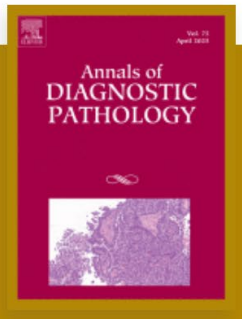
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Annals of Diagnostic Pathology

Supports open access

Menu Search in this journal

Annals of Diagnostic Pathology

ISSN

1092-9134

EISSN

1532-8198

JCR ABBREVIATION

ANN DIAGN PATHOL

ISO ABBREVIATION

Ann. Diagn. Pathol.

Journal information

EDITION

Science Citation Index Expanded (SCIE)

CATEGORY

PATHOLOGY

LANGUAGES	REGION	1ST ELECTRONIC JCR YEAR
English	USA	2009

Publisher information

PUBLISHER	ADDRESS	PUBLICATION FREQUENCY
ELSEVIER SCIENCE INC	STE 800, 230 PARK AVE, NEW YORK, NY 10169	6 issues/year

Journal's performance

Journal Impact Factor

The Journal Impact Factor (JIF) is a journal-level metric calculated from data indexed in the Web of Science Core Collection. It should be used with careful attention to the many factors that influence citation rates, such as the volume of publication and citations characteristics of the subject area and type of journal. The Journal Impact Factor can complement expert opinion and informed peer review. In the case of academic evaluation for tenure, it is inappropriate to use a journal-level metric as a proxy measure for individual researchers, institutions, or articles. Learn more

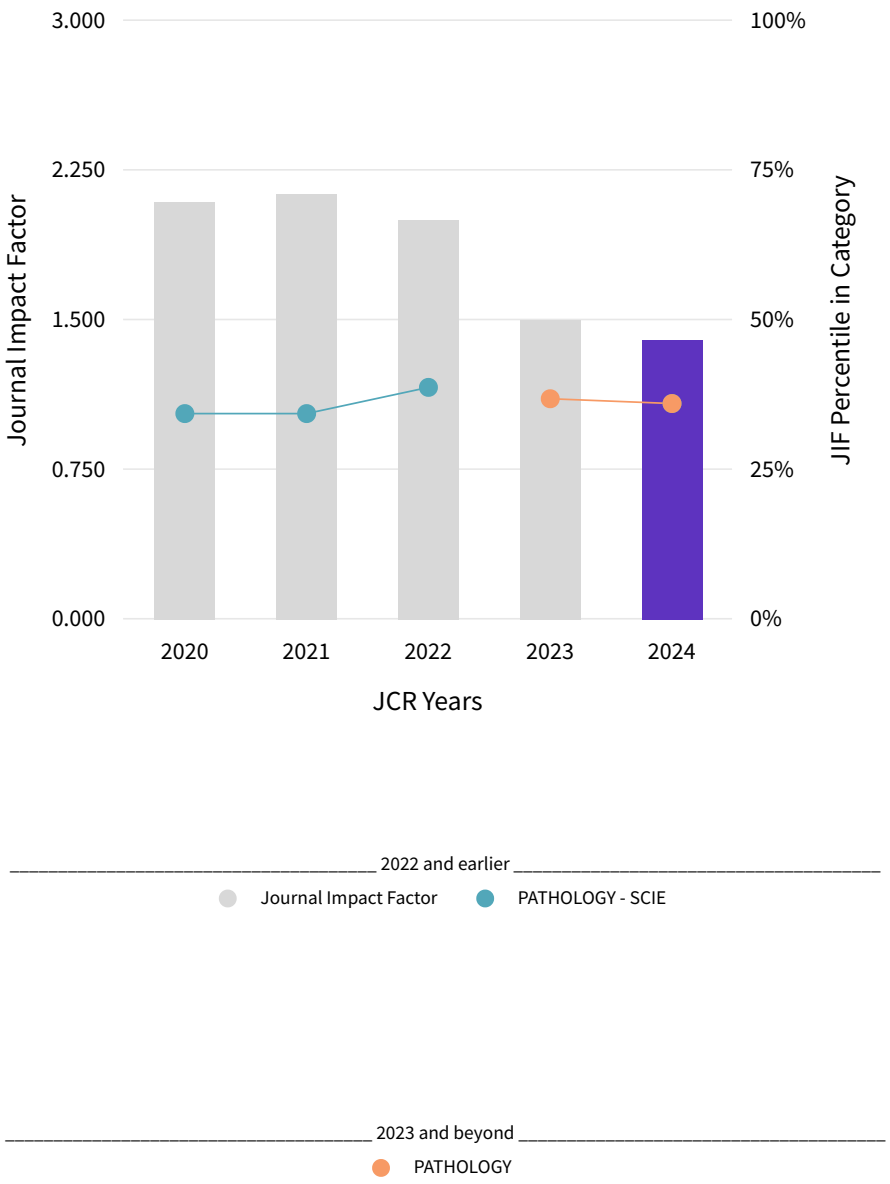
2024 JOURNAL IMPACT FACTOR	JOURNAL IMPACT FACTOR WITHOUT SELF CITATIONS
1.4	1.3
View calculation	View calculation

