The Efficacy, Safety and Durability of Selective Renal Arterial Embolization in Treating Symptomatic and Asymptomatic Renal angiomyolipoma

Chi Kwok Chan, Simon Yu, Sidney Yip, and Paul Lee

OBJECTIVE To review the long-term outcome of selective renal arterial embolization (SAE) in treating renal angiomyolipomas (AMLs) in both elective and emergency settings.

MATERIALS AND METHODS Between October 1988 and September 2008, 27 patients (28 renal units) were treated with SAE, either on an emergency basis for 15 (53.6%) bleeding AMLs or prophylactically for 13 (46.4%) asymptomatic high-risk (size >4.1 cm) AMLs. Six males and 21 females with a mean age of 46.3 years (range, 26–68) were followed for a mean period of 7.1 years (range, 1.3–20.2) for recurrence of symptoms, need for re-embolization, or need for renal surgery. SAE outcome was evaluated using the Kaplan-Meier method. Predictor(s) of outcome were identified with univariate analysis by log-rank test.

RESULTS Mean size of AMLs was 10.9 cm (range, 4–30). Eight (29.6%) patients had bilateral and 19 (70.4%) had unilateral AMLs. Seventeen (60.7%) kidneys had solitary AMLs; 11 (39.2%) kidneys had multicentric AMLs. Of the 15 bleeding AMLs, 12 (80%) patients required a blood transfusion. Twenty-six (93%) AMLs were successfully embolized in the first SAE. During follow-up, four (14.8%) patients required re-embolization. Renal surgery was required in four (14.8%) patients. From the Kaplan-Meier analysis, the overall renal surgery sparing rate at 5 years was 85% (95% CI: 71–99%), whereas the single session SAE success rate at 5 years was 63% (95% CI: 42–84%). Of all the variables, only AML >10 cm was significantly associated with the subsequent need for renal surgery (P = .03). No renal malignancy was noted at final follow-up.

CONCLUSIONS SAE is effective and durable in preventing large AMLs from bleeding, treating AMLs presenting with bleeding, and sparing the need for renal surgery. UROLOGY 77: 642–648, 2011. © 2011 Elsevier Inc.

Most renal angiomyolipomas (AMLs) are asymptomatic at diagnosis; nevertheless, they are the most common renal tumors (48%). AMLs cause spontaneous perirenal hemorrhage, and 33% of patients who presented with bleeding AMLs developed hypovolemic shock.[1,2] Their likelihood of bleeding can be predicted by size (>4 cm), presence of abnormal vascularity (eg, dilated vessels, micro- or macro-aneurysms), and the association with tuberous sclerosis (TS).[1–3] Accordingly, therapeutic intervention for symptomatic/bleeding AMLs and prophylactic intervention for asymptomatic high-risk AMLs are equally justified.

Open surgery, exemplified by enucleation[4] or nephrectomy (partial/total),[5–9] is the conventional intervention for treating high-risk or symptomatic AMLs. However, other modes of minimally invasive therapy (laparoscopic,[10] robotic partial nephrectomy,[11] selective renal arterial embolization [SAE],[3,12–18] radiofrequency ablation,[19] cryoablation[20]) have recently gained favor as the primary treatment for AMLs.

To date, opinions differ about whether SAE is valuable long term[21] for both therapeutic and prophylactic purposes. We report on the efficacy, safety, and durability of SAE in treating AMLs and identify factors that affect the long-term outcome of this mode of therapy.

PATIENTS AND METHODS

We reviewed our results for SAE treatment of AMLs, confirmed by contrast computed tomography (CT) of the abdomen, between October 1988 and September 2008. SAE is

Part of the content of this article was presented in the 30th Congress of the SIU, November 1–5, 2009, Shanghai, China, in the moderated poster session (Adrenal, Kidney, and Ureter).

From the Division of Urology, Department of Surgery, 4/F Prince of Wales Hospital, Shatin, New Territories, Hong Kong SAR, People's Republic of China; and Department of Diagnostic and Interventional Radiology, Prince of Wales Hospital, the Chinese University of Hong Kong, Hong Kong SAR, People's Republic of China.

Reprint requests: Dr. Chi Kwok Chan, Division of Urology, Department of Surgery, Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong SAR. E-mail: chansdu@hotmail.com

Submitted: February 28, 2010, accepted (with revisions): August 26, 2010

 © 2011 Elsevier Inc.
All Rights Reserved 0090-4295/11/$36.00
doi:10.1016/j.urology.2010.08.040

primarily indicated to treat AMLs in our institution in the following conditions: acute hemorrhage caused by spontaneous rupture of AMLs, symptomatic AMLs caused by visceral compressive effect, and asymptomatic high-risk AMLs for which prophylactic treatment is believed to be appropriate (eg, size >4 cm).

