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Original Article

Long-term outcomes of selective arterial embolization in giant renal angiomyolipoma: a retrospective single-center study

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ABSTRACT

Objectives: To evaluate the long-term outcomes of selective trans-arterial embolization (TAE) in patients with giant (≥10 cm in size) renal angiomyolipomas (AMLs) at our tertiary referral center.

Methods: This retrospective, single-center study included 44 patients who underwent selective TAE for AMLs of ≥10 cm size between July 2018 and June 2024. Collected data included demographics, tumor characteristics, clinical symptoms, type of intervention, tumor size before and after embolization, and renal function. Outcomes assessed were tumor size reduction, preservation of renal function, reintervention rates during follow-up and complications following SAE. Results: The study included 46 tumors in 44 patients. Mean patient age was 40.4 years (range:23-60), with 86.3% being females. Mean follow-up duration was 25.2 months (range:6-70 months). Eleven patients (25%) were associated with TSC, and all were offered Everolimus postoperatively. The mean tumor size decreased significantly from 13.2 \pm 3.12 cm pre-embolization to 10.3 \pm 2.45 cm postembolization (p =0.003). Renal function remained stable during follow-up, with no significant changes in serum creatinine (p = 0.6) and eGFR (p = 0.8). The overall success rate was 84.7%, with 13.6% experiencing re intervention. Complications included post-embolization syndrome (43.1%) and allergic reactions (6.8%), while one patient required nephrectomy due to a perinephric abscess.

Conclusions: Selective TAE is a safe and effective treatment for giant renal AMLs, resulting in significant tumor size reduction, symptom relief, and preservation of renal function. It offers a minimally invasive alternative to traditional surgical approaches, particularly for patients with high surgical risk or those requiring nephron-sparing procedure.

Keywords: Giant Renal Angiomyolipomas (gAMLs), Selective trans-arterial angioembolization (TAE), Tuberous sclerosis complex (TSC).

INTRODUCTION

Renal angiomyolipoma (rAML) is a benign renal mesenchymal tumor of the kidney, more commonly observed in females. The overall prevalence of AMLs in the general population ranges from 0.2% to 0.6% ^[1]. Approximately 80% of renal AMLs are sporadic, while the remaining 20% are associated with tuberous sclerosis complex (TSC) or pulmonary lymphangioleiomyomatosis (LAM), both are rare genetic conditions. ^[2-3] Histologically, angiomyolipomas (AMLs) consist of varying amounts of adipose tissue, blood vessels, and smooth muscle cells. ^[4]

Imaging plays a crucial role in the diagnosis and management of renal AMLs. These tumors classically diagnosed by the characteristic presence of fat on computed tomography (CT), magnetic resonance imaging (MRI) or ultrasonography (US) of the kidneys. [5]

Angiomyolipomas (AMLs) are prone to spontaneous rupture due to their tortuous, aneurysmatic arteries, which can cause pain, haematuria, retroperitoneal haemorrhage, or even death. Although benign in nature, AMLs carry significant risks during pregnancy and when lesions are larger than 4 cm, warranting prophylactic treatment to prevent rupture. [6] AMLs

with tuberous sclerosis complex (TSC) can be treated with mammalian target of rapamycin (mTOR) inhibitors such as Everolimus. [7]

Traditional surgical options include open or laparoscopic tumor removal via nephron-sparing surgery or total nephrectomy, with the latter reserved for large or complex tumors. Minimal invasive treatments include cryo-and radiofrequency ablation or selective endovascular trans-arterial embolization (TAE). [8] Selective TAE is a less invasive alternative to surgery, offering targeted treatment of bleeding vessels with a low risk of serious complications. This minimally invasive procedure has been the preferred approach for renal AMLs for many years. [9]

Despite its growing utilization, limited data are available on the long-term efficacy and safety of TAE, particularly in the management of giant AMLs. [10-11]

This study aims to evaluate the long-term outcomes of selective trans-arterial angioembolization (TAE) in patients with giant (\geq 10 cm in size) renal angiomyolipomas (AMLs) at our tertiary referral centre.

