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Safety and Efficacy of CT-Guided Percutaneous Cryoablation of Large Angiomyolipomas: Case Series and Review of Literature

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Abstract

To evaluate the safety and clinical outcomes of percutaneous cryoablation of large renal angiomyolipomas (AMLs), three patients with large predominantly fat-containing AMLs measuring over 4 cm were treated with cryoablation. Two patients underwent cryoablation alone and one patient underwent selective arterial embolization followed by cryoablation. All patients were followed up with cross-sectional imaging. All procedures were performed safely and successfully. The first two patients had no side effects or complications. The third patient developed tachycardia following the procedure that required additional cardiac monitoring and resolved without difficulty. The follow-up imaging demonstrated reduction in size of the AMLs in all three patients. CT-guided percutaneous cryoablation is a minimally invasive, viable, and safe treatment option for large AMLs without a significant vascular component while improving the patient's clinical outcomes.

Keywords
- angiomyolipoma
- AML
- percutaneous cryoablation

Introduction

Renal angiomyolipoma (AML) is a type of benign mesenchymal tumor composed of adipose tissue, smooth muscle, and blood vessels.[1] It is rare and makes up only 1 to 2% of all kidney tumors with an incidence rate of 0.3 to 3%.[2] Approximately 80% of AMLs are isolated from sporadic origins, with the remaining 20% being associated with tuberous sclerosis syndrome.[3] The majority of AMLs are incidental findings during workup of unrelated symptoms, and the increased use of cross-sectional imaging has led to a growing amount of diagnosis of these lesions.[4] Traditionally, AMLs are diagnosed by detecting the negatively attenuating intratumor macroscopic fat component on nonenhanced computed tomography (CT) or magnetic resonance imaging (MRI), or the sonographic appearance

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of a hyperechoic signal and acoustic shadowing on ultrasound.[2,5]

The clinical presentation of renal AML is generally asymptomatic; however, 40% of patients present with a classic triad of symptoms including abdominal pain, palpable mass, and hematuria.[6] Renal AMLs are known to enlarge slowly over time and the risk of spontaneous bleeding is proportional to the tumor's size, increasing significantly when size exceeds 4 cm with a risk of 51%.[2,7] Interventions are recommended in AMLs over 4 cm, in fast growing lesions (>2.5 mm a year), with the occurrence of intratumoral aneurysms and female patients in child-bearing age as the lesions tend to grow faster during pregnancies. Currently, there are several options for management of AMLs, all focused to be nephron sparing[1]: active surveillance[2]; partial nephrectomy[3]; selective arterial embolization (SAE)[4]; and thermal ablative techniques, including cryoablation.

Cryoablation, defined as therapeutic tissue destruction through freezing, induces cell membrane rupture, cellular dehydration, and local tissue ischemia, leading to complete tissue destruction when temperatures range between –20 and –50°C.[8,9] Percutaneous cryoablation has been used to treat various tumor types at locations such as the liver, bone, soft tissue, and renal parenchyma.[9,10] In percutaneous cryoablation, probes are targeting the tissue using CT guidance, with a typical sequence involving a freeze cycle followed by a passive thaw cycle to maximize cell death.[8,9] The limited published data on using cryoablation for AML tumors, with only a few reported cases worldwide, suggest that the procedure can be conducted with complete safety and efficacy.[11] This case series presents three cases of large renal AML over 4 cm that were treated with percutaneous cryoablation under CT guidance.

Case 1

A 75-year-old man presented with a symptomatic left renal AML with significant flank pain, with MRI revealing a lesion measuring approximately 6.5 × 4.1 cm (►**Fig. 1A** and ►**Fig 1B**). The patients' medical history included hypertension and obstructive sleep apnea. The preoperative laboratories were all within normal limits. On imaging, the AML contained predominantly fat and lacked blood vessels' supply. Therefore, the choice was made to not treat the AML via transarterial embolization to devascularize the tumor, but to directly ablate the tumor.

