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Case Report

Rare presentation of intraparenchymal renal artery aneurysm disguised as renal cell carcinoma: a case report and literature review

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Abstract: Renal artery aneurysms (RAAs) are rare vascular abnormalities that are often detected incidentally, as most patients are asymptomatic and the lesions are discovered during imaging for unrelated conditions. Differentiating intraparenchymal RAAs (IPRAAs) from renal tumors using non-invasive imaging techniques remains challenging. Misdiagnosis as a renal malignancy, such as renal cell carcinoma (RCC), poses a significant risk of catastrophic hemorrhage if inadvertently subjected to biopsy or surgical procedures. We reported the case of a 75-year-old female with an IPRAA that mimicked RCC on contrast-enhanced computed tomography (CECT). However, a suspicious feeding artery to the renal mass was identified on computed tomography angiography (CTA) images. Further evaluation with positron emission tomography/magnetic resonance imaging (PET/MR) suggests the diagnosis of IPRAA. This was confirmed by digital subtraction angiography (DSA), and the aneurysm was successfully treated with transcatheter embolization. This case highlights the importance of including IPRAA in the differential diagnosis of renal masses and emphasizes the need for careful imaging evaluation to avoid potentially life-threatening complications from misdiagnosis.

Keywords: Renal artery aneurysm, renal cell carcinoma, digital subtraction angiography, PET/MR

Introduction

Renal artery aneurysms (RAAs) are uncommon vascular abnormalities characterized by localized dilatation of the renal artery, potentially leading to serious complications such as rupture, thrombosis, or embolism [1]. Their pathogenesis is multifactorial and has been associated with atherosclerosis, fibromuscular dysplasia, vasculitis, trauma, and connective tissue disorders [1]. The estimated prevalence of RAAs is less than 1% in the general population and approximately 2.5% among hypertensive patients undergoing angiography [2]. They are frequently detected incidentally during imaging examinations performed for unrelated conditions. A female predominance (60%) and right-sided predilection (60%) have been reported [2]. While most RAAs occur at the main renal artery bifurcation [3], intraparenchymal RAAs (IPRAAs) are exceedingly rare, accounting for fewer than 10% of all RAAs [2, 4].

Differentiating IPRAA from renal tumors, particularly renal cell carcinoma (RCC), using standard cross-sectional imaging remains diagnostically challenging because of overlapping enhancement characteristics [5-7]. Each imaging modality provides partial yet complementary diagnostic information. Contrast-enhanced computed tomography (CECT) remains the most widely used technique in clinical practice, as it effectively demonstrates vascular continuity, mural calcification, or intraluminal, which are characteristic indicators of aneurysm. However, when RAAs are partially thrombosed or exhibit a saccular configuration, they may appear as solid masses, leading to overlapping imaging features with RCCs. Magnetic resonance (MR) imaging offers superior soft-tissue contrast and dynamic angiographic reconstruction, allowing a clearer depiction of vascular structure morphology and renal parenchymal enhancement pattern. Nevertheless, high-resolution MR remains inconclusive when tumor coexists with aneurysm or blood flow artifacts supervene. In such context, positron emission tomography (PET) imaging can serve as an important adjunct for molecular-level differentiation [7]. Conventional [^{18}F] FDG-PET, however, has limited sensitivity for these lesions, primarily due to renal tracer excretion and the variable glucose metabolism of RCCs. RAAs typically demonstrate a homogeneous blood-pool distribution without focal hypermetabolism, which can be further clarified when integrated with CT or MR imaging.

A mistaken diagnosis of RCC may lead to percutaneous biopsy or surgical intervention, carrying a substantial risk of aneurysm rupture or life-threatening hemorrhage. Conversely, missing a malignant diagnosis may forfeit the

