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A Case Report: Two-Stage Nephron-Sparing Strategy for Ruptured High-Risk Renal Epithelioid Angiomyolipoma

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Case Report

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Abstract

Epithelioid angiomyolipoma (EAML) is a rare renal tumor with malignant potential that may present with spontaneous rupture and Wunderlich syndrome. We report a 37-year-old woman with a ruptured left renal EAML who remained hemodynamically stable and was initially managed conservatively. After a 2-month interval allowing hematoma organization, she underwent retroperitoneal robot-assisted partial nephrectomy (RAPN). The 8 × 7 × 4 cm tumor was completely excised with a warm ischemia time of 20 minutes and minimal blood loss. Histopathology confirmed EAML demonstrating aggressive malignant features; the tumor met the adverse prognostic parameters of the 2022 WHO classification (including > 70% atypical epithelioid cells, pathologic mitotic figures, and coagulative necrosis) and simultaneously fulfilled all four malignant risk criteria established by Brimo and Nese, defined by a maximum diameter of 8 cm, > 70% atypical epithelioid component, pathologic mitoses, and coagulative necrosis. Genetic analysis identified a somatic TSC2 frameshift mutation without germline alterations. No recurrence or metastasis was detected during early follow-up. This case suggests that delayed nephron-sparing surgery may be a feasible option for selected stable patients with ruptured high-risk EAML.

Introduction

Angiomyolipoma (AML) is usually a benign renal mesenchymal tumor, but epithelioid angiomyolipoma (EAML), a rare perivascular epithelioid cell tumor (PEComa) subtype, can behave aggressively and metastasize[1, 2]. According to the 2022 WHO classification, EAML diagnosis relies on an epithelioid-predominant component or specific high-risk features[3]. Spontaneous renal hemorrhage may lead to Wunderlich syndrome (WS), which typically presents with acute flank pain, although the classic triad is uncommon[4]. In EAML, the risk of rupture increases with tumor size because of abnormal vascular architecture and microaneurysm formation[5]. Management of ruptured giant renal tumors remains controversial: emergency radical nephrectomy is effective in unstable patients but sacrifices renal function, while transcatheter arterial embolization may be incomplete and acute nephron-sparing surgery is technically difficult because of bleeding, edema, and poor anatomical planes. Here, we report a hemodynamically stable patient with ruptured high-risk EAML successfully treated using a two-stage strategy: initial conservative stabilization followed by delayed retroperitoneal robot-assisted partial nephrectomy. This case highlights the feasibility of delayed nephron-sparing surgery in selected stable patients and provides insight into pathological risk stratification and molecular findings[6, 7].

Case Presentation

Patient Demographics and Medical History

The patient was a 37-year-old woman with no significant past medical history, no family history of renal tumors, and no features suggestive of tuberous sclerosis complex or other hereditary syndromes **(Table 1)**. She recalled that a routine abdominal CT about 1.5 years earlier had shown a left renal mass containing distinct macroscopic fat attenuation signals, which initially favored a classic benign angiomyolipoma (AML) (Figure 2A), but no further evaluation or follow-up was performed.

Timeline

Table 1: Timeline of Clinical Course Relative to Initial Presentation (Day 0 = Emergency Admission)