Antibiotic prophylaxis (cefuroxime intravenous infusion (IVI) 1.5 g plus metronidazole IVI 500 mg) was routinely given to cover SAE, which was performed under local anesthesia by the transfemoral approach, using 4–5 Fr angiographic catheters (Cook Medical, Bloomington, IN) and coaxial microcatheter (3 Fr, Tracker—18 two-tips, Boston Scientific, Target, Cork, Ireland). The feeding vessels to the AMLs were then identified, cannulated, and embolized accordingly. In our institution, a combination of various particulate and liquid embolic materials were used, including: microcoils (Fibered platinum Coil, Boston Scientific) for 4 bleeding AMLs; a mixture of lipiodol and absolute alcohol (LEM) (lipiodol: Ultrafluid, Guerbet, Aulnay-sous-Bois, France; dehydrated alcohol: Martindale Pharmaceuticals, Romford, Essex, UK) (1–10 mL) for 10 prophylactic SAEs and 2 emergency SAEs; a combination of microcoils and ethanol for 1 prophylactic SAE; a combination of polyvinyl alcohol particles (PVA) (contour embolization particles 150–250 μm, Boston Scientific), and microcoils for 2 prophylactic SAEs and 7 emergency SAEs. A postembolization angiogram was performed to confirm the completeness of embolization (devascularization).

All patients were followed up on a 3-month basis for the first 6 months and then annually. Abdominal CT imaging was performed to detect any recurrence of the abnormal vasculature to the AMLs and any progression in the size of the AMLs. Follow-up angiograms were not routinely performed unless re-embolization was considered necessary. Re-embolization was considered if the follow-up CT imaging showed evidence of incomplete devascularization of AMLs, progression of AMLs characterized by increasing size, recurrence of abnormal vasculature, or a combination of them. Nephrectomy (partial/total) was performed for AMLs if SAE failed to control the bleeding from the AMLs or the AMLs produced persistent symptoms/progression refractory to SAE therapy.

Patients were followed for a mean period of 7.1 years (range, 1.3–20.2). The re-emergence of symptoms related to AMLs or the need for further embolization therapy and/or nephrectomy (partial/total) for the treatment of AMLs was taken as the outcome measure to evaluate the efficacy of SAE.

Kaplan-Meier analysis was used to evaluate the success of SAE. The primary outcome measure was taken to be the length of time since the first SAE without undergoing further partial/total nephrectomy. The secondary outcome measure referred to the symptom/intervention-free period in terms of time from the first SAE. Univariate analysis (log-rank test) was carried out to evaluate whether gender, age (≤46 or >46 years), bilateral presentation of AMLs, AML size (≤10 or >10 cm), urgency of SAE (emergency vs elective), and multicentricity of AMLs were determining factor(s) in the success of SAE therapy. To compare groups, chi-square /Fisher exact tests and paired Student's *t*-test were used for nominal data and continuous data, respectively. Statistical significance was defined as $P < .05$ (2-sided). The statistical package SPSS (SPSS, Inc., Chicago, IL) was used for the analysis.

Table 1. Patient demographic data

Gender: Male (%); Female (%)	6 (22); 21 (78)
Mean age at presentation, years (range)	46.3 (25–68)
Mean follow-up time, years (range)	7.1 (1.33–21.2)
Tuberous sclerosis (%)*	1 (3.7)
SAE to treat bleeding AMLs, renal units (%)	15 (53.6)
SAE to treat large/symptomatic AMLs, renal units (%)	13 (46.4)
Blood transfusion for bleeding AMLs (%)	12 (80)
Mean maximum size of AMLs, cm (range)	10.9 (4–30)
No. of AMLs 4–5 cm	2 (7.1%)
No. of AMLs 5.1–10 cm	12 (42.9%)
No. of AMLs >10 cm	14 (50%)
Bilateral presentation of AMLs (%)†	8 (29.6)
Unilateral presentation of AMLs (%)	19 (70.4)
Side of AMLs: right (%); left (%)	14 (50); 14 (50)
Solitary AML in a single kidney (%)	17 (60.7)
Multiple AMLs in a single kidney (%)	11 (39.3)

* Female patient.
† Eight patients were diagnosed with AMLs in both kidneys. Of these, 1 male patient needed to undergo SAE to treat his bilateral symptomatic AMLs. For the other 7 patients, the AMLs in the contralateral kidneys were of small size (<4 cm) and they opted for observation.