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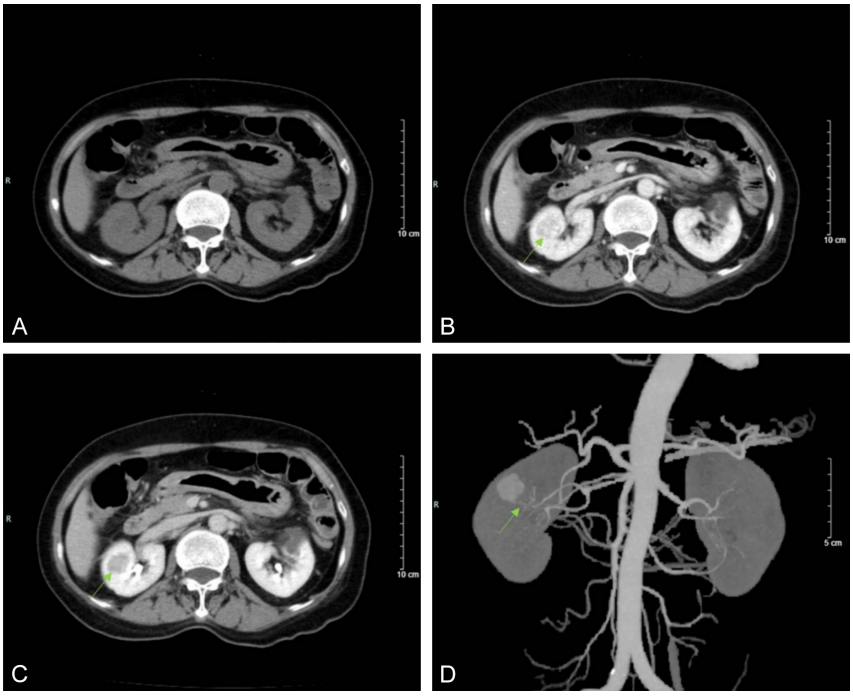

Figure 1. Contrast-enhanced CT (CECT) images of the right kidney. A. Unenhanced phase shows the lesion with attenuation similar to renal parenchyma. B. Arterial phase demonstrates heterogeneous enhancement of the lesion (arrow). C. Excretory phase shows further washout (arrow). D. Three-dimensional CTA reconstruction image clearly shows the feeding artery (arrow) from the right renal artery segmental branch supplying the mass. Multiple renal cysts are also present.

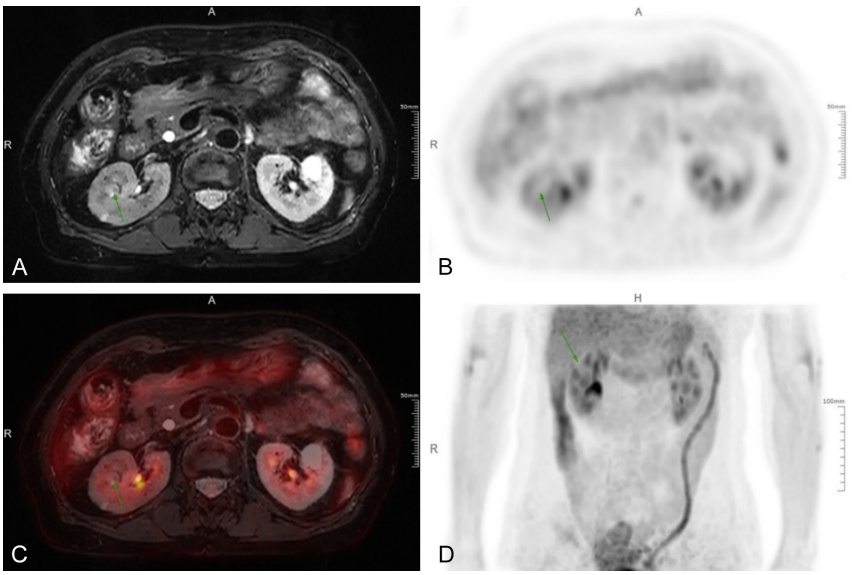

Figure 2. [^{18}F] FDG-PET/MR images of the right kidney. A. T2WI shows a heterogeneously hyperintense mass (arrow). B. FDG emission image shows a corresponding hypometabolic defect in the same region. C. Hybrid FDG-PET/MR image. D. 3D MIP image of FDG-PET/MR shows a hypometabolic defect lesion (arrow) in the kindey.

optimal window for curative treatment. Therefore, a comprehensive imaging assessment including CT, MRI and/or nuclear medicine examinations, should be conducted for any enhancing renal mass before proceeding with invasive procedures. The possibility of IPRAA must be carefully considered and excluded.

Here, we present an instructive case of a saccular IPRAA that radiologically mimicking RCC. This case highlights the diagnostic pitfalls and emphasizes the critical imaging features that can aid in distinguishing these entities, thereby preventing potentially catastrophic management errors.

Case presentation

A 75-year-old female presented to the Department of Gastroenterology two months earlier with gastrointestinal bleeding. An abdominal CECT scan incidentally revealed a well-circumscribed, heterogeneously enhancing nodule in the upper pole of the right kidney. This finding raised a strong suspicion of RCC. Several simple renal cysts were also identified. The patient was subsequently referred to our Department of Urology in stable condition. Her medical history included hypertension, well-controlled with medication, and a prior laparoscopic cholecystectomy. Physical examination was unremarkable, with normal blood pressure, blood glucose, and renal function.