Phase	Study Day	Clinical Events and Interventions	Key Indicators and Test Results
Acute Onset	Day 0	Emergency admission for sudden left flank pain for 6 hours; imaging confirmed rupture and hemorrhage of a massive left renal tumor	Hb 125 g/L, BP 133/92 mmHg; hemodynamically stable
Conservative Decision	Day 1	Urgent urological consultation, emergency resection ruled out, absolute bed rest and dynamic monitoring plan established	Hb 115 g/L; tumor marker NSE 32.4 ng/ml
Acute Phase Resolution	Day 5	Clinical symptoms relieved, no signs of persistent bleeding, discharged with advice for 1 month of bed rest	Hb 117 g/L; hs-CRP 50.35 mg/L(peak value on day 3 of admission)
Delayed Readmission	Day 64	Follow-up after 2 months; CT showed exudate organization and hematoma absorption, but the lesion had slightly enlarged	Preoperative VTE assessment: Caprini score 0 (Low risk)
Surgical Treatment	Day 67	Robot-assisted laparoscopic partial nephrectomy performed	Warm ischemia time 20 min, surgical margin 0.5 cm from tumor, blood loss 50 ml
Pathological Confirmation	Day 73	Postoperative pathology confirmed the diagnosis; patient recovered well and was discharged	EAML, met 4 high-risk WHO parameters, indicating high malignant potential
Follow-up Phase	Day 248	Outpatient review at 6 months postoperatively; contrast-enhanced abdominal CT performed	Regular post-surgical changes, left renal cyst stable (0.8 cm); no evidence of local recurrence or metastasis

Initial Evaluation and Conservative Management During the Acute Phase

On Day 0, the patient developed sudden severe left flank pain and presented to the emergency department 6 hours later. She had no gross hematuria or urinary symptoms, and her vital signs were stable on admission. Emergency CT and subsequent MRI showed a ruptured left renal mass with perirenal hematoma, suggesting tumor-related hemorrhage (Figure 2B). Because she remained hemodynamically stable without evidence of persistent active hemorrhage, worsening flank pain, or gross hematuria, the clinical team initiated an intensive first-stage conservative regimen. This conservative management comprised strict absolute bed rest, ECG monitoring, prophylactic hemostatic therapy, and empirical antibiotic coverage with prophylactic Cefazolin Sodium Pentahydrate following a multidisciplinary urological consultation. Throughout the acute monitoring phase, her systemic parameters and hemoglobin levels stabilized successfully, and her acute flank pain subsided promptly. Given the excellent

therapeutic response and the patient's explicit preference for non-invasive medical optimization over immediate interventions, transcatheter arterial embolization (TAE) was deliberately withheld. The patient was discharged after 5 days with instructions for prolonged rest, with a clinical recommendation for outpatient reassessment after the planned observation period. During the conservative observation period, a follow-up CT was performed on Day 36 to monitor the hematoma status (Figure 2C). Her pain gradually improved, and she was discharged after 5 days with instructions for continued rest and follow-up.

Second-Stage Deferred Surgery: Implementation of RAPN

After a 64-day rest period, the patient was readmitted for delayed surgery. Repeat CT performed on Day 64 demonstrated that the hematoma had entered the organized phase, although the lesion had slightly enlarged (Figure 2D), and physical examination showed resolution of left flank tenderness. To objectively evaluate anatomical complexity before delayed surgery, the R.E.N.A.L. nephrometry score was calculated based on preoperative contrast-enhanced CT scans as 9P. The components were detailed as follows: R (Radius) = 3 points (maximum diameter 8.0 cm); E (Exophytic/Endophytic) = 1 point (≥ 50% exophytic); N (Nearness to collecting system/renal sinus) = 3 points (≤ 4 mm); A (Anterior/Posterior) = P (Posterior aspect); and L (Location relative to polar lines) = 2 points (crossing the upper polar line). This high-complexity classification highlighted the severe technical challenges of retroperitoneal RAPN following prior tumor rupture. Therefore, we plan to perform a postponed robot-assisted laparoscopic partial nephrectomy, while keeping radical nephrectomy as a backup plan. During surgery, dense adhesions were found around the tumor because of prior rupture and inflammation, but the robotic system allowed careful dissection and precise tumor removal (Figure 1A). The mass was completely excised and immediately isolated using a specimen retrieval bag (endobag) to strictly prevent tumor seeding (Figure 1B). Following reconstruction of the renal defect (Figure 1C), the retroperitoneal space was extensively irrigated with sterile saline; the total warm ischemia time was 20 minutes with only 50 mL blood loss.