RESULTS

Twenty-seven patients (28 renal units) underwent SAE to treat bleeding/symptomatic AMLs (n = 15) or as prophylactic treatment against high-risk AMLs (size >4 cm, abnormal vasculature on CT) (n = 13). The mean size of AMLs was 10.9 cm and the median size 10.4 cm, 7.1% (n = 2) were 4 to 5 cm, 42.9% (n = 12) 5.1 to 10 cm, and 50% (n = 14) >10 cm. Other patient demographic data are presented in Table 1.

Two (7%) bleeding AMLs failed to be embolized because their feeding vessels could not be identified at the time of SAE, whereas the other 26 (93%) AMLs were successfully embolized in the first instance. Four re-embolizations were necessitated during the follow-up, resulting in a total of 30 successful SAE procedures.

The angiographic appearance of AML was characterized by a single feeding vessel (3 bleeding and 3 symptomatic/large AMLs), 2 feeding vessels (3 bleeding AMLs and 2 symptomatic/large AMLs), 3 or more feeding vessels (7 bleeding AMLs and 8 symptomatic/large AMLs), macro-aneurysms of the arterial feeders to the AMLs (4 bleeding AMLs and 1 large nonbleeding AMLs) and arteriovenous shunting (2 bleeding AMLs).

All but 2 patients were discharged home within 5 to 7 days after SAE. The other 2 patients stayed in the hospital for a total of 12 (emergency SAE) and 20 (prophylactic SAE) days because of prolonged postembolization syndrome, which responded to conservative treatment with analgesic and antipyretic medications. Statistically, the duration of hospital stay was unrelated to whether SAE was performed on an elective or emergency basis (*t*-test, $P = .14$). No renal abscess formation, pleural effusion, or in-

Table 2. Outcome of SAE in treating renal AML within a mean follow-up period of 7.1 years

Outcome	Variables: Prophylactic SAE (n = 13)	Variables: Emergency SAE (n = 15)	*P* value
Mean size of AMLs, cm (range)	9.4 (5–14)	12.3 (4–30)	.16*
Successful trial of first embolization	13	13	.48†
Mean hospital stay (days) after successful SAE	5.1 (1–20)	7.7 (4–12)	.14*
Need for re-embolization after first successful SAE	1	3	.59†
Recurrence of symptoms	1	0	1.0†
Renal surgery (total/partial nephrectomy)	1 (total nephrectomy)	2 (total nephrectomy) 1 (partial nephrectomy)	.60†
Postembolization syndrome	6 (out of 17 elective SAE, including 4 reembolization sae)	5	1.0†
Patient death	0	0	1.0†
Renal replacement therapy	0	0	1.0†
Renal malignancy	0	0	1.0†
	Male (n = 6)	Female (n = 21)	
Avoidance of renal surgery	5	18	1.0‡
Successful SAE in single session	4	14	.56‡
	≤46y.o (n = 15)	≥46 y (n = 12)	
Avoidance of renal surgery	13	10	.80‡
Successful SAE in single session	10	8	.80‡
	Unilateral AMLs (n = 20)	Bilateral AMLs (n = 8)	
Avoidance of renal surgery	17	7	.87‡
Successful SAE in single session	14	5	.82‡
	≤10 cm (n = 14)	>10 cm (n = 14)	
Avoidance of renal surgery	14	10	.03‡
Successful SAE in single session	3	6	.16‡
Pre-SAE size (mean, median, SD)	7.2, 7.3, 1.7	14.6, 13.0, 5.0, 0.001*	
Post-SAE size (mean, median, SD)	6.1, 6.2, 2.6	9.1, 10.6, 3.6 (n = 10), 0.08*	
	Prophylactic SAE (n = 13)	Emergency SAE (n = 15)	
Avoidance of renal surgery	12	12	.34‡
Successful SAE in single session	10	9	.50‡
	Solitary AMLs (n = 17)	Multicentric AMLs (n = 11)	
Avoidance of renal surgery	14	10	.55‡
Successful SAE in single session	12	7	.92‡

* Student's *t*-test.
† Fisher exact test.
‡ Univariate analysis (log-rank test).

fected intraabdominal fluid collection was identified. The outcomes of SAE are tabulated in Table 2.