MATERIALS AND METHODS

Study Design and patients:

This study included all patients who underwent prophylactic or emergency treatment with selective TAE for AMLs of \geq 10 cm size at our institute between July 2018 to June 2024. A total of 52 patients were initially identified, but 4 were excluded due to missing clinical documents, and 4 were lost to follow-up, leaving 44 patients for final analysis. HIS (hospital information system) records were used to collect all data until June 2024. The radiological and clinical follow-up period in this study was defined as the time interval from the selective arterial embolization (SAE) procedure until June 2024. This study received approval from institute ethical committee. (2023-114-Mch-EXP-22)

We collected demographic data, including age, gender, type of AML (sporadic or TSC-associated), laterality, lesion location and number, and the type of intervention (prophylactic or emergency for acute bleeding AMLs). Clinical symptoms and complications were recorded before and after selective arterial embolization (SAE), along with any need for reintervention on follow up (either due to the recurrence of symptoms or tumor size increase of more than 2 cm on follow-up imaging). Laboratory evaluations included complete blood count, coagulation profile, and serum creatinine levels before SAE and during the follow-up period.

Triple phase computed tomography (CT) or magnetic resonance imaging (MRI) were performed for all patients prior to embolization. Tumor size and vascularity, both before and after embolization, was assessed by an experienced radiologist. The final tumor size after embolization was determined from the most recent available imaging (CT/MRI) until June 2024. Maximum tumor diameter on axial CT/MR scans was used for documentation. Tumor measurements were taken at various points during the follow-up period.

Selective Arterial Embolization:

TAE was performed through the common femoral artery under local anesthesia using modified Seldinger's technique. A 5 Fr diagnostic catheter was used for selective renal arteriography. Microcatheter was used for super-selective catheterization and embolization of the feeding artery or arteries. Particulate agents, such as nonspherical polyvinyl alcohol (nsPVA) 355–500µm or 250 µm microspheres, were used for embolization (Fig.1). In selected cases, one or more microcoils were used in combination with particles to treat microaneurysms.

Follow-up:

All medical records and outpatient charts were reviewed. Follow-up data, including clinical examinations and laboratory tests, were obtained from the Hospital Information System (HIS). CT or MRI scans were typically performed 3–6 months after SAE and annually thereafter. Treatment failure (need for reintervention) was defined as the recurrence of symptoms and/or an increase in tumor size greater than 2 cm on follow-up.

Outcome:

The primary outcomes of our study included tumor size reduction, preservation of renal function, and low reintervention rate following SAE for giant AMLs. The secondary outcome was the limited perioperative complications.

Statistical analysis:

Version 25.0 of the IBM SPS® software package for Windows was used to conduct the analysis. Numbers (n) and percentages (%) were used to characterize the qualitative data, and the Chi-Square, Fischer Exact, and Monte Carlo tests were used for analysis. The mean±SD for parametric data and the median (range) [minimum and maximum] for nonparametric data were used to characterize the quantitative data.

RESULTS

The present study included 44 patients with 46 AMLs (two patients had bilateral tumor >10 cm). Patients ages ranged from 23-60 years with mean \pm SD of 40.39 \pm 11.8 years. Majority of patients were females (86.3%). Pain was the most common symptom observed, while 32.6% tumors detected incidentally on imaging. Bilateral tumors were observed in 12 patients (27.2%), with 40.9% of tumors located on the right side and 31.8% on the left side. 11(25%) patients associated with TSC complex and all were offered everolimus postoperatively. 34 (77.2%) underwent prophylactic SAE, while 22.7% underwent as an emergency intervention as shown in Table 1.

Table 1: Demographic and Clinical characteristics of patients

Demographic and Clinical characteristics	No. (%)	
No. of patients	44	
No. of tumours	46	
Age (years) (Mean ± SD)	40.39 ± 11.8	
Gender		
Male	06 (13.6)	
Female	38 (86.3)	
Laterality		
Right	18 (40.9)	
Left	14 (31.8)	
Bilateral	12 (27.2)	
Tuberous Sclerosis	11 (25.0)	
Everolimus treatment	11 (25.0)	
Clinical presentation		
Pain	18 (39.1)	
Retroperitoneal haemorrhage	10 (21.7)	
Haematuria	03 (6.5)	
Incidental	15 (32.6)	
Indication of SAE		
Prophylactic	34 (77.2)	
Emergency	10 (22.7)	
Side of Embolization		
Right	24 (54.5)	
Left	18 (40.9)	
Bilateral	02 (4.5)	