Pathological Diagnosis and Risk Stratification

Frozen section initially suggested a vascular smooth muscle tumor with hemorrhage and necrosis. Final histopathology confirmed EAML with extensive hemorrhage and necrosis (Figure 1D). The mass (8 X 7 X 4 cm) contained >70% atypical epithelioid cells and definitive pathologic mitotic figures. This presentation strictly fulfilled the malignant risk classification established by Brimo and Nese across all four parameters (tumor size >7 cm, >70% atypical epithelioid cell component, presence of pathologic mitoses, and coagulative necrosis)[8,9]. Concurrently, these adverse features aligned with the 2022 WHO classification parameters for predicting aggressive behavior in renal EAML. NGS revealed a somatic TSC2 frameshift mutation, while no germline pathogenic mutation was detected, suggesting a sporadic tumor driven by TSC2 alteration and potentially sensitive to mTOR-targeted therapy if recurrence occurs.

Postoperative Recovery and Follow-up

Although a transient, self-limiting systemic inflammatory spike (peak hs-CRP 202.48 mg/L, PCT 0.58 ng/mL) and a mild observational fluctuation in serum creatinine (86 μmol/L) were recorded on postoperative day 3 due to extensive retroperitoneal adhesions, no active intervention was required, and renal function spontaneously recovered to baseline prior to discharge. At the 6-month postoperative follow-up (Day 248), contrast-enhanced CT showed expected postoperative changes without evidence of local recurrence or distant metastasis (Figure 2E).

Discussion

Key Findings and Clinical Relevance

This case demonstrates the clinical feasibility of a "two-stage delayed surgery" protocol for ruptured high-risk renal EAML in hemodynamically stable patients. Rather than performing emergency radical nephrectomy, the first stage utilizes conservative stabilization. The subsequent 2-month interval allows the acute hematoma to organize and retroperitoneal inflammation to subside, facilitating a safe, delayed RAPN. Despite dense adhesions, delayed RAPN achieved an R0 resection, a short WIT (20 minutes), minimal blood loss (50 mL), and maximum preservation of the functional renal parenchyma. Postoperative pathology and NGS confirmed sporadic EAML with a somatic TSC2 frameshift mutation, fulfilling the 2022 WHO adverse prognostic features and all four Brimo and Nese criteria[10]. Crucially, the preoperative R.E.N.A.L. nephrometry score was calculated as 9P. Successfully eradicating this high-complexity ruptured tumor via delayed retroperitoneal RAPN demonstrates a potential technical reference for late-stage minimally invasive nephron preservation in carefully selected patients.

Comparison with Existing Literature

The clinical course, diagnostic hurdles, and management of EAML vary widely across published reports **(Table 2)**. Spontaneous retroperitoneal rupture is heavily correlated with tumor size (typically >4 cm or >7 cm) due to abnormal, elastin-poor angiogenesis and aneurysm formation[11]. In the cases reported by Benincasa et al. (2021) and Chhatbar et al. (2023), unstable patients presenting with hemorrhagic shock underwent emergency transperitoneal radical nephrectomy as a life-saving measure. Similarly, Cao et al. (2025) performed laparoscopic radical nephrectomy on the third day of admission for a giant 17.5 cm ruptured tumor in a patient with TSC.

Table 2: Comparative Analysis of Interventions for Spontaneously Ruptured EAML/AML (2021–2026)

