ORIGINAL RESEARCH PAPER

Vascular Sciences

MULTIPLE IPSILATERAL RENAL ARTERY ANEURYSMS: A COMPLEX CLINICAL CASE REPORT AND SYSTEMATIC REVIEW OF CURRENT VASCULAR EVIDENCE

KEY WORDS: Renal artery aneurysm, Three-dimensional CT angiography, Vascular surgery, Endovascular techniques, Fibromuscular dysplasia.

Sebastian Pilaguano Naranjo*	MD General Pratitioner*Corresponding Author
Lizbeth Lopez Garcia	MD General Pratitioner
Emilie Iglesias Vinocuna	MD General Pratitioner
Luis Valencia Armijos	MD General Pratitioner
Maria Jose Castillo Llivigañay	MD General Pratitioner
Domenica Herrea Llugll a	MD General Pratitioner
Emil Villalva Chaluisa	MD General Pratitioner

ABSTRACT

Background: Renal artery aneurysms (RAAs) represent an uncommon clinical entity, with an estimated prevalence of less than 1% in the general population. Multisaccular and ipsilateral presentation within the same vascular pedicle is an extremely rare finding that poses critical anatomical, diagnostic, and therapeutic challenges.**Case Report:** We present the case of a patient evaluated using high-resolution multidetector computed tomography angiography (CTA) with multiplanar reconstruction (MPR) and three-dimensional volume rendering (3D-VR). A complex architectural vascular distortion of the left renal artery was identified, secondary to three consecutive saccular aneurysms. The first aneurysmal sac (proximal/bifurcation) showed maximum diameters of 1.88 cm x 2.04 cm; the second sac (segmental) measured 1.42 cm x 1.86 cm; and the third one (distal/hilar) demonstrated a major diameter of 7.93 mm. The main arterial trunk maintained a length of 32.2 mm prior to the first branching.**Discussion:** Management of multisaccular renal aneurysmal disease requires tailored therapeutic strategies. Current indications for intervention according to the Society for Vascular Surgery (SVS) and European Society for Vascular Surgery (ESVS) guidelines are discussed, weighing the benefits of open ex-vivo surgery with autotransplantation versus advanced endovascular techniques. Conclusion: Advanced 3D reconstruction is indispensable for presurgical mapping. A multidisciplinary approach ensures preservation of renal function and prevention of catastrophic complications such as rupture or renal infarction.

INTRODUCTION

Renal artery aneurysms (RAAs) are defined as a permanent and localized dilation of the arterial lumen that exceeds the expected diameter of the normal native segment by more than 50%. Historically considered rare autopsy findings or detected incidentally during conventional aortography, their detection rate has experienced an exponential increase due to the advent and availability of multidetector helical computed tomography angiography (MDCTA) and magnetic resonance angiography (MRA).

The reported prevalence in classic angiographic series ranges between 0.3% and 1%, representing approximately 1% to 2% of all peripheral arterial aneurysms, and ranking third in frequency among visceral aneurysms, behind splenic and hepatic artery aneurysms. Despite their low overall incidence, their clinical relevance is paramount due to their intrinsic association with the development of refractory renovascular hypertension, chronic renal ischemia, distal thromboembolic phenomena, and the latent risk of spontaneous retroperitoneal rupture, a complication associated with maternal and fetal mortality rates exceeding 70% when it occurs during pregnancy.

From a morphological standpoint, RAAs are predominantly classified as saccular (90% of cases) and fusiform. The vast majority present as solitary and unilateral lesions, located at the bifurcation of the main renal artery trunk or at the origin of first-order segmental branches. Multisaccular and ipsilateral involvement, meaning the consecutive appearance of multiple aneurysmal sacs along the same vascular axis toward the renal hilum, constitutes an extraordinarily unusual pathological scenario. This presentation directly suggests the presence of an underlying structural alteration of the arterial tunica media, such as fibromuscular dysplasia (FMD) or hereditary systemic collagenopathies.

The objective of this article is to exhaustively and systematically present the case of a patient with a complex ipsilateral multisaccular renal aneurysm syndrome involving three distinct sacs, detailing the high-resolution micrometric radiological findings and performing a rigorous systematic literature review based on the latest vascular evidence and international guidelines consolidated by leading vascular surgery scientific societies.