CECT confirmed a round-to-oval mass (approximately 2 cm) in the upper pole of the right kidney. The mass exhibited prominent heterogeneous enhancement. Although CECT showed features similar to RCC, characterized by rapid contrast uptake and washout, careful image analysis suggested that the lesion might actually represent an IPRAA. This diagnosis was supported by three-dimensional reconstruction and computed tomography angiography (CTA), which clearly demonstrated a feeding artery arising from a segmental branch directly connected to the mass (**Figure 1**).

To confirm the diagnosis and minimize radiation exposure, [^{18}F] fluorodeoxyglucose-positron emission tomography/magnetic resonance imaging ([^{18}F] FDG-PET/MR) scan was performed (**Figure 2**). This scan revealed a well-circumscribed nodule in the upper-middle portion of the right kidney, measuring approximately 1.9×1.4 cm. In the MR imaging sequences, the nodule showed as an iso- to hypo-intensity on T1-weighted imaging (T1WI) and as a heterogeneous hyper-intensity on T2-weighted imaging (T2WI). During contrast enhancement, it exhibited prominent enhancement in the arterial phase, with decreased enhancement in the nephrograph-

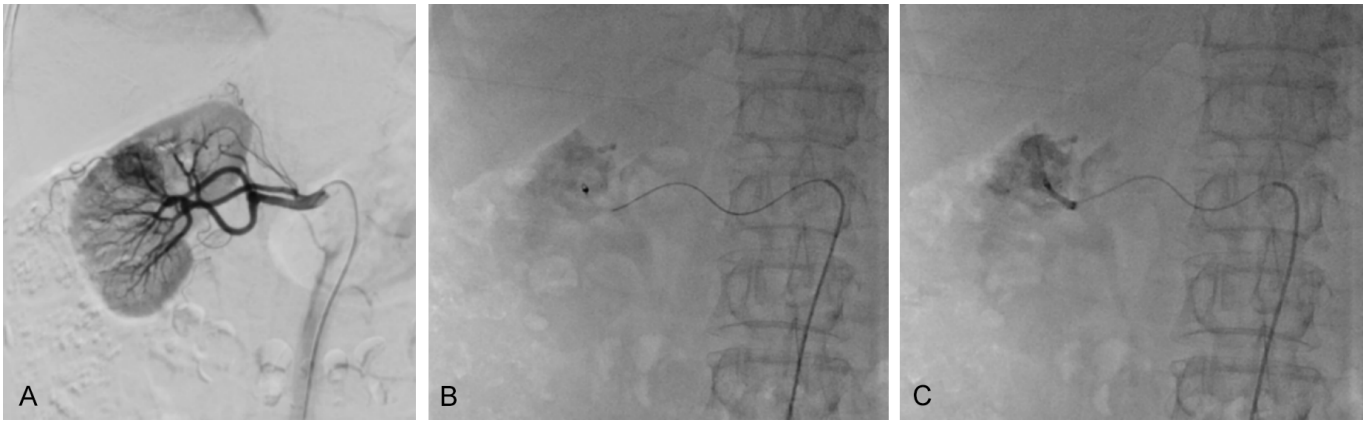

Figure 3. Digital subtraction angiography (DSA) and embolization. A. Selective right renal arteriography confirms a saccular intraparenchymal renal artery aneurysm (IPRAA, arrowhead) approximately 2 cm in diameter. B. Super-selective catheterization of the feeding branch and deployment of embolization coils (arrow) within the aneurysm sac and proximal feeding artery. C. Post-embolization angiography demonstrates complete occlusion of the aneurysm sac and the feeding branch, with no residual filling. Surrounding renal parenchymal perfusion is preserve

ic and delayed phases. Corresponding areas on [^{18}F] FDG-PET demonstrated a defect in radioactive tracer uptake.

Based on these multimodal imaging findings, the primary differential diagnosis favored IPRAA over RCC. In order to confirm the nature of the lesion and to guide treatment planning, digital subtraction angiography (DSA) was performed. Selective right renal arteriography confirmed the presence of a cystic IPRAA, approximately 2 cm in diameter (**Figure 3A**). The aneurysm was successfully treated with super-selective transcatheter coil embolization of the feeding branch (**Figure 3B**). Post-embolization angiography confirmed complete obliteration of the aneurysmal sac with preservation of surrounding renal parenchyma (**Figure 3C**). The patient tolerated the procedure well and was discharged without complications.