Author & Year	Age / Sex	Tumor Size	Acute Presentation	Acute Management	Surgical Mode	Pathological Features & Outome
Liulytė et al. (2020) [12]	40/ Male	4.3 cm	Asymptomatic	Elective planning	Left partial nephrectomy	Benign EAML; no recurrence at 6 years
Benincasa et al. (2021) [13]	40/ Male	8.0 x 6.0 cm	Severe pain, shock	Fluid resuscitation	Emergency right radical nephrectomy	EAML with necrosis; uneventful recovery
Luo et al. (2022) [14]	34/ Female	9.0 x 4.7 cm	Asymptomatic (giant mass)	Elective surgery	Right retroperitoneal RAPN	CAML; no recurrence at 1 year
Chhatbar et al. (2023) [15]	32/ Female	Giant mass	Severe pain, shock	Emergent blood transfusion	Emergency right radical nephrectomy	AML with necrosis; discharged day 5
Li et al. (2023) - Case 1 [16]	34/ Female	4.7 x 4.5 cm	Acute left flank pain	Diagnostic workup	Left retroperitoneal laparoscopic radical nephrectomy	EAML (epithelioid ≥80%); no recurrence
Li et al. (2023) - Case 2 [16]	20/ Male	5.8 x 5.2 cm	Pain, hematuria	Non-diagnostic biopsy	Right retroperitoneal laparoscopic partial nephrectomy	EAML (carcinoma-like); no recurrence at 4 years
Zhang et al. (2023) [17]	51/ Male	13.8 cm	Painless mass	Radical nephrectomy	Right radical nephrectomy	Malignant EAML; liver metastasis at 2 years
Zhang et al. (2024) [18]	58/ Female	2.5 x 2.5 cm	Severe left pain	Symptomatic care	Laparoscopic left radical nephrectomy	EAML with venous tumor thrombus; stable
Cao et al. (2025) [19]	59/ Male	17.5 x 13.3 cm	Severe pain, TSC	Acute stabilization	Laparoscopic right radical nephrectomy	RAML; everolimus for 2 months, stable at 6 months
Mehramouz et al. (2025) [20]	27/ Female	5.3 x 4.1 cm	Pain, hematuria	CT and MRI staging	Left open partial nephrectomy	EAML (intermediate risk, 100% epithelioid); stable

Current Case (2026)	37/ Female	8.0 x 7.0 cm	Left pain, stable	Stage I: Conservative stabilization (2 months)	Stage II: Delayed retroperitoneal RAPN	Malignant EAML (4 WHO criteria); somatic *TSC2* mutation; stable at 6 months

In contrast, the present case highlights that if hemodynamic stability is achieved, immediate intervention is not mandatory. Adopting a two-stage delayed approach successfully avoided the morbidity of acute emergency surgery and salvaged the kidney. Notably, transcatheter arterial embolization (TAE) is widely preferred for acute stabilization in Wunderlich syndrome[4]. However, because our patient maintained excellent vital signs and a stable hemoglobin level (125 g/L) without evidence of active, ongoing hemorrhage, TAE was deliberately withheld.[21] This watch-and-wait strategy successfully circumvented potential ischemic injury to the adjacent normal renal parenchyma, thereby optimizing functional preservation during the subsequent deferred RAPN[22]. This aligns with conservative strategies proposed for selected stable Wunderlich syndrome cases. Beyond initial hemodynamic stabilization, the selection of partial nephrectomy (PN) over radical nephrectomy in this delayed phase was guided by four clinical considerations: (1) Patient Demographics and Function: At 31 years of age, long-term renal function preservation is paramount to reduce lifetime cardiovascular and metabolic risks; (2) Pre-rupture Tumor Nature: Historical CT imaging 1.5 years earlier demonstrated classic benign AML features, supporting an initial presumption of a primary mesenchymal lesion rather than aggressive RCC; (3) Feasibility of Complete Margin Control: Post-absorption imaging demonstrated a localized mass with clear margins from the major renal vessels. Although high-risk EAML carries malignant potential, complete R0 resection via robotic precision allows effective local oncological control while maximizing nephron salvage; (4) Discussion and Informed Consent: After comprehensive multidisciplinary discussions, we fully disclosed all relevant perioperative risks to the patient and their next of kin, and the final surgical decision was reached via a shared decision-making process.