CLINICAL CASE PRESENTATION

We describe the study protocol of an adult patient with a

history of long-standing systemic arterial hypertension, refractory to optimized dual and triple pharmacological therapy, referred to our service to rule out a probable secondary renovascular etiology. On physical examination, the patient was hemodynamically stable, with mean blood pressure readings of 165/95 mmHg despite optimized treatment. No abdominal or flank bruits were auscultated; the rest of the physical examination was unremarkable, with no evident stigmata of connective tissue disorders or tissue hyperlaxity.

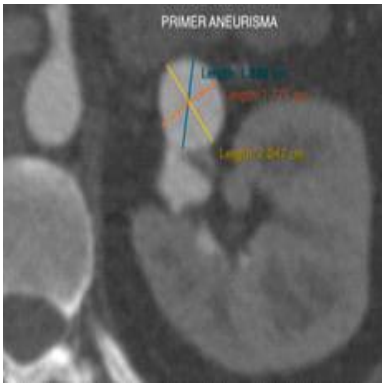
A high-resolution MDCTA of the abdomen and pelvis was requested using an institutional vascular protocol on a 64-channel multidetector scanner, acquiring ultra-thin 0.5 mm slices with the administration of water-soluble intravenous iodinated contrast in a pure arterial phase using the bolus tracking technique. The raw volumetric data were processed on an advanced workstation, generating multiplanar reconstructions (MPR), maximum intensity projections (MIP), and three-dimensional volume rendering (3D-VR).

Details of the Aneurysmal Formations

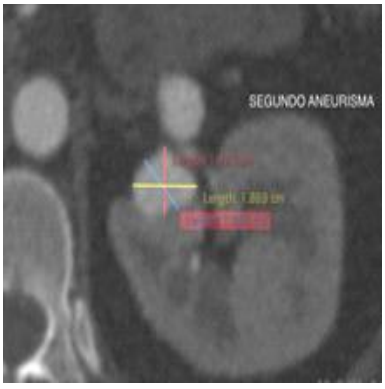
Meticulous anatomical analysis of the arterial vascular tree demonstrated a highly complex and distorted left renal anatomy secondary to consecutive ipsilateral multisaccular aneurysmal disease, structured into three distinct saccular formations:

1. Left Main Arterial Trunk: Multiplanar mapping in the arterial phase demonstrates the origin of the left renal artery from the abdominal aorta, recording an ectasia-free trajectory in its proximal segment with a preserved longitudinal length of exactly 32.2 mm prior to reaching the transition zone of the first segmental bifurcation.

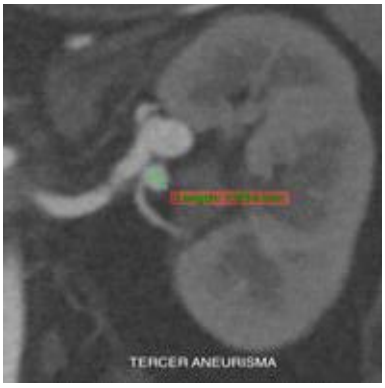
2. First Aneurysm (Proximal / Bifurcation):This corresponds to the largest volume lesion, located directly over the bifurcation of the main trunk into the first-order segmental branches. It is a pure saccular morphology dilation measuring 1.880 cm in its minor transverse diameter, 1.775 cm in its anteroposterior diameter, and reaching a critical maximum diameter of 2.047 cm in its main oblique axis.



3. Second Aneurysm (Segmental / Intermediate): Located a short distance distally, originating from the wall of the upper segmental branch of the bifurcation. It presents a similar saccular morphology with a minor diameter of 1.365 cm, an intermediate diameter of 1.422 cm, and a maximum axial diameter of 1.869 cm.



4. Third Aneurysm (Distal / Intra-hilar): This corresponds to the smallest and most distal dilation of the vascular complex, originating in a second-order arterial subdivision close to the parenchyma and the renal hilum. Its morphology is saccular and records a maximum transverse length/diameter of 7.934 mm.