Discussion

The clinical presentation of RAAs is highly variable, ranging from asymptomatic incidental findings to symptomatic cases presenting with flank pain, hematuria, or hypertension [8]. This heterogeneity complicates the diagnostic process. The majority of RAAs are incidentally detected during cross-sectional imaging examinations and exhibit a predilection for elderly female population, with a higher incidence on the right side. Our case precisely conforms to the typical demographic: a 75-year-old woman with an incidentally discovered RAA on the right side. The rarity of IPRAAs - particularly in elderly patients - highlights the importance of including them in the differential diagnosis of enhancing renal masses when RCC is suspected. This case accurately demonstrates the diagnostic challenge of such lesions and the potentially severe consequences of misdiagnosis.

Previous studies identified hypertension (73%), fibromuscular dysplasia (34%), atherosclerosis (25%), smoking (15%), and concurrent extrarenal aneurysms (6.5%) as common risk factors for RAAs [3]. The primary causes of IPRAAs involve intrinsic vascular pathologies, including fibromuscular dysplasia, atherosclerosis, and vasculitis (e.g., polyarteritis nodosa). In addition, trauma or congenital vascular malformations may also trigger this disease, but such cases are relatively rare [2]. At present, there are several classification systems for RAAs. Among them, the classification scheme proposed by Rundback et al. [9, 10] is the most widely used. Type I refers to cystic aneurysms of the main trunk or branches of the renal artery, Type II refers to the spindle-shaped dilation of the main trunk of the renal artery, and Type III refers to aneurysms within the renal parenchyma. This classification provides valuable guidance in determining the optimal therapeutic strategy. Gonzalez et al. [11] proposed that for type I RAAs, both endovascular interventional therapy and open surgery are viable options; while for type II RAAs, only open surgery is recommended; for type III RAAs, the optimal treatment strategy is selective embolization of renal artery branches.

In actual clinical practice, the treatment of renal aneurysms mainly includes observation and follow-up, surgery, and vascular interventional techniques [2-4]. The specific treatment plan remains controversial, especially in terms of the timing of surgery, surgical methods, and follow-up plan. The currently recommended treatment plan is [1-4, 10-13]: 1. For small aneurysms (less than 2 cm) without symptoms, observation and follow-up can be adopted. 2. For those with the following conditions, surgical treatment should be performed: (1) If the aneurysm diameter is greater than 2 cm with clinical symptoms; (2) If it is a young woman of childbearing age; (3) If the aneurysm progresses during follow-up examinations; (4) If there is severe hypertension and the effect of antihypertensive drugs is poor. The selection of an appropriate treatment strategy requires a comprehensive evaluation of multiple factors, including the aneurysm's size, location (intrarenal or extrarenal), morphology, and number, as well as the

patient's age, comorbidities, renal function, and clinical presentation. For type III IPRAAs, as in the present case, super-selective transcatheter embolization is generally considered the preferred first-line therapeutic option. This minimally invasive technique offers the advantages of effectively occluding the aneurysm while preserving maximal renal parenchyma [11]. With the ongoing advancement of endovascular interventional technologies, the need for nephrectomy has markedly declined [4, 14]. Currently, this surgical procedure is typically only used when embolization or vascular reconstruction cannot be performed technically, or when the implementation risk is too high.

Various imaging modalities provide complementary but imperfect information, as each has its own limitations [15, 16]. Conventional anatomical imaging techniques, such as computed tomography angiography (CTA) and magnetic resonance angiography (MRA), are superior for delineating vascular anatomy and structural morphology. Among these, CECT remains the most widely used examination technique at present: it reliably demonstrates vascular continuity, mural calcifications, or intraluminal thrombus, and these features are important indications of aneurysms. However, when an aneurysm develops internal thrombosis or assumes a cystic morphology, it may mimic a solid mass, making it difficult to distinguish from RCC. Partially thrombosed RAAs can anatomically mimic necrotic or complex cystic RCCs. MR imaging offers superior soft-tissue contrast and facilitates dynamic angiographic reconstructions, thereby enhancing visualization of vascular structures and renal parenchymal enhancement patterns. However, even high-resolution MR imaging may fail to resolve equivocal cases, particularly when tumor and aneurysm coexist or when flow-related artifacts obscure vascular details.