Furthermore, EAML presents a major preoperative diagnostic challenge due to its paucity of fat, frequently mimicking RCC or retroperitoneal sarcoma on CT and MRI[23]. Intriguingly, our case captures a unique radiological evolution: the initial tumor was rich in fat signals, but it completely transformed into a fat-paucity, heterogeneously hyper-enhancing mass by the time of rupture. This chronological transition perfectly mirrors the aggressive clonal expansion of atypical epithelioid cells, which progressively compressed and obliterated the fat component. Consequently, like the cases of Li et al. (2023, Case 1), Zhang et al. (2023), and Zhang et al. (2024), the ruptured mass lacked typifying fat on emergency imaging and was highly suspicious for RCC, leading to radical nephrectomies. This underscores the utility of delayed partial nephrectomy as a diagnostic and therapeutic tool. It is worth noting that Li et al. (2023, Case 2) and Mehramouz et al. (2025) attempted intervention via nephron-sparing surgery in patients presenting with acute abdominal pain or hematuria and achieved good renal preservation outcomes,

which is consistent with the clinical practice in this case of striving to maximize renal function preservation.

Pathologically, EAML behaves aggressively compared to classic AML[24]. While small EAMLs (e.g., 4.3 cm reported by Liulytė et al.) can follow a benign course, high-risk cases easily metastasize. Zhang et al. (2023) reported liver metastasis 2 years after radical nephrectomy of a 13.8 cm malignant EAML, and Zhang et al. (2024) reported vascular invasion and tumor thrombi in a 2.5 cm EAML. Our case satisfied the classic adverse parameters under the 2022 WHO classification and met all four Brimo and Nese malignancy criteria (maximum diameter 8 cm, coagulative necrosis, >70% atypical epithelioid components, and definitive pathologic mitoses), justifying tight R0 margins and strict long-term follow-up. At the molecular level, EAML pathogenesis is driven by hyperactivation of the mTOR pathway[25,26]. The somatic *TSC2* frameshift mutation identified in this case is consistent with sporadic malignant EAMLs reported by Espinosa et al. and Rammal et al. (2), providing a strong rationale for future everolimus therapy in the event of progression[26].

Limitations

Despite its success, several limitations of the two-stage strategy must be noted. First, the 2-month delay induces dense retroperitoneal fibrosis and chronic inflammation, significantly increasing surgical difficulty and risking adjacent organ injury[27,28]. This inflammatory state likely caused the patient's transient postoperative SIRS and creatinine fluctuation. Second, there is a risk of tumor progression during the conservative observation phase, as evidenced by the minor interval enlargement of EAML in this patient. Furthermore, spontaneous tumor rupture inherently escalates the risk of retroperitoneal tumor cell dissemination[3,4,21]. Although we strictly adhered to tumor-free principles via intraoperative endobag entrapment and thorough irrigation, the short 6-month follow-up remains a major limitation, as malignant EAML can exhibit late recurrences up to 9 or 12 years post-resection, long-term oncological control remains unproven[29]. Finally, as a single-case report, selection bias is inherent; this protocol is only applicable to highly compliant, hemodynamically stable patients managed at centers with advanced robotic surgical platforms.

Theoretical and Practical Implications

Theoretically, this study supports the unified PEComa disease spectrum, demonstrating that sporadic EAML shares the same *TSC2* driver mutation and mTORC1 hyperactivation pathway as TSC-associated tumors[30]. Practically, it suggests an alternative, nephron-sparing strategy for managing hemodynamically stable Wunderlich syndrome[31]. Instead of immediate emergency radical surgery, clinicians can employ a "cool-down" conservative period, leveraging retroperitoneal self-tamponade. Subsequent robotic assistance overcomes the technical difficulties of post-inflammatory adhesions, ensuring an R0 margin while maximizing renal unit preservation[32]. For patients with *TSC2* mutations and high-risk pathology, this integration of genomic profiling offers a precise blueprint for personalized mTOR-targeted surveillance[25].