The patient underwent percutaneous cryoablation under CT guidance. The patient received general endotracheal and local anesthesia. Under CT guidance, two 17-gauge IceRod needles were placed in parallel within the midportion of the mass, relative to craniocaudal dimensions (►**Fig. 1D**). Next, a 14-gauge IceForce needle was placed at the inferior aspect of the mass (►**Fig. 1E**). Finally, an additional 14-gauge IceForce needle was placed at the superior aspect of the mass (►**Fig. 1C**). The cryoablation procedure involved two freezing cycles, each lasting 10 minutes, with intermittent thawing cycles in between. CT scans were performed to confirm needle positioning and to monitor the ablation process. A final postprocedural CT scan was performed, which demonstrated an adequate ablation zone without any immediate complications. The patient was monitored overnight in the short stay unit of the hospital and discharged home the next day. The patient denied having any side effects after the procedure.

The subsequent postprocedural MRI after 1 month demonstrated no significant change in the size of left renal AML, with a new hypointense T2 rim and mild decreased internal vascularity, compatible with favorable treatment response to ablation. The patient received another MRI at 8 months postprocedure, which revealed an AML measuring 5.0 × 3.7 cm in the superior pole of the left kidney, decreased from previous 6.5 × 4.1 cm, without any new enhancing components (►**Fig. 1F**).

Case 2

A 63-year-old man, with past medical history of hypertension secondary to chronic kidney disease, was diagnosed with multiple fat-containing lesions in the right kidney. The largest lesion arose from the anterior cortex inferior pole and nearly completely encased the kidney tissue; it measured approximately 11.1 × 7.5 cm (►**Fig. 2A**). The patient did experience symptoms of flank pain before cryoablation.

The patient received general endotracheal anesthesia. By utilizing Epione robotic-assisted CT guidance (Quantum Surgical), seven 13-gauge 15-cm V-Probe cryoablation needles were advanced and positioned within the inferior aspect of the large right renal AML (►**Fig. 2B**, ►**Fig. 2C**). The cryoablation procedure involved three alternating freeze–thaw cycles, with intermittent CT scans at various intervals, and concluded with a final postprocedural C,. which showed technical success without complications. The patient tolerated the procedure well. He was kept in the postoperative unit overnight for observation and pain control, and denied having any side effects following the procedure. The patient was discharged home the next day. The patient received a follow-up contrast-enhanced CT scan 1 month after the procedure, which demonstrated a right-sided AML measuring 10.6 × 7.5 cm with expected post-treatment inflammatory changes (►**Fig. 2D**). Further follow-up imaging is pending.

Case 3

A 76-year-old man presented with a persistent right renal AML lesion, despite prior cryotherapy and partial right nephrectomy of the right kidney mass at an outside hospital. The patient's history included end-stage renal failure on hemodialysis. CT imaging demonstrated a solid, enhancing exophytic mass arising from the anterior cortex of the right kidney measuring 8.8 × 9.8 cm, with central area of nonenhancement (►**Fig. 3A**). Due to the contrast-enhancing feature of this mass, a renal arteriogram and particle embolization of the subselective right renal arterial branches was planned for prior to the cryoablation to