As a molecular metabolic imaging modality, PET cannot fully replace CT or MR but rather serves a complementary role. The principal advantage of PET lies in its ability to characterize lesions based on metabolic activity. Most RCC subtypes, particularly clear cell RCC, demonstrate increased glucose metabolism and show significantly increased tracer uptake on [^{18}F] FDG-PET imaging. This characteristic can be quantitatively demonstrated by the increased maximum standardized uptake value (SUV_{max}) [17]. In contrast, RAAs, being non-neoplastic vascular malformations, typically show no [^{18}F] FDG uptake and appear as radioactive defect areas on PET images. This metabolic "mismatch" - intense enhancement on CT scans with absent [^{18}F] FDG uptake - is a strong specific sign indicating RAA.

Traditional [^{18}F] FDG PET has limited diagnostic value for primary RCC, given the variability in glycolytic activity among RCC subtypes and the potential masking effect from urinary tracer excretion [18]. However, [^{18}F] FDG-PET remains clinically value for detecting metabolically active metastatic lesions and for prognostic assessment in selected clinical scenarios [19]. When used alone, [^{18}F] FDG-PET provides limited accuracy in characterizing renal masses; both hypometabolic RCCs and IPRAAs - typically showing only blood-pool distribution - can yield negative or indeterminate results. Without the support of vascular imaging, such findings are insufficient to confirm or exclude malignancy. Therefore, integrating metabolic information from PET with anatomical data from CT or MR enables comprehensive lesion characterization. This multimodal approach can reveal defining features of aneurysms - such as luminal continuity, mural thrombus, and wall calcification - thereby facilitating accurate differentiation from renal neoplasms.

Two emerging PET modalities - PSMA-targeted and carbonic anhydrase IX (CAIX)-targeted immuno-PET - offer valuable potential for differentiating RAAs from RCCs [20]. PSMA is expressed in the neovasculature of various solid tumors and exhibits variable expression levels in RCCs. A systematic review indicates that that PSMA PET/CT achieves meaningful detection rates at all stages of the disease course [21]. Moreover, PSMA PET/CT demonstrates superior efficacy to conventional imaging modalities in the localization of metastatic lesions [20, 21]. In distinguishing RAAs from RCCs, the malformed vessels of aneurysms - although abundant - typically exhibit absent or minimal PSMA uptake owing to a lack of PSMA expression. When this metabolic pattern is supported by anatomic vascular imaging findings consistent with a benign vascular lesion, a diagnosis of aneurysm can be confidently established.

The carbonic anhydrase 9 (CAIX) immunotargeted PET using [^{89}Zr] Zr-girentuximab as a tracer may have greater potential in differentiating aneurysms from malignant tumors. Girentuximab is a chimeric monoclonal antibody targeting CAIX, which is a tumor-associated antigen highly expressed in clear cell RCC. This approach may aid in distinguishing RCC from other renal lesions [22, 23]. Multicenter phase III ZIRCON Trial demonstrates that [^{89}Zr] Zr-girentuximab PET achieves high sensitivity (85.5%) and specificity (87.0%) in identifying clear cell RCC among indeterminate renal masses, with a favorable safety profile and excellent inter-observer agreement. A positive [^{89}Zr] Zr-girentuximab PET scan strongly suggests a malignant solid tumor due to the absence of CAIX expression in aneurysms. Conversely, a negative result, when corroborated by characteristic vascular imaging findings, supports a benign vascular lesion and may obviate the need for biopsy. Early clinical experience has confirmed the tracer's safety and tolerability, providing a foundation for broader clinical application [24].

Although initial interpretation favored RCC due to the enhancing renal mass, detailed analysis of specific imaging features - particularly the visible feeding artery and the FDG photopenic defect - strongly suggested an IPRAA. This prompted definitive evaluation with DSA, the gold standard for vascular imaging, which confirmed the diag-

nosis (**Figure 3A**) and allowed for successful and minimally invasive endovascular management (**Figure 3B**, **3C**).

Conclusion

In conclusion, this case of an IPRAA mimicking RCC highlights a critical diagnostic pitfall in renal mass assessment. Misdiagnosis can lead to catastrophic complications if percutaneous biopsy or nephron-sparing surgery is attempted. Radiologists and urologists should maintain a high index of suspicion for IPRAAs when encountering an enhancing renal mass, especially in elderly patients. For renal masses indeterminate between RCC and IPRAA on CECT, further evaluation with PET is recommended. Awareness of these distinguishing features and prompt consideration of confirmatory DSA in equivocal cases are essential for accurate diagnosis and safe management, such as endovascular embolization for IPRAAs. This approach helps prevent unnecessary and potentially hazardous interventions aimed at presumed renal malignancy.

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Disclosure of conflict of interest

None.

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