall survival and intrahepatic disease progression as surgical resection for lesions smaller than 7 cm. Ablation alone for small renal masses up to 4 cm results in excellent local tumor control and lack of residual enhancement to suggest viable tumor. A small number of studies have been performed combining embolization and ablation, which result in high rates of local tumor control for tumors smaller than 5 cm. Based on this small cohort, combined embolization and ablation may be most indicated for central or mixed tumors where ablation alone suffers from the greatest degree of “heat sink” effect. This article reviews the theory, methods, and outcomes of combining percutaneous ablative and embolic modalities in the treatment of renal masses.

Objectives: Upon completion of this article, the reader will be able to discuss patient selection and the role of combined embolization and ablation therapy in the treatment of renal cell carcinoma.

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Minimally invasive therapies including percutaneous thermal ablation and intra-arterial embolization have become emerging therapeutic options for patients with small renal masses who are poor surgical candidates.^{1–3} Thermal ablation has been shown to

be most effective in terms of local tumor control for lesions smaller than 4 cm.^{4,5} In the liver, there is evidence that a combination of embolization and ablation results in equivalent overall survival and intrahepatic disease progression as surgical resection for lesions smaller than 7 cm.⁶ Embolization has historically been performed in the kidney for palliation of flank pain and hematuria associated with renal cell carcinoma (RCC), or for reduction of intraoperative blood loss.^{7–10} Advances in catheter technology has allowed for more selective embolization and sparing nephrons, increasing its utility. Combining embolization with ablation theoretically potentiates the effect of ablation because of the elimination of heat sink effects.

Theory

Percutaneous ablation of renal masses performs well for local control when used to treat exophytic, small lesions (< 4 cm).^{3,4,11} Radiofrequency ablation (RFA) and cryoablation are the most studied modalities, with cryoablation offering minimal survival benefit over radiofrequency ablation.¹² RFA tends to fail when treating centrally located

tumors due to the added “heat sink” effect. Cryoablation has improved local tumor control compared with RFA with a local recurrence rate of 5 and 12%, respectively.¹² Thus, ablation is recommended for small renal masses by the American Urological Association in patients with major comorbidities, and is a viable option for healthy patients with a small renal mass.¹³

Embolization of the renal artery for small renal masses has not been performed with great frequency in the literature. At some centers, preoperative embolization is used to reduce operative blood loss, ease dissection, and decrease operative time. Improvement in catheters, wires, and embolic materials has led to improved efficacy and limited nontarget embolization to normal renal parenchyma. Embolization has also been thought to instigate an immune response, which may improve tumor control and patient survival rates.^{9,14,15} Embolization of the renal arteries can be performed with several different materials including spherical embolic particles, polyvinyl alcohol, Lipiodol (Guerbet LLC, Bloomington, IN), and ethanol. A combination of ablation and embolization for the treatment of small renal masses is theorized to improve local tumor control and patient survival over either modality alone.

Proposed Technique

There are various methods of combination therapy proposed, and it remains uncertain which combination results in optimal

therapy. Several decisions need to be made regarding the type of ablation, type of embolic material, and sequential order of procedures before embarking on combination therapy. The majority of cases in the published literature on combination embolization and ablation used radiofrequency ablation rather than cryoablation. The embolic material was different for each study and included 40 μ m spherical embolic particles; 250 μ m spherical embolic particles; Gelfoam (Pharmacia and Upjohn Company, Kalamazoo, MI); and a mixture of polyvinyl alcohol, Lipiodol (Guerbet LLC), and ethanol. One study evaluated the order of embolization and ablation in a porcine model of liver cancer showed that embolization with 40 μ m particles before RFA was more effective than ablation before embolization with 40 μ m and 250 μ m spherical embolic particles.¹⁶ Adjacent blood flow is the major limiting factor of radiofrequency ablation, due to tissue cooling and decreased coagulative necrosis.^{17,18} Therefore, it is logical to decrease blood flow to the tumor by embolization before ablation. Preablation embolization also has the added benefit of protection against a major complication of renal ablation, renal hemorrhage. Finally, static embolic material within the tumor also serves as a marker at the time of ablation.