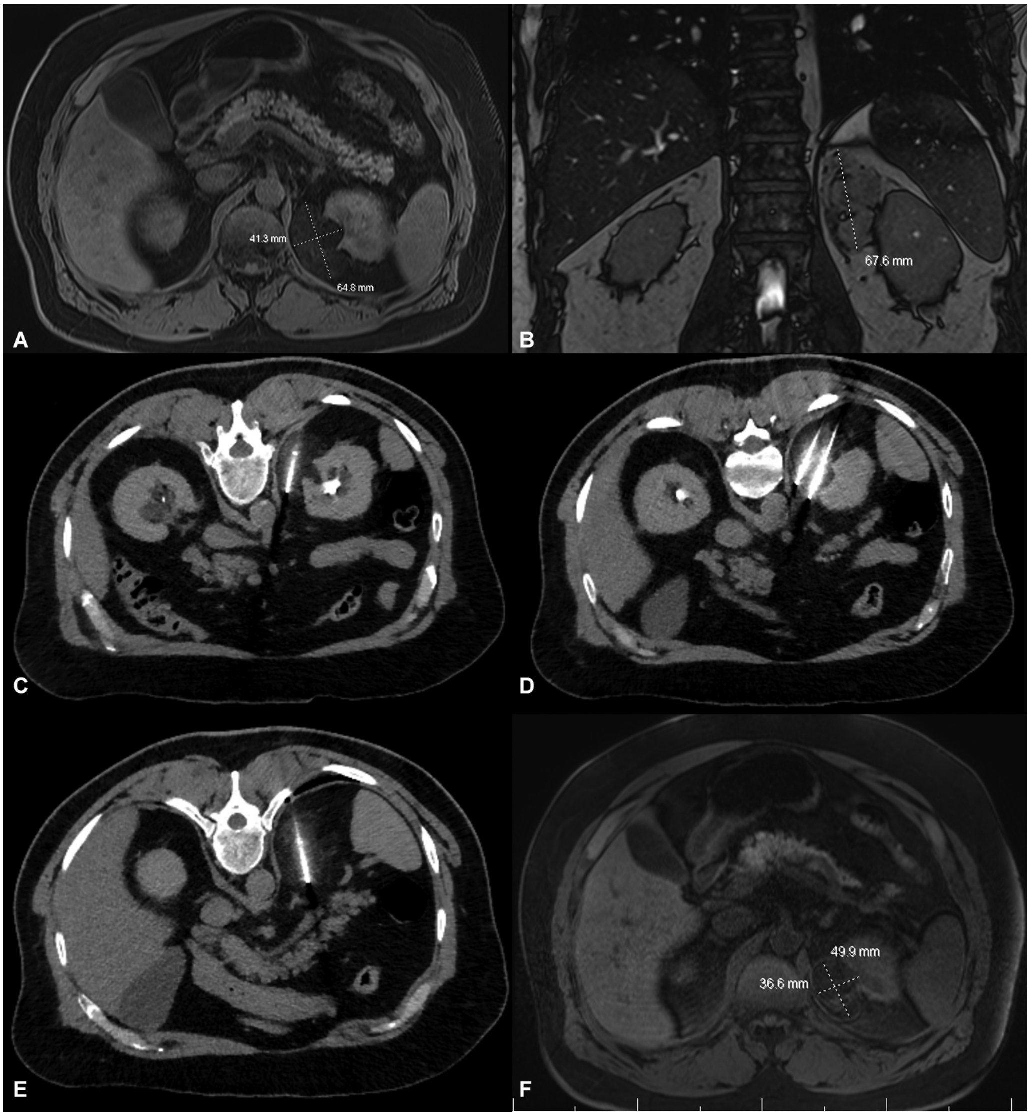

Fig. 1 (**A, B**) Initial magnetic resonance imaging (MRI) revealing a left renal angiomyolipoma (AML) measuring approximately 6.5 × 4.1 cm. (**C**) One 14-gauge IceForce needle placed at the superior aspect of the mass out of the craniocaudal dimensions. (**D**) Two 17-gauge IceRod needles in parallel within the midportion of the mass, relative to craniocaudal dimensions. (**E**) One 14-gauge IceForce needle at the inferior aspect of the mass, again relative to craniocaudal dimensions. (**F**) Follow-up MRI at 8 months demonstrates a left-sided AML measuring 5.0 × 3.7 cm.

reduce the risk of hemorrhage. The diagnostic selective arteriogram of the right renal artery demonstrated opacification of the right renal parenchyma with hypervascularity of the right renal lesion (►**Fig. 3B**). His postembolization diagnostic arteriogram of the right main renal artery demonstrated absence of enhancement of the right renal mass, which indicated successful embolization of the subselective renal arterial branches arising from the right main renal artery (►**Fig. 3C**). The patient tolerated the procedure well and was kept in the hospital for cryoablation the next day.

The following day, cryoablation of the AML mass was performed. He received general endotracheal anesthesia. Under CT guidance, six 2.4-mm right angle V-Probe cryoablation needles and two 1.7-mm PCS-17 cryoprobes were advanced and positioned within the large AML (►**Fig. 3D, E**). The cryoablation procedure involved three 10-minute freeze cycles, interspersed with CT scans and 8-minute thaw cycles. Due to the close proximity of the renal mass with adjacent colon, the most lateral probes were not activated during the second treatment session. The patient tolerated the procedure well and no adverse events occurred periprocedurally. Final CT scan demonstrated an adequate ablation zone, which partially encapsulated the right renal mass. The patient was kept in the cardiovascular care unit for overnight observation and recovery. The patient was feeling well on postoperative day 1 and denied any symptoms. He received scheduled hemodialysis on the same day. During the hemodialysis session, however, the patient developed tachycardia and atrial fibrillation with rapid ventricular response. The patient was eventually stabilized after cardiologic optimization and recovered from the episode without any difficulty. The patient was discharged on the fifth day after the cryoablation procedure. His length of stay at the hospital was due to the procedure exacerbating an underlying cardiac issue. Five months after the procedure, the patient received a