In our study cohort, partial/total nephrectomy for 4 renal AMLs was performed despite the primary treatment with SAE therapy. All of these AMLs were larger than 10 cm on presentation (28.6% of AMLs >10 cm) and three presented with acute retroperitoneal hemorrhage. SAE failed in 2 of these 3 bleeding AMLs because no arterial feeders could be identified at the time of angiogram. One (male) patient had to undergo emergency total nephrectomy for salvage. The other (female) patient responded to initial fluid replacement and blood transfusion and subsequently underwent elective partial nephrectomy, whereby the pathology confirmed renal AML. The other bleeding AML (30 cm) showed a large arteriovenous shunt, which subjected the (female) patient to hyperdynamic heart failure. SAE failed to completely devascularize this AML and the patient later underwent a right total nephrectomy with uneventful recovery. One AML (11 cm) progressively increased in size (to 14 cm) and caused a visceral compressive effect despite prior prophylactic SAE with absolute ethanol. This (female) patient declined the option of re-embolization and elected to undergo left total nephrectomy in another medical center 25 months after her first SAE.

Another 4 (14.3%) patients required elective re-embolization therapy (3 AMLs <10 cm and 1 AML >10 cm) for persistent vascularization/recanalization of the abnormal vasculature to AMLs (1 prior prophylactic SAE and 3 prior emergency SAEs). Re-embolization was successful in devascularizing all of these AMLs.

Of the 24 AMLs successfully devascularized by SAE, at the latest follow-up their mean size decreased from 9.9 cm (SD: 3.9; range, 4.0–19.0) to 7.4 cm (SD: 3.4; range, 1.2–13.8) ($P = .005$). For the subgroup of AMLs >10 cm (n = 14), renal surgery was spared for 71.4% (n = 10) after a mean follow-up of 7.1 years and their mean size decreased from 13.7 cm (SD: 2.7; range, 11.0–19.0) to 9.1 cm (SD: 3.6; range, 2.1–13.8) ($P = .017$). For the subgroup of AMLs 4 to 10 cm (n = 14), renal surgery was spared in all cases and their mean size decreased from 7.2 cm (SD: 1.7; range, 4.0–9.8) to 6.1 cm (SD: 2.6; range, 1.2–9.4) (P = .08). No patients experienced a visceral compressive effect of the residual AMLs or developed loin pain/hematuria, except for one (female) patient who developed hematuria and loin pain caused by minor bleeding 20 months after her first elective SAE (AML on presentation: 14 cm). However, the follow-up contrast CT of her abdomen did not show any revascularization or increase in the size of the previously embolized AML and she was managed successfully with conservative treatment without further need of embolization/surgical intervention.

Kaplan-Meier analysis showed that 5 years after the first session of SAE, the overall success rate for sparing renal surgery was 85% (95% CI: 71%–99%). Five years after the first session of SAE, 63% (95% CI: 42%– 84%) of patients were free of AML symptoms, had been spared renal surgery, and did not need further re-embolization treatment. Of the variables shown in Table 2, only the size of AMLs (>10 cm) was statistically significant (P = .03) in predicting the avoidance of renal surgery after the first session of SAE. At latest follow-up, no patients had died of AML or other diseases, and none had developed renal malignancy or required renal replacement therapy because of loss of renal function.

COMMENT

Most (95%) AMLs can be confidently identified by contrast CT of the abdomen, which shows characteristic fat-containing lesions associated with a defect in the renal parenchyma and abnormal vascularity in the lesions.[22] Diagnosis of AMLs with minimal fat content may have to rely on more advanced methods, such as the opposed-phase chemical shift magnetic resonance imaging technique.[23] Except for the very rare epithelioid variant,[24] malignant transformation of AML is extremely rare, with no more than 15 cases reported.[24] Apart from 1 report[8] that showed that 18.5% of AMLs treated by partial nephrectomy were serendipitously associated with concomitant renal cell carcinoma (RCC) of the same kidney, coexistence of AMLs and renal malignancy is uncommon, with only approximately 50 cases reported, and the association has been reported to occur in 18 cases of 2160 nephrectomies.[25] The coexistence of AMLs with RCC develops in 1% to 3% of tuberous sclerosis (TS), although some of them may actually have epithelioid AMLs instead of RCC.[26] Hence, exclusion of malignant transformation by biopsy is usually not mandatory before treatment is offered. None of our patients developed renal malignancy at final follow-up.