Table 2: Outcomes (tumor size, kidney function, success rate and complications) after selective arterial embolization

(SAE) of renal angiomyolipomas (rAMLs)

Variables	No. (%)	p-value
	Mean±SD	
Follow-up, months (Mean \pm SD)	25.2 ± 17.1	
Size of rAMLs, cm (Mean \pm SD)		
Before SAE	13.2 ± 3.12	0.003*
After SAE	10.3 ± 2.45	
Tumor size reduction, cm (Mean \pm SD)	2.9 ± 3.97	
Serum creatinine, mg/dl (Mean ± SD)		
Before SAE	1.0 ± 0.3	0.6
After SAE	0.93 ± 0.5	
e-GFR, mL/min/1.73 m ² (Mean \pm SD)		
Before SAE	76.1 ± 26.0	0.8
After SAE	70.9 ± 22.5	
Hospital stay (in days) (Mean ± SD)	2.2 ± 1.0	
Overall success rate, n (%)	39(84.7)	
Re-intervention on follow-up (Increase in tumor size and/or	06 (13.6)	
recurrence of symptoms)		
Underwent repeat angioembolization	04(9.09)	
Underwent partial nephrectomy	02(4.5)	
Perinephric abscess formation and underwent total nephrectomy	01 (2.2)	
Complications (within months) n (%)	25(56.8)	

Minor		
Post embolization syndrome (PES)	19 (43.1)	
Allergic reaction	03 (6.8)	
Puncture site hematoma	02(4.5)	
Major		
Perinephric abscess	01 (2.2)	

^{*}p-value<0.05 is significant

Table 2 shows the outcomes following SAE among patients. The patients were followed until June 2024. The mean follow-up was 25.2 months(range,6-70).

The reduction in tumor size was assessed based on CTs/MRIs obtained before and after SAE. The mean preoperative tumor size was 13.2 ± 3.12 and significantly reduced to 10.3 ± 2.45 during the follow up time (p-0.003). The change in tumor size during the study period depicted in figure 2. The mean tumor size reduction was 2.9 ± 3.97 . (Fig. 1 c,d,e,f).

The mean creatinine levels before and after SAE were 1.0 ± 0.3 and 0.93 ± 0.5 respectively, after a mean follow up of 25.2 months. The variation was not statistically significant (p-0.6). (Fig.3). The change in e-GFR before and after SAE not statistically significant (p- 0.8). (Fig.4)

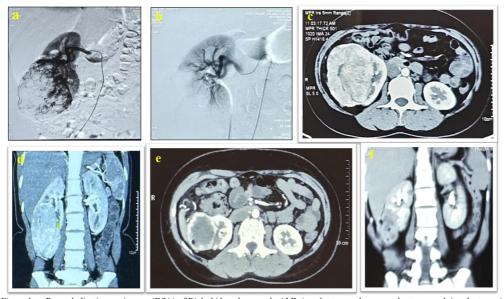


Figure 1: a. Pre-embolization angiogram (DSA) of Right kidney lower pole AML (renal artery and segmental artery supplying the tumor), b. Post-embolization Angiogram of the same kidney with nonspherical polyvinyl alcohol particles (nsPVA) 355–500 µm, (c,d). CT axial and coronal images before SAE. Huge right renal parenchymal fat-containing lesion (AML), (e,f). CT axial and coronal images 6 months after SAE. Tumor size reduction of about (36%).

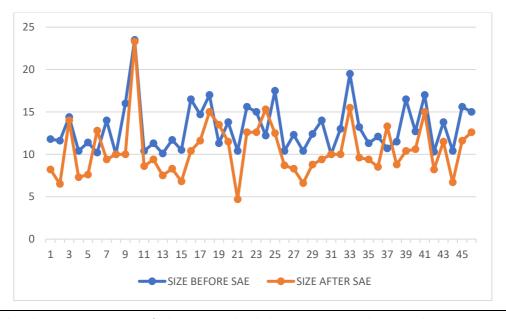
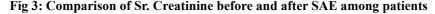