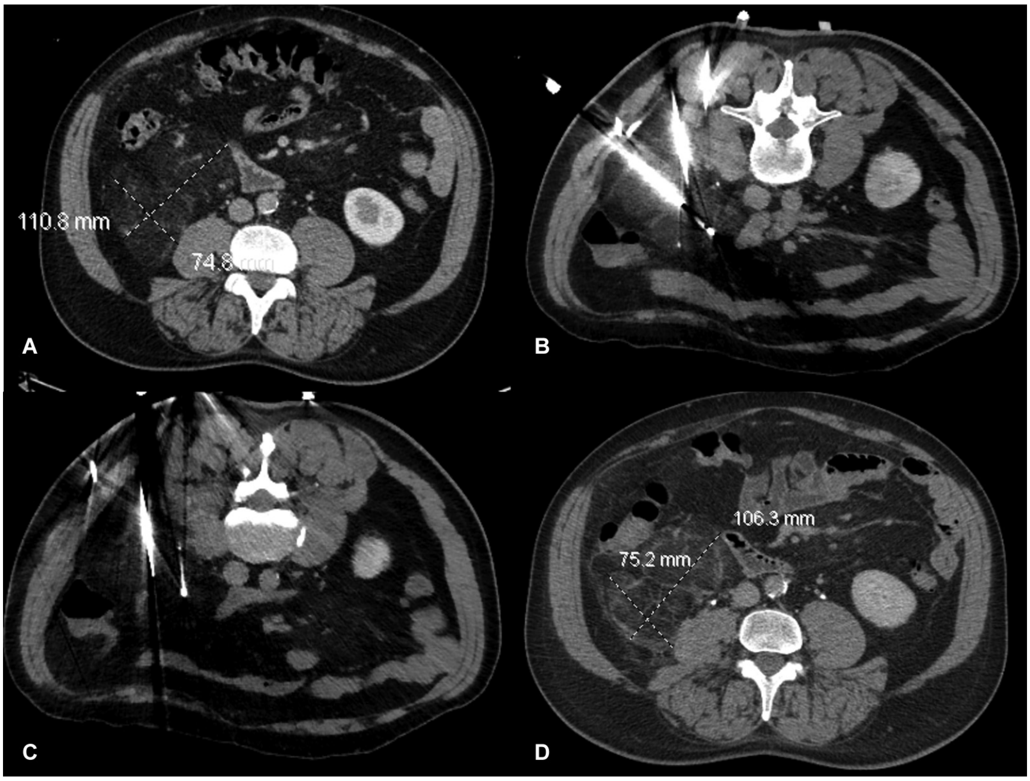

Fig. 2 (**A**) Initial contrast-enhanced computed tomography (CT) revealing a right renal angiomyolipoma (AML) measuring approximately 11.1 × 7.5 cm. (**B, C**) Utilizing Epione robotic assistance and under CT guidance, seven 13-gauge 15-cm V-Probe cryoablation needles positioned within the inferior aspect of the large right renal AML. Imaging shows the placement of 5 needles. (**D**) Follow-up contrast-enhance CT at 1 month demonstrates a right-sided AML measuring 10.6 × 7.5 cm.

contrast-enhanced CT scan that showed decreased peripheral enhancement of the myeloid component of the lesion in the right kidney; it measured approximately 8.1 × 9.6 cm, mildly decreased in size compared with prior CT scan (►**Fig. 3F**).

Discussion

Various nephron-sparing management options for AMLs are available in current literature, including active surveillance, partial nephrectomy, SAE, and thermal ablative techniques. Since AMLs are benign lesions, AMLs smaller than 4 cm are traditionally managed conservatively through surveillance, due to the lack of malignancy and risk of potentially life-threatening hemorrhage. However, regular follow-up is recommended to assess their growth as the frequency of symptoms increases with the size of the mass. Interventions are only indicated when the patient is symptomatic, or if the tumor size meets the current threshold of 4 cm for intervention.[12] Renal AMLs are at risk of spontaneous bleeding, which increases significantly with sizes over 4 cm.[2,7]