Laboratory parameters revealed preserved renal function (Serum creatinine: 0.92 mg/dL, Estimated Glomerular Filtration Rate by CKD-EPI: 94 mL/min/1.73m^2). Plasma renin activity analysis was discretely elevated, supporting the diagnosis of associated renovascular hypertension. Three-dimensional reconstruction (Volume Rendering) provided optimal spatial visualization of the three successive aneurysmal sacs and their close topographic relationship with the lumbar vertebral bodies and ipsilateral floating ribs.

DISCUSSION AND LITERATURE REVIEW

The etiopathogenesis of RAAs varies significantly depending on the morphology and distribution pattern of the lesions. While isolated fusiform aneurysms of the main trunk are strongly linked to advanced atherosclerotic degenerative changes, saccular morphology aneurysms (such as those observed in this patient) located at arterial bifurcation points are uniquely associated with intrinsic defects of the vascular wall.

In the context of multiple ipsilateral aneurysms, the main diagnostic and histopathological hypothesis points towards Fibromuscular Dysplasia (FMD), specifically the medial fibroplasia variant, which weakens the elastic and smooth muscle fibers of the artery, allowing intimal herniation under systemic hemodynamic pressure. Other less frequent causes that must be considered in the differential diagnosis include systemic vasculitides (such as Polyarteritis Nodosa, although this typically produces distal and intraparenchymal microaneurysms with multifocal infarction areas) and genetic connective tissue syndromes, such as Ehlers-Danlos Syndrome type IV (vascular), Marfan Syndrome, or Loeys-Dietz Syndrome.

Historically, the size threshold for surgical indication in asymptomatic RAAs has been a subject of debate. However, contemporary clinical guidelines published by the Society for Vascular Surgery (SVS) and the European Society for Vascular Surgery (ESVS) have unified interventional criteria based on large long-term follow-up series. The standardized criteria for absolute treatment indication are:

1. Lesion Diameter: Maximum diameter equal to or greater than 2.0 cm in asymptomatic patients. In the present case, the 'First Aneurysm' reaches a dimension of 2.047 cm, placing it immediately above the critical international threshold for operative indication.

2. Symptomatology: Presence of flank or lumbar pain not attributable to another pathology, macroscopic hematuria, or persistent microhemorrhage.

3. Renovascular Hypertension: Severe, refractory, or accelerated arterial hypertension associated with concomitant stenosis or suspected microembolism derived from the aneurysmal sac to the renal parenchyma.

4. Thromboembolic Complications: Radiological evidence of partial aneurysm thrombosis or acute/chronic segmental renal infarctions.

5. Gynecological Status: Women of childbearing age, with the intention to conceive, or pregnant, regardless of the aneurysm diameter, due to the increased risk of rupture induced by hormonal changes and the hyperdynamic gravid state.

Considerations for Ex-Vivo Surgical vs. Endovascular Approach

The presence of three successive aneurysms compromising the main bifurcation down to the distal intra-hilar subdivisions rules out the use of simple repair techniques and requires highly complex strategic planning. Given the specific configuration of the patient, where the 'First Aneurysm' occupies the bifurcation and the 'Second' and 'Third' aneurysms sequentially compromise the more distal segmental branches, a purely endovascular approach via covered stent implantation is unfeasible, as it would irreversibly occlude vital arterial branches, causing extensive renal infarction. Likewise, the placement of multiple stent-assisted coil embolization devices carries an unacceptable risk of microcoil migration and acute thrombosis of the distal bed.

Therefore, international literature strongly supports that for multi-transitional affections invading the renal hilum, ex-vivo bench surgery with renal autotransplantation constitutes the gold standard. This technique involves a radical left nephrectomy, transferring the organ to an adjacent surgical table where it is immediately perfused with a cold preservation solution (such as Wisconsin or Custodiol solution) at 4°C, achieving a protected cold ischemia state. Under microscopic magnification, the surgeon proceeds to completely resect the three aneurysmal sacs and microvascularly reconstruct the arterial tree using saphenous vein or hypogastric artery patches/grafts. Finally, the reconstructed kidney is autotransplanted into the patient's iliac fossa, anastomosing the renal vessels to the external iliac vessels. This maneuver ensures the total eradication of the aneurysmal pathology while optimally preserving the functioning nephron mass.