AMLs are predominantly vascularized by one or a few tortuous and aneurysmal end arteries derived from branches of the renal artery or aberrant renal arteries.[3,12-18] Their arterial feeders are thought to possess poor elastic layers and a disorganized adventitial cuff of smooth muscle, making the vessels become aneurysmal and prone to rupture.[1] Williams et al[17] reported that intratumoral aneurysms are very common (80%) in TS-AMLs, with a mean aneurysm size of 5 mm (range, 2–10 mm). Thirty-five percent of AMLs had >5 aneurysms, 45% had 1 to 5 aneurysms, and the remaining 20% had no intratumoral aneurysms.

These features make SAE an attractive treatment of choice for AMLs in both emergency and prophylactic settings. However, SAE is contraindicated in the conditions where the renal lesions showed features of malignant tumor or malignant condition, for example, in epithelioid AMLs or AMLs associated with tumor thrombus in the renal vein, the inferior vena cava,[27] and even the right atrium.

Treatment of Bleeding AMLs

Embolization is clearly beneficial in treating acute hemorrhage from AMLs, allowing the patient's condition to be stabilized and often obviating the need for subsequent surgery. It may also be useful in patients with multiple symptomatic AMLs, in whom even nephron-sparing surgery poses a substantial risk of renal failure or other complications. Particulate[13,14,17] and liquefied[12,15,16] materials (ethanol or combined ethanol and lipiodol) are equally effective in achieving hemostasis for 77% to 100% of bleeding AMLs after a single session of SAE. In our series, 85% of bleeding AMLs were successfully embolized on the first attempt.

Early Complications Following SAE Lee et al[13] reported that percutaneous drainage of pleural effusion of a moderate amount was required in 1 case (5%) after SAE (mixture of iodized oil and absolute ethanol). Abscess formation (5%) after SAE was reported, all of which were drained percutaneously with subsequent resolution. No mortality was reported in the larger series where SAE was commonly practiced. No cases of renal insufficiency were noted.[3,12-18] Unintended embolization of the lower extremities or spinal arteries has never been reported in SAE treatment for AMLs. Nontarget embolization of renal tissue[18] other than AMLs has been reported but it is rare.

After SAE, 6.25% to 100% of patients developed postembolization syndrome, manifested as flank pain, fever, leukocytosis, and nausea and attributable to inflammatory mediators released after SAE therapy.[3,12–18] In our series, the overall occurrence of postembolization syndrome was 36.7% and the occurrence was similar for both elective and emergency SAE. Postembolization syndrome usually responded to conservative treatment with antipyretics, nonsteroidal antiinflammatory medications, antibiotics, and other supportive measures. In Williams et al's[17] series, the patients had received anti-postembolization syndrome medication as per protocol before SAE and the reported postprocedure fever occurrence was particularly low (6.25%).

Elective SAE

Since its inception in 1994,[28] prophylactic SAE has gained favor and is advocated to be performed before the

Table 3. Comparison of NSS and SAE in treating renal AML

Reference (year)	Number of patients/ renal units	Mode of therapy	Mean age, years (range)	Male/Female (%)	Mean size, cm (range)	Mean follow-up time, months (range)	Operative mortality	Adverse events	Remarks (nephrectomy/dialysis)
Fazeli-Martin et al 1998[1]	27/27	NSS	50 (14–73)	8/19 (30/70)	7.4 (1.5–26)	(median) (2–177)	0	3 urinary fistula; 1 wound infection; 1 UTI; 1 *C. difficile* colitis, 1 adrenal insufficiency	No dialysis
De Luca et al 1999[2]	20/20	NSS	46.7 (26–74)	4/16 (20/80)	4.7 (2.5–17)	Not available	Not mentioned	Not mentioned	14 partial nephrectomy; 6 total nephrectomy
Heidenreich et al 2002[3]	28/28	NSS	55.6 (median) (34–78)	4/24 (14/86)	5.5 (median) (2.5–15)	58 (median) (3–114)	0	3 urinary fistula (all 3AMLs >8 cm)	No dialysis
Boorjian et al 2007[4]	58/58	NSS	57.(median) (26–84)	14/44 (24/76)	3.9 (median) (0.8–12.5)	72 (median) (12–372)	0	3 urinary leak; 1 wound abscess; 5 ileus; 1 pneumothorax; 1 hemorrhage	2 radiological recurrence for observation: No dialysis
Ramon et al 2009[5]	41/48	SAE	51 (24–82)	5/37 (10/90)	10.3 9.0 (median) (2.5–20)	58 (3-148)	0	1 transient renal artery spasm; 5 postembolization syndrome	No dialysis; 1 partial nephrectomy; 1 total nephrectomy
Chick et al 2009[6]	34/NA	SAE	44 (22–72)	5/29 (15/85)	11.9 (2.9–24.4)	44 (12–116)	0	11 postembolization syndrome; 1 nontarget embolization leading to transient renal impairment	No dialysis; 1 partial nephrectomy; 2 total nephrectomy
Current series (2010)	27/28	SAE	46 (25–68)	6/21 (22/78)	10.9 10.4 (median) (4–30)	85 (16–242)	0	11 postembolization syndrome	No dialysis; 3 total nephrectomy; 1 partial nephrectomy

UTI, urinary tract infection.