Fig 2: Comparison of size of tumor before and after SAE among patients



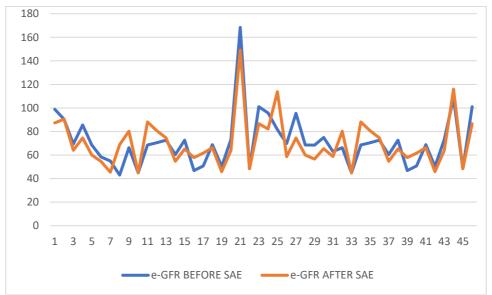


Fig 4: Comparison of e-GFR before and after SAE among patients

The overall success rate was also satisfactory which was 84.7%. 6 (13.6%) patients required re-interventions on follow up. Out of 6 patients, 4 underwent successful repeat angioembolization while 2 patient required partial nephrectomy after repeated failed angioembolization. One patient developed a perinephric abscess 3 weeks after angioembolization, which was initially managed with intravenous antibiotics and percutaneous drainage. Later, she underwent a total nephrectomy due to the kidney's non-functioning status.

The mean hospital stay was 2.2 days. The most common minor complication observed was Post embolization syndrome (PES) in 19 (43.1%) patients followed by allergic reactions and punction site hematoma in 3(6.8%) and 2(4.5%) patients respectively. All minor complications were managed conservatively with NSAIDs, oral antibiotics, and compression dressings at the puncture site.

DISCUSSION

This study demonstrated a significant reduction in tumor size with preserve renal function and low recurrence requiring surgical reintervention following selective embolization of giant renal AML. All procedures were conducted under local anesthesia, which offers an advantage over surgical options that typically require general anesthesia and longer hospital stays.

Traditional surgical options include open or laparoscopic tumor removal via nephron-sparing surgery or total nephrectomy. Minimal invasive treatments include cryo-and radiofrequency ablation or selective endovascular trans-arterial embolization (TAE). Selective Arterial Embolization (SAE) has emerged as a new modality for both preventive and emergency management of renal AMLs, offering a minimally invasive approach that targets small arterial feeders, after the first study by Adler et al^[12] Further, in 1991, Soulen et al. confirmed that embolization of renal angiomyolipomas is safe, well tolerated, and effective in preventing life-threatening hemorrhage. There is limited research directly comparing complete nephrectomy, nephron-sparing surgery, and Selective Arterial Embolization (SAE) for the treatment of renal AMLs [14]. Compared to partial nephrectomy (12%), Selective Arterial Embolization (SAE) for renal AMLs demonstrates lower post-operative morbidity (6.9%), is minimally invasive, and requires a shorter hospitalization period [12, 15]. Additionally, SAE offers rapid stabilization in cases of acute hemorrhage, while preserving renal function by sparing healthy renal tissue, which is especially crucial for patients with tuberous sclerosis complex (TSC) and those with bilateral involvement

Literature on Selective Arterial Embolization (SAE) for giant renal angiomyolipomas (AMLs) is limited. Only a few studies have specifically focused on this subset of AMLs, offering valuable but limited insights into the outcomes and efficacy of SAE for treating giant AMLs^[10-11]

This study evaluated the long-term outcomes of selective arterial embolization (SAE) in patients with giant renal angiomyolipomas (AMLs) and included a cohort of 44 patients with 46 AMLs. In comparison, Abouelkheir et al. [16] and Nozadze et al. [17] included 33 and 56 patients, respectively. However, studies focusing exclusively on giant AMLs. Bishay et al. [10] reported outcomes in 23 AMLs, while El-Assmy et al. [11] included only 9 AMLs.

The present study observed a predominantly female population (86.3%), consistent with the higher prevalence of AMLs in females. Similar findings were reported by Abouelkheir et al. [16] and Nozadze et al. [17], where females constituted 72.7% and 79.6% of their cohorts, respectively. The mean age of patients in this study was 40.39 ± 11.8 years, comparable to the findings of Abouelkheir et al. [16] where the mean age was 38.27 ± 13.9 years, and Bardin et al. [18], which reported a mean age of 52 years. These studies collectively indicate that AMLs most commonly present in middle adulthood. Our study included 25% of patients had TSC, similar with the 36.4%, 40.8%, and 26% reported by Abouelkheir et al. [16], Nozadze et al. [17] and Bardin et al. [18] respectively.

Prophylactic embolization was performed in 77.2% of cases while emergency SAE for acute bleeding was performed in 22.7% of cases. Similar distribution was found by Bardin et al.^[18] and Nozadze et al.^[17], where prophylactic SAE was done in 79% and 79.6% of cases, respectively. The frequent use of prophylactic SAE in these studies highlights its crucial role in preventing rupture, especially in larger renal angiomyolipomas.