Future Research Directions

Future research should focus on three priorities. First, improve the integration of advanced imaging and digital technologies. Large multicenter imaging datasets should be used to develop radiomics models based on 3D reconstruction and deep learning (e.g., ResNet) to improve the non-invasive differentiation of EAML from clear cell renal cell carcinoma[33]. Second, establish an international multicenter registry with long-term follow-up to evaluate recurrence, progression-free survival (PFS), and overall survival (OS) after delayed nephron-sparing surgery for spontaneously ruptured EAML, providing evidence for future clinical guidelines[34]. Third, conduct prospective clinical trials to assess whether short-term postoperative mTOR inhibitors (e.g., everolimus) can safely reduce local and systemic recurrence in high-risk patients after complete resection without distant metastases[23].

Conclusion

For hemodynamically stable patients presenting with spontaneous rupture of high-risk EAML, a two-stage protocol comprising initial conservative stabilization followed by delayed RAPN provides a safe, precise, and nephron-sparing solution. Given the 80% progression risk associated with tumors fulfilling all four WHO adverse criteria, strict R0 resection margins must be maintained. Postoperative genomic screening for TSC1/TSC2 mutations is mandatory to refine prognostic stratification, mandate long-term imaging surveillance, and establish a targeted blueprint for mTOR-inhibitor interventions.

Declarations

Statements Required by CARE Guidelines

Patient Perspective: As a medical professional, experiencing a sudden life-threatening renal tumor rupture was exceptionally challenging. The decision to adopt an initial conservative monitoring strategy instead of undergoing immediate emergency surgery successfully stabilized my condition and preserved my left kidney. The subsequent robot-assisted partial nephrectomy allowed a rapid recovery with minimal pain. The postoperative genetic testing provided critical clarity regarding the sporadic nature of the tumor and offered a clear blueprint for my future surveillance and potential targeted treatments. At my 2-month postoperative follow-up, I have fully returned to my clinical practice with normal renal function and no symptoms.

Informed Consent: The patient provided full written informed consent for the publication of this case report, including all associated clinical timelines, pathological data, genomic sequencing results, and radiological images.

Data Availability Statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics Statement

The studies involving humans were approved by Ethics Committee of the affiliated Yantai Yuhuangding Hospital of Qingdao University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author Contributions

F.L. and H.-W.Z. were the attending surgeon, conceived the study, and stabilized the clinical strategy. C.-Y.L. and M.-Z.S. reviewed the pathological and genetic data. F.L. and J.-D.Z drafted the manuscript. F.L. and G.-L.T wrote and edited the review. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Figures