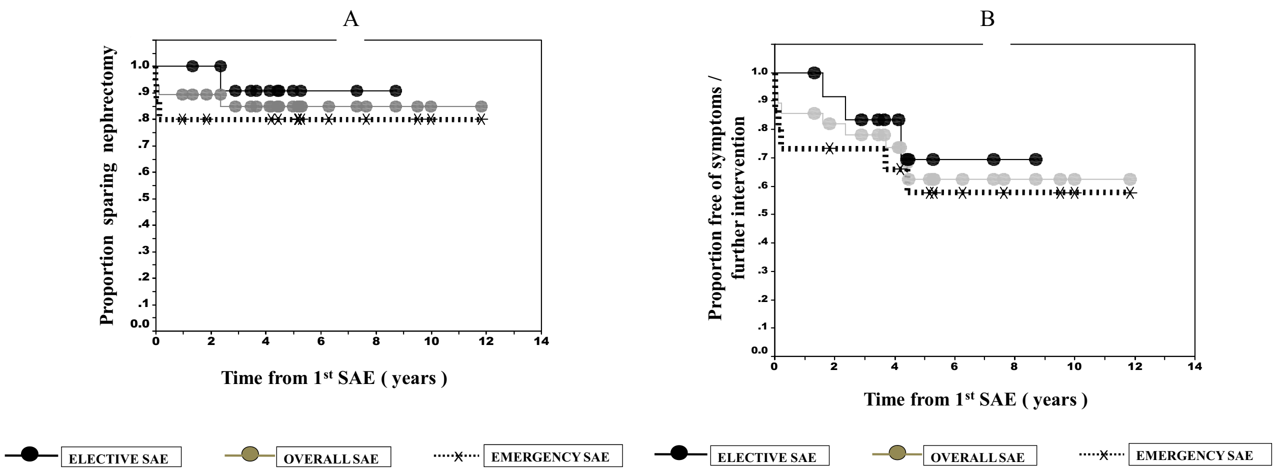

Figure 1. The relation of the primary and secondary outcome of SAE with respect to time from first SAE.Figure 1. **(A)** Renal surgery sparing rate. Kaplan-Meier curve showing the proportion of patients spared partial/total nephrectomy with respect to time (years) from the first session of SAE in different categories of SAE (elective/overall/emergency) (log-rank test, $P =$ .34). (**B**) Success rate after a single session of SAE. Kaplan-Meier curve showing the proportion of patients free of symptoms or further intervention (re-embolization/nephrectomy) with respect to time (years) from the first session of SAE in different categories of SAE (elective/overall/emergency) (log-rank test, $P =$ .50)

AML grows large enough to bleed. In fact, one of the bleeding AMLs in our series was about 4 cm. Han et al[12] reported that all 16 symptomatic renal AMLs in 14 patients, with a mean follow-up time of 33 months, showed complete devascularization in the postembolization angiograms. Ninety-three percent of patients were free of symptoms after SAE. Only 1 female patient (7%) had to undergo nephrectomy after SAE because of large cystic changes in the embolized AML site. Kothary et al[15] showed that prophylactic SAE could completely devascularize all nonbleeding AMLs (12 patients; 23 AMLs). Neither Ramon et al's[3] series nor our series reported any bleeding from renal AMLs after elective SAE for symptomatic and large AMLs.

Durability of SAE (Re-embolization/Partial or Total Nephrectomy/Obviation of Surgery)

Lee et al[13] reported a re-embolization rate of 15.3% for treating AMLs with recurrent hemorrhage or recurrence of symptoms within a mean follow-up time of 3 years. Kothary et al[15] reported that after SAE no recurrences occurred in patients with sporadic AMLs, whereas 42.9% of TS-AMLs (9 of 21) showed recurrence. Of these 9 recurrent AMLs, all were re-embolized after a mean follow-up time of 6.8 years (range, 3–11 years) because of recurrent symptoms, hemorrhage, or an increase in size of >2 cm. In Tso et al's[16] series, 1 patient required re-embolization for treating a recurrence of symptomatic AML 16 months after the first treatment. One patient (7.7%) underwent partial nephrectomy and another (7.7%) underwent total nephrectomy because of revascularization and an increase in size of the original AML associated with visceral pain, 1 year and 4 years after SAE with embolotherapy, respectively. Re-embolization was needed in 37% of patients followed for a mean period of 4.8 years in the cohort reported by Ramon et al,[3] mainly treating recanalization of the abnormal vessels according to angiographic follow-up. We reported an overall success rate of 68% after a single session of SAE after a mean follow-up time of 7.1 years.