Journal Impact Factor Trend 2024 Export

Journal Impact Factor contributing items Export

Citable items (232) Citing Sources (199)

TITLE	CITATION COUNT
Superficial CD34-positive fibroblastic tumor (SCPFT): A review of pathological…	8
Clinicopathologic and molecular features of denosumab-treated giant cell tumou…	7



View all years

High-grade transformation of low-grade biphenotypic sinonasal sarcoma:…	7
The amplification of CNS damage in Alzheimer's disease due to SARS-CoV2…	7
Carbon footprint evaluation of routine anatomic pathology practices using eco…	6
Juvenile and adult xanthogranuloma: A 30-year single-center experience and…	6
Wolf in sheep's clothing- Oral proliferative verrucous leukoplakia: Progression wit…	6
MYC amplification in angiosarcoma depends on etiological/clinical subgrou…	5
Diagnostic accuracy of fine needle aspiration cytology and core needle…	5
Discordance in receptor status between primary and metastatic breast cancer a…	5

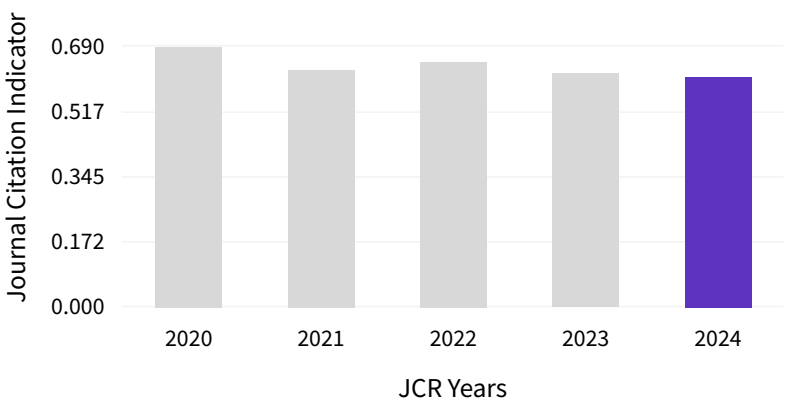
View All in Web of Science

Journal Citation Indicator (JCI)

Export

0.61

The Journal Citation Indicator (JCI) is the average Category Normalized Citation Impact (CNCI) of citable items (articles & reviews) published by a journal over a recent three year period. The average JCI in a category is 1. Journals with a JCI of 1.5 have 50% more citation impact than the average in that category. It may be used alongside other metrics to help you evaluate journals. Learn more



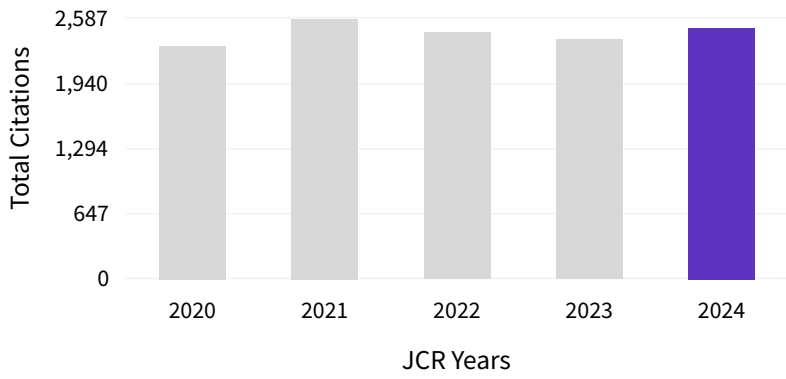
View all years

Total Citations

Export

2,497

The total number of times that a journal has been cited by all journals included in the database in the JCR year. Citations to journals listed in JCR are compiled annually from the JCR years combined database, regardless of which JCR edition lists the journal.



View all years

15

Citation distribution

Export

The Citation Distribution shows the frequency with which items published in the year or two years prior were cited in the JCR data year (i.e., the component of the calculation of the JIF). The graph has similar functionality as the JIF Trend graph, including hover-over data descriptions for each data point, and an interactive legend where each data element's legend can be used as a toggle. You can view Articles, Reviews, or Non-Citable (other) items to the JIF numerator. Learn more

ARTICLE CITATION MEDIAN