Surgical Management

Although surgical management of AML is generally safe and effective, the potential morbidity and the risk of serious complications might prompt the exploration of alternative options.[13,14] Recent urological literature has embraced surgical management, particularly favoring nephron-sparing surgery, associated with low recurrence rates and effective preservation of renal function.[7] In the largest series of sporadic AML, Boorjian et al evaluated open nephron-sparing surgery, revealing a recurrence rate of 3.4% and de novo chronic kidney disease in 12% of cases at 8 years of follow-up.[15] Nephron-sparing surgery demonstrated a surgical complication rate of 21.4% with a very low re-intervention requirement (<1%).[7,12]

Thermal Ablation

Recently, minimally invasive procedures using SAE and thermal ablative techniques, such as radiofrequency ablation (RFA), microwave ablation (MWA), and cryoablation, have emerged.[16] SAE recently arose as the first-line treatment option for prophylactic management of symptomatic AMLs or treatment of active hemorrhages.[16,17] Spontaneous retroperitoneal hemorrhage can occur in 10 to 15% of AML patients, which may cause hypovolemic shock in up to 30% of them.[12,18,19] SAE is a safe and minimally invasive alternative with a success rate of 90 to 100%.[20,21] In prophylactic and symptomatic management, reduction of renal AML volume by 26 to 99% has been noted, with reported recurrence rates of 43%.[22,23] Various embolic agents have been used, including foam, coil, and microparticles, with none demonstrating superiority over the others.[24] However, a pooled analysis of multiple studies showed a reintervention rate at 3 years of 38%, which is relatively high compared with other treatment modalities.[18]