Long-term Follow-up of SAE vs Partial Nephrectomy

The advantage of SAE is that it can prevent renal loss and spare surgery. The amount of nephron can be largely preserved after SAE after long-term follow-up[29] as a result of improved techniques, availability of smaller microcatheters, more precise embolic agents, and superior imaging equipment, which allow much greater precision and the preservation of normal renal parenchyma.[29] Ramon et al[3] reported that 5 years after SAE therapy for renal AMLs, 94% of his patients could be spared renal surgery for AMLs. In our experience, 89.3% of renal units could be preserved when prophylactic SAE was used to treat asymptomatic high-risk AMLs. Nephron-sparing surgery (NSS) has been advocated by others[5–9] as another treatment alternative for AMLs, especially on an elective basis, due to the exclusion of malignancy, treatment for spontaneous rupture, obviation of repeated angiographic procedures, and a combination of relative indicators, including eradication of massive lesions and control of pain in association with high likelihood of preservation of renal function. Table 3 summarizes the results of the most recent series of NSS and SAE; it shows that the average dimension of AMLs treated by NSS was smaller than that treated by SAE in the reported series. Urinary fistula/leakage is not a rare occurrence in the reported NSS series, and it occurs more frequently in patients with larger AMLs. Unless the diagnosis of AMLs cannot be ascertained by radiological imaging, most (85%–96%) AMLs treated by SAE can be left for surveillance without the need for surgical removal. No renal malignancy was reported in the SAE series.

Shrinkage of AMLs After SAE

SAE may be of value in decreasing the size of AMLs by diminishing the vascular angiomatous component of AMLs after embolization.[12,16,18] However, the degree of reduction in AML size may not be an effective measure because most AMLs only shrank by 20% to 30%[16,18] depending on the predominance of the fatty component, even after effective SAE. This is well exemplified in our cohort because the mean decrease in the dimension of AMLs after successful SAE (n = 24) was ~2.5 cm (a 26% reduction in linear dimension).

After SAE, continued surveillance is mandatory to identify the subset of patients who may need repeat embolization therapy, as indicated by an increase in the size of AMLs or any increase in their enhancement or vascularity.[15]

CONCLUSIONS

Our study has further clarified and defined the role of this minimally invasive nephron-sparing procedure in the management of renal AML, be it on an elective or emergency basis. We believe that SAE is primarily effective in arresting hemorrhage and preventing hemorrhagic complications from large renal AMLs. SAE is effective, safe, and durable provided that continued surveillance can be ensured. Figure 1.

Acknowledgment. The authors would like to thank Helen Lam for the help in the processing of the manuscript.