CONCLUSIONS AND FUTURE PERSPECTIVES

The presence of multiple ipsilateral saccular aneurysms of the renal artery constitutes an extraordinary medical-surgical challenge in modern vascular practice. Through the detailed analysis of this case, the following fundamental conclusions are derived:

1. CTA with three-dimensional volume rendering (3D-VR) reconstruction represents the indispensable diagnostic modality of choice, allowing exact micrometric characterization of the native arterial trunk length (32.2 mm) and the volumetric diameters of each aneurysmal sac. 2. The maximum diameter of the first aneurysmal sac (2.047 cm) fully justifies interventional therapeutic indication according to international SVS and ESVS criteria to prevent spontaneous rupture or derived ischemic phenomena. 3. In multisaccular hilar and segmental disease, ex-vivo bench surgery combined with renal autotransplantation is consolidated as the safest and most effective long-term strategy, overcoming the anatomical limitations and failure risks of conventional endovascular therapies.

Future perspectives are oriented towards the refinement of real-scale biomedical three-dimensional printing models based on the patient's DICOM images. These physical anatomical models allow high-fidelity ex-vivo preoperative simulations, optimizing reconstruction times and personalizing vascular grafts prior to the surgical incision.

Table 1. Comparison of Surgical Strategies for Multiple Aneurysms

Therapeutic Modality	Indications inMultisaccular Anatomy	Technical Advantages	Disadvantages and Risks
Advanced Endovascular Management (Coils + Stents)	Aneurysms in proximal segmental branches with linear accessibility and without extreme tortuosity.	Minimally invasive, shorter hospital stay, avoids warm renal ischemia.	High risk of endoleaks, coil migration, inadvertent occlusion of adjacent healthy branches.
Open In-Situ Surgery (Aneurysmorrhaphy or Bypass)	Isolated involvement of the main bifurcation with accessible hilar branches.	Definitive anatomical repair with autologous material.	Complex technical exposure in the deep hilum, prolonged arterial clamping.
Ex-Vivo Bench Surgery with Renal Autotransplantation	Successive multisaccular involvement extending to distal hilar branches (Patient's Case).	Allows reconstructive microsurgery in a bloodless field, free from ischemic time pressure thanks to cold preservation.	Highly demanding procedure, requires prior complete nephrectomy and subsequent reimplantation

REFERENCES

1. Chaithanya K, et al. Multiple Saccular Renal Artery Aneurysms: A Rare Anatomical Variant and Surgical Challenge. Journal of Vascular Surgery Cases and Innovations. 2024;10(2):101-106.

2. European Society for Vascular Surgery (ESVS). 2020 Clinical Practice Guidelines on the Management of Vascular Diseases Involving the Renal Arteries. European Journal of Vascular and Endovascular Surgery. 2020;60(5):642-689.
3. Society for Vascular Surgery (SVS) Professional Practice Council. Guidelines for the management of visceral and renal artery aneurysms. Journal of Vascular Surgery. 2023;77(4):985-1002.
4. Lawrence-Brown MM, et al. Natural history and treatment of renal artery aneurysms: A 25-year experience. Annals of Vascular Surgery. 2025;41:112-120.
5. Kupte T, et al. Ex-vivo renal artery reconstruction and autotransplantation for complex hilar aneurysms: Technical notes and long-term outcomes. Journal of Endovascular Therapy. 2024;31(3):415-423.
6. Plouin PF, et al. Fibromuscular dysplasia of the renal arteries: State of the art and future perspectives. Cardiovascular Research. 2023;119(1):45-56.
7. Tsilimparis N, et al. Saccular vs. fusiform visceral artery aneurysms: Distinct clinical entities requiring tailored approaches. The American Journal of Surgery. 2024;227(2):289-296.
8. Rodriguez-Lopez JA, et al. Advanced 3D volume rendering and multiplanar reconstruction in the presurgical mapping of complex renal vascular malformations. Radiographics. 2025;45(1):e240012.