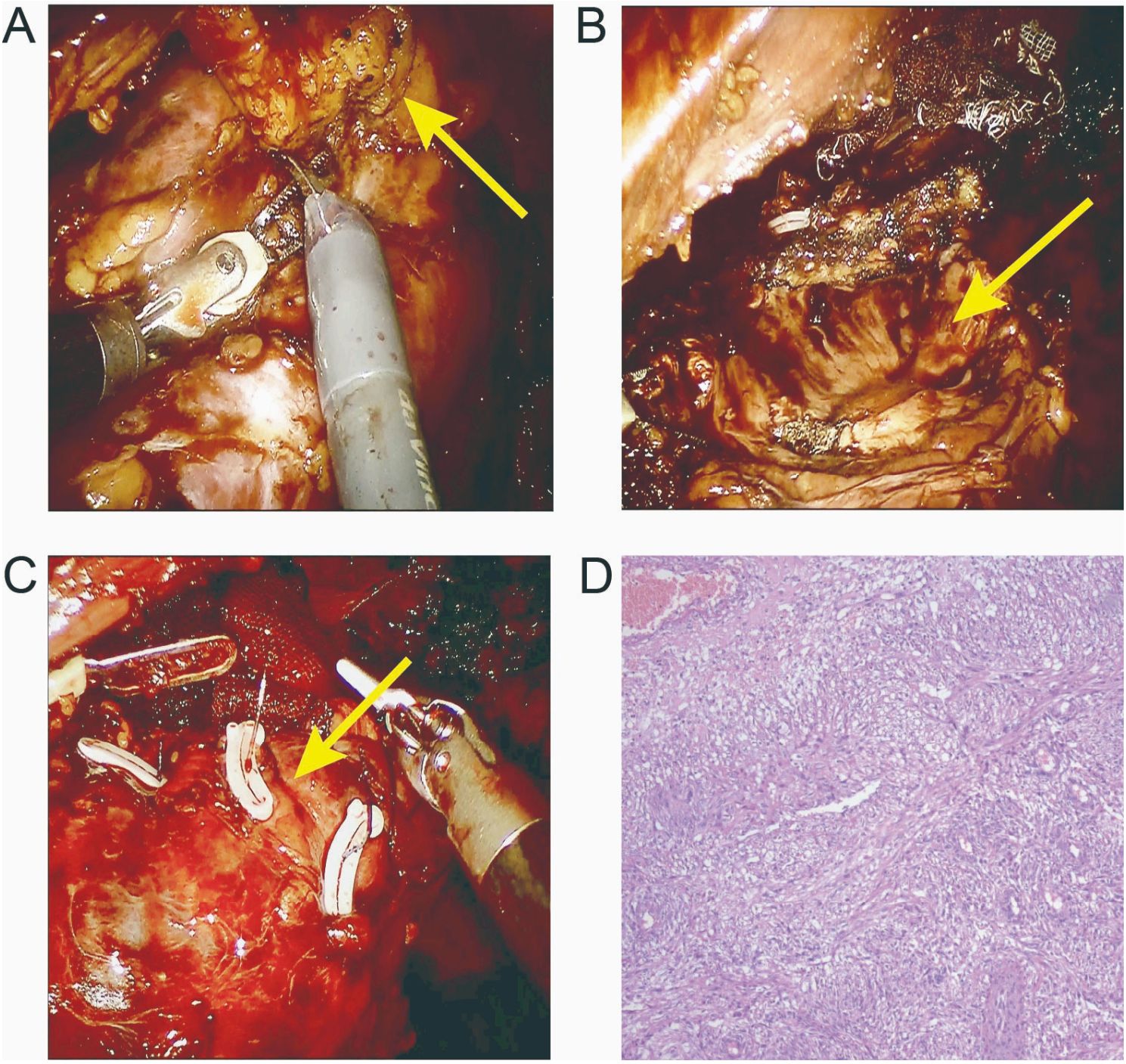


Figure 1

Intraoperative findings of retroperitoneal robot-assisted partial nephrectomy (RAPN) and postoperative pathological examination. (A–C) Intraoperative robotic views showing: **(A)** precise dissection of the tumor through dense retroperitoneal adhesions resulting from prior rupture; **(B)** complete excision of the mass maintaining a strict safe parenchymal margin; and **(C)**running suture reconstruction of the renal defect. **(D)** Postoperative histopathological examination (Hematoxylin and eosin [H&E] stain) confirming epithelioid angiomyolipoma (EAML) with prominent atypical epithelioid cells, coagulative necrosis, and mitotic activity.