References

1. Osterling JE, Fishman EK, Goldman SM, et al. The management of renal angiomyolipoma. *J Urol.* 1986;135(**6**):1121-1124.
2. Steiner MS, Goldman SM, Fishman EK, et al. The natural history of renal angiomyolipoma. *J Urol.* 1993;150(**6**):1782-1786.
3. Ramon J, Rimon U, Garniek A, et al. Renal angiomyolipoma: long-term results following selective arterial embolization. *Eur Urol.* 2009;55(**5**):1155-1161.
4. Minervini A, Giubilei G, Masieri L, et al. Simple enucleation for the treatment of renal angiomyolipoma. *BJU Int.* 2007;99(**4**):887-891.
5. Yip SK, Tan PH, Cheng WS, et al. Surgical management of angiomyolipoma: nephron-sparing surgery for symptomatic tumour. *Scand J Urol Nephrol.* 2000;34(**1**):32-35.
6. Boorjian SA, Frank I, Inman B, et al. The role of partial nephrectomy for the management of sporadic renal angiomyolipoma. *Urology.* 2007;70(**6**):1064-1068.
7. De Luca S, Terrone C, Rossetti SR. Management of renal angiomyolipoma: a report of 53 cases. *BJU Int.* 1999;83(**3**):215-218.
8. Fazeli-Matin S, Novick AC. Nephron-sparing surgery for renal angiomyolipoma. *Urology.* 1998;52(**4**):577-583.
9. Heidenreich A, Hegele A, Varga Z, et al. Nephron-sparing surgery for renal angiomyolipoma. *Eur Urol.* 2002;41(**3**):267-273.
10. Zhang X, Li HZ, Ma X, et al. Retroperitoneal laparoscopic nephron-sparing surgery for renal tumours: report of 32 cases. *Urology.* 2005;65(**6**):1080-1084; [Discussion:1084-1085].
11. Stein RJ, White WM, Goel RK, et al. Robotic laparoendoscopic single-site surgery using GelPort as the access platform. *Eur Urol.* 2010;57(**1**):132-136.
12. Han YM, Kim JK, Roh BS, et al. Renal angiomyolipoma: selective arterial embolization-effectiveness and changes in angiomyogenic components in long-term follow-up. *Radiology.* 1997;204(**1**):65-70.
13. Lee W, Kim TS, Chung JW, et al. Renal angiomyolipoma: embolotherapy with a mixture of alcohol and iodized oil. *J Vasc Interv Radiol.* 1998;9(**2**):255-261.
14. Ewalt DH, Diamond N, Rees C, et al. Long-term outcome of transcatheter embolization of renal angiomyolipomas due to tuberous sclerosis complex. *J Urol.* 2005;174(**5**):1764-1766.
15. Kothary N, Soulen MC, Clark TW, et al. Renal angiomyolipoma: long term results after arterial embolisation. *J Vasc Interv Radiol.* 2005;16(**1**):45-50.
16. Tso WK, Wong S, Tsang J, et al. Embolotherapy with a mixture of lipiodol and ethanol for renal angiomyolipoma: Retrospective Study. *J HK Coll Radiol.* 2005;8:78-82.
17. Williams JM, Racadio JM, Johnson ND, et al. Embolization of renal angiomyolipomata in patients with tuberous sclerosis complex. *Am J Kidney Dis.* 2006;47(**1**):95-102.
18. Chick CM, Tan BS, Cheng C, et al. Long-term follow-up of the treatment of renal angiomyolipomas after selective arterial embolization with alcohol. *BJU Int.* 2010;105(**3**):390-394.
19. Prevoo W, van den Bosch MA, Horenblas S. Radiofrequency ablation for treatment of sporadic angiomyolipoma. *Urology.* 2008;72(**1**):188-191.
20. Byrd GF, Lawatsch EJ, Mesrobian HG, et al. Laparoscopic cryoablation of renal angiomyolipoma. *J Urol.* 2006;176(**4** Pt. 1):1512-1516.
21. Sooriakumaran P, Gibbs P, Coughlin G, et al. Angiomyolipomata: challenges, solutions, and future prospects based on over 100 cases treated. *BJU Int.* 2010;105(**1**):101-106.
22. Israel GM, Bosniak MA, Slywotzky CM, et al. CT differentiation of large exophytic renal angiomyolipomas and peri-renal liposarcomas. *AJR Am J Roetgenol.* 2002;179(**3**):769-773.
23. Israel GM, Hindman N, Hecht E, et al. The use of opposed-phase chemical shift MRI in the diagnosis of renal angiomyolipomas. *AJR Am J Roentgenol.* 2005;184(**6**):1868-1872.
24. Park HK, Zhang S, Wong MK, Kim HL. Clinical presentation of epithelioid angiomyolipoma. *Int J Urol.* 2007;14(**1**):21-25.
25. Jimenez RE, Eble JN, Reuter VE, et al. Concurrent angiomyolipoma and renal cell neoplasia: a study of 36 cases. *Mod Pathol.* 2001;14(**3**):157-163.
26. Eble JN, Amin MB, Young RH. Epithelioid angiomyolipoma of the kidney: a report of five cases with a prominent and diagnostically confusing epithelioid smooth muscle component. *Am J Surg Pathol.* 1997;21(**10**):1123-1130.
27. Tan YS, Yip KH, Tan PH, et al. A right renal angiomyolipoma with IVC thrombus and pulmonary embolism. *Int Urol Nephrol.* 2010;42(**2**):305-308.
28. Soulen MC, Faykus MH Jr., Shlansky-Goldberg RD, et al. Elective embolization for prevention of hemorrhage from renal angiomyolipomas. *J Vasc Interv Radiol.* 1994;5(**4**):587-591.
29. Lee SY, Hsu HH, Chen YC, et al. Evaluation of renal function of angiomyolipoma patients after selective transcatheter arterial embolization. *Am J Med Sci.* 2009;337(**2**):103-108.