The primary outcomes of this study were tumor size reduction, preservation of renal function, and low reintervention rate. Tumor size significantly decreased from a mean of 13.2 ± 3.12 cm pre-SAE to 10.3 ± 2.45 cm post-SAE (p = 0.003). A similar trend was observed in the studies by Prigent et al. [19] and Bardin et al. [18], which reported a mean tumor size reduction of 1.9 ± 1.4 cm and 2.1 ± 2.1 cm, respectively, closely matching the 2.9 ± 3.97 cm reduction observed in the present study.

Renal function was preserved in the majority of patients, with stable serum creatinine levels observed (1.0 ± 0.3 mg/dL pre-SAE versus 0.93 ± 0.5 mg/dL post-SAE, p = 0.6). These results are consistent with findings from Hocquelet et al. [20], Prigent et al. [19], Nozadze et al. [17], and Bardin et al. [18], who also demonstrated that selective SAE has a minimal long-term impact on renal function.

Minor complications observed in this study were post-embolization syndrome (PES) (43.1%), allergic reactions (6.8%) and puncture site hematoma (4.5%). Similar prevalence of PES was observed in other studies, such as Bardin et al. ^[20]and El-Assmy et al. ^[11], where rates ranged from 40% to 50%. Major complications were rare, with only one case of a perinephric abscess leading to nephrectomy, reflecting the overall safety of the procedure.

The overall success rate in this study was 84.7% almost similar with 91.7 % in Abouelkheir et al. [16],85% in Re- Bishay et al. [10] intervention done in 13.6% of patients, which is slightly higher than Hocquelet et al. [20] and Abouelkheir et al. [16] which reported 10% and 5.5 % reintervention rate on follow-up. However, repeat SAE was effective in most cases in this study, with only two patients requiring partial nephrectomy.

To date, only a few studies, including those by Bishay et al. [10]. and El-Assmy et al. [11]., have specifically evaluated SAE for giant AMLs. Our study has a larger cohort of 44 patients compared to 23 in Bishay et al. [10], and 9 in El-Assmy et al. [11]. Moreover, the success rate in our study was notably higher at 84.7%, in contrast to 62% in Bishay et al. [10], (with 38% requiring repeat embolization) and 44% in El-Assmy et al. [11]. These findings highlight the efficacy of SAE as a reliable treatment option for giant renal AMLs, offering improved outcomes compared to earlier studies.

All 11 patients with TSC in this study were prescribed everolimus therapy, but poor compliance noted due to side effects such as skin rashes and ulcer, severe stomatitis and nasopharyngitis and gastritis, only a few patients were able to continue therapy beyond six months. The EXIT-2 trial demonstrated that Everolimus reduced tumor volume by more than 50% in 42% of patients with tuberous sclerosis complex (TSC) and renal angiomyolipomas (AMLs) during long-term follow-up.^[7]

Main limitations of this study are that it was a single-center study with retrospective design and relatively small cohort size. Additionally, the population was heterogeneous, comprising both sporadic and TSC-related cases, as well as patients with different indications for intervention, such as prophylactic versus emergency treatment. Furthermore, the use of Everolimus in all TSC patients could introduce bias, as this medication may reduce tumor volume and potentially influence the outcomes.

CONCLUSION

Selective TAE is a safe and effective treatment modality for giant renal AMLs, offering significant tumor size reduction, symptom relief, and renal function preservation with minimal complications. It represents a valuable alternative to surgical approaches for large AMLs, particularly in high-risk patients or those seeking nephron-sparing options. Future research should focus on optimizing embolization techniques, reducing reintervention rates, and establishing standardized follow-up protocols to further enhance patient outcomes.

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Declaration of Intrest

- Conflict of interest: The authors declare no conflict of interest regarding this study.
- Funding: The funding source had no role in the design, practice or analysis of this study.
- Approval of the research protocol by an Institutional Reviewer Board and the approval number: The study protocol was approved by the Institutional Ethics Committee Approval No. (2023-114-Mch-EXP-22).
- Informed Consent: Written informed consent was obtained from all participants prior to inclusion.
- Registry and the Registration No. of the study/trial-N/A
- Animal Studies-N/A

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