Outcomes

All studies published thus far examined local tumor control after embolization-ablation of renal masses and demonstrated

Figure 1 Left renal artery embolization and cryoablation. (A) Selective left renal arteriogram in preparation for embolization of the enhancing tumor. (B) Planning computed tomography for ablation procedure, demonstrating an exophytic mass (arrow). (C) Lidocaine needles in the subcutaneous tissues following hydrodissection to separate the colon (black arrow) from the mass (white arrow). (D) Image during the ablation demonstrating hypoattenuation surrounding the probes adequately covering the lesion representing the ice ball (arrows).

Figure 2 Pre- and postprocedure magnetic resonance imaging (MRI). (A) Arterial phase MRI demonstrating an enhancing exophytic mass (arrow) projecting anterolaterally from the left kidney. (B) Postembolization/ablation image demonstrating lack of enhancement of the tumor (arrow).

a 97 to 100% success rate of eradication of enhancing tumor (►Figs. 1 and 2).^{19–21} The largest cohort evaluated 36 stage 1 RCCs with a mean tumor size of 3.1 ± 1.2 cm. Embolization was performed with a combination of ethanol, iodized oil, and polyvinyl alcohol, which was followed by ablation 6 days later using a Cool-tip RF probe (Cool-tip Radiofrequency Ablation System, Integra Radionics, Inc., Burlington, MA).¹⁹ In this study, there was one patient who had tumor recurrence that was controlled with repeat RFA; at 24.3 months, there was local control in 97% of patients. In a study of 12 RCCs treated with embolization using gelatin sponge and iodized oil followed by ablation using a monopolar RF generator (RF3000; Boston Scientific Corporation, San Jose, CA), no local tumor recurrence was identified at 47 ± 3.8 months.²⁰ Yamakado et al studied 12 RCC patients treated with embolization using either ethanol and iodized oil mixture or polyvinyl alcohol 250 μ m particles followed by ablation using Cool-tip RF probe (Integra Radionics, Inc.). These authors demonstrated 100% eradication of enhancing tumor at 1 week following ablation.²¹ Although these results are promising, the studies by Arima et al and Nakasone et al were performed on lesions with a mean tumor diameter less than 4 cm, which has similar outcomes following ablation alone.¹¹ In addition to tumor size, tumor location as defined by Gervais et al⁴ plays a large role in the expected

outcome following ablation. These cohorts suggest an improved outcome for central and mixed tumors following combined embolization and ablation compared with ablation alone (►Table 1).^{19–21}

Complications

There were no technique-specific major complications reported in any of the studies of embolization and ablation. Back pain/flank pain were expected findings and found in 50 to 100% of patients.^{19,20} A subcapsular hematoma developed in 6% of patients (2/31) in the study by Arima et al and in 9% of patients (1/11) in the study by Yamakado et al. Neither case was associated with a significant decrease in hemoglobin or the need for further intervention. Pyonephrosis and an abscess developed in 3% of patients (1/31) in one study, which resolved following percutaneous drainage and antibiotic administration.¹⁹ A postoperative fluid collection was seen in 8.3% of patients (1/12) in another study, which resolved with only antibiotics.²⁰ These data compare favorably to the review reported by Uzzo and Novick following nephron-sparing surgical procedures, which showed a major complication rate ranging from 4 to 30%.²²

Table 1 Cohort studies evaluating combination therapy for renal cell carcinoma

	Arima et al	Nakasone et al	Yamakado et al
Number of RCC treated	36	12	12
Mean tumor diameter	3.1 ± 1.2 cm	3.1 ± 0.4 cm	5.2 ± 1.7 cm
Number of exophytic masses	14	6	2
Number of central masses	3	2	1
Number of mixed masses	19	4	9
Embolic material	Ethanol, iodized oil, PVA	Gelatin sponge + iodized oil	Ethanol + iodized oil/PVA
Ablation	RFA	RFA	RFA
Local tumor control	97%	100%	100%
Time interval	24.3 mo	47 ± 3.8 mo	1 wk

Abbreviations: mo, months; PVA, polyvinyl acetate; RCC, renal cell carcinoma; RFA, radiofrequency ablation; wk, week.

Combination embolization and ablation confers similar complication rates to those reported for ablation alone without adding increased morbidity related to the embolization procedure. No embolization-related complications were reported in these small studies; however, the embolization procedure adds the typical risk of complications related to percutaneous arterial puncture, angiography, and embolization.

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