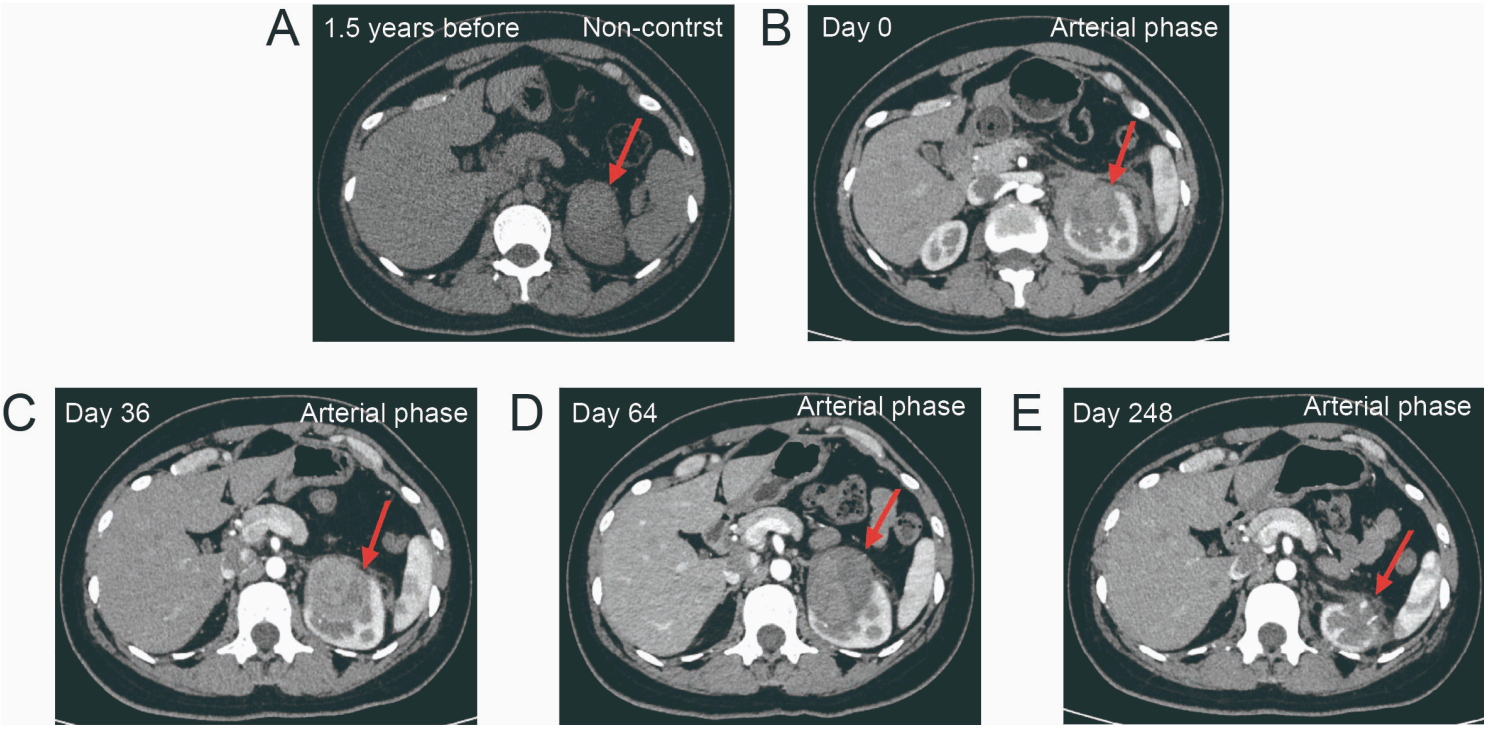


Figure 2

Longitudinal computed tomography (CT) imaging timeline of the patient. (A) Routine abdominal CT performed approximately 1.5 years before emergency presentation showing the initial asymptomatic left renal mass. **(B)** Emergency CT obtained on Day 0 demonstrating spontaneous rupture and acute hemorrhage of the mass with a prominent perirenal hematoma (Wunderlich syndrome). **(C)** Follow-up CT obtained on Day 36 during the conservative management phase showing early hematoma changes. **(D)** Preoperative CT performed on Day 64 demonstrating exudate organization and hematoma absorption. Axial imaging reveals high anatomical complexity with a R.E.N.A.L. score of 9P, showing a posterior tumor location and a proximity of ≤ 4 mm to the central collecting system and renal sinus. **(E)** Postoperative contrast-enhanced CT performed on Day 248 (6 months postoperatively) demonstrating expected regular post-surgical anatomy without evidence of local recurrence or distant metastasis.