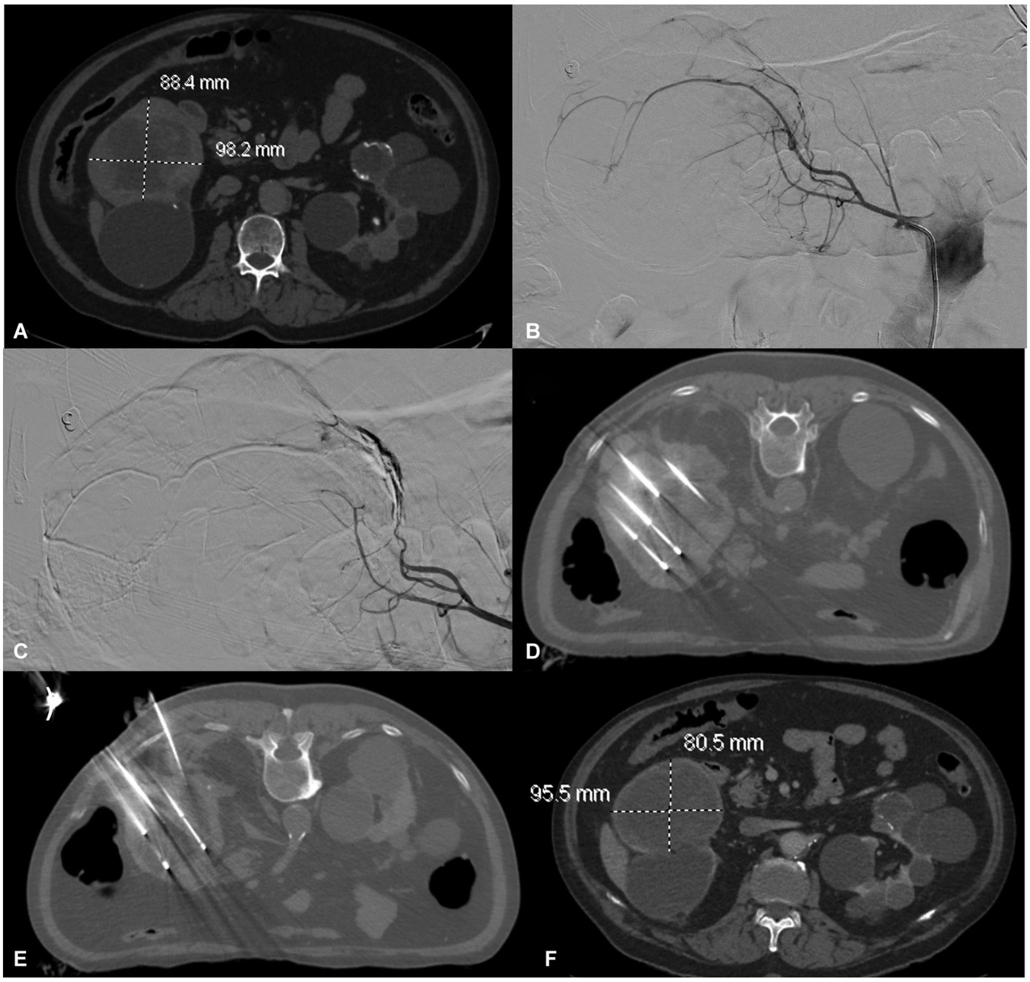

Fig. 3 (**A**) Initial contrast-enhanced computed tomography (CT) revealing a right renal angiomyolipoma (AML) measuring approximately 8.8 × 9.8 cm. (**B, C**) Successful particle embolization of right renal mass via subselective renal arterial branches arising from the right main renal artery. (**D, E**) Six 2.4-mm right angle V-Probe cryoablation needles and two 1.7-mm PCS-17 cryoprobes advanced and positioned within the large right AML. (**F**) Follow-up contrast-enhanced CT at 5 months demonstrates a left-sided AML measuring 8.1 × 9.6 cm.

In large AMLs that are predominantly fat containing and poorly vascularized, the bleeding risk is low.[25,26] Therefore, SAE is believed to be less effective, while percutaneous ablative therapies such as RFA, MWA, and cryoablation have emerged with goals to preserve renal function and restrict the growth of the AML. Different types of percutaneous thermal ablative techniques using RFA and MWA have been performed in treating AML tumors less than 6 cm in size.[16] Ablation has been considered superior to nephron-sparing surgery in comparative studies regarding renal function preservation.[27–29] Few studies have shown effectiveness with minor complications and low re-intervention rates during follow-up.[7]

RFA is the most common used and studied technique in the literature. Two series showed good effectiveness, low re-intervention rates, and minor complications during follow-up.[7,27] Prevoo et al reported the successful case of treating a sporadic 4.5-cm renal AML with RFA in a solitary kidney.[30] The patient did not have recurrence of the lesion as indicated in the follow-up imaging and his renal function was well preserved at 12 months. The tumor size decreased from 4.5 to 2.9 cm at follow-up after 12 months. MWA in relatively small (up to 4.9cm) renal AMLs showed a mean size decrease from 3.4 to 2.4 cm.[31] Percutaneous cryoablation has only been described in the literature very few times worldwide. Makki et al reported success in using cryoablation to treat subclinical AMLs with low complication rates, lack of retreatment, and good preservation of renal function.[11] However, there is no strong evidence for any ablative modality to be superior in terms of effectiveness and the long-term efficacy data are lacking.

The third patient described in our report had previously received partial nephrectomy, status post cryotherapy to the mass, but the mass persisted and did not reduce in volume or size following the surgery. The patient subsequently developed end-stage renal disease 1 year later but was denied as a suitable candidate for renal transplant or a second nephrectomy surgery. Therefore, the patient opted for a less invasive treatment, which made cryoablation a better choice for him. The patient underwent SAE prior to cryoablation to reduce the risk of bleeding. SAE has also been widely used as a minimally invasive method to stop hemorrhagic AMLs or restrict their growth prophylactically. When compared with surgery, it provides advantages such as fewer major complications, less bleeding, and shorter hospital stays.[6] Its most common and relevant complication is postembolization syndrome characterized by fever, flank pain, and leukocytosis, which can present in up to 89% of the cases.[30] Currently, there is limited evidence that shows advantages to embolize nonsymptomatic large AMLs greater than 4 cm prophylactically.[2] Additionally, SAE is associated with high recurrence and reintervention rates compared with surgical alternatives despite an effective volume reduction.

Conclusion

In the treatment of larger AMLs, minimally invasive percutaneous cryoablation might offer an alternative safe, effective, and minimally invasive treatment option. Percutaneous cryoablation could be considered when treating large AMLs over 4 cm, and for large AMLs without a significant vascular component. Subsequent follow-ups on patients' tumor progression and clinical outcomes are warranted to assess its long-term effect and validity.

Compliance with Ethical Standards

For this type of study formal consent is not required. Informed consent was waived and has been approved by the institutional review boards. For this type of study consent for publication is not required.

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None.

Conflict of Interest
G.N. received consulting fees for AngioDynamics, Stryker, and Varian Interventional Solutions and is part of the advisory board of Quantum Surgical and BetaGlue. The other authors declare that they have no conflict of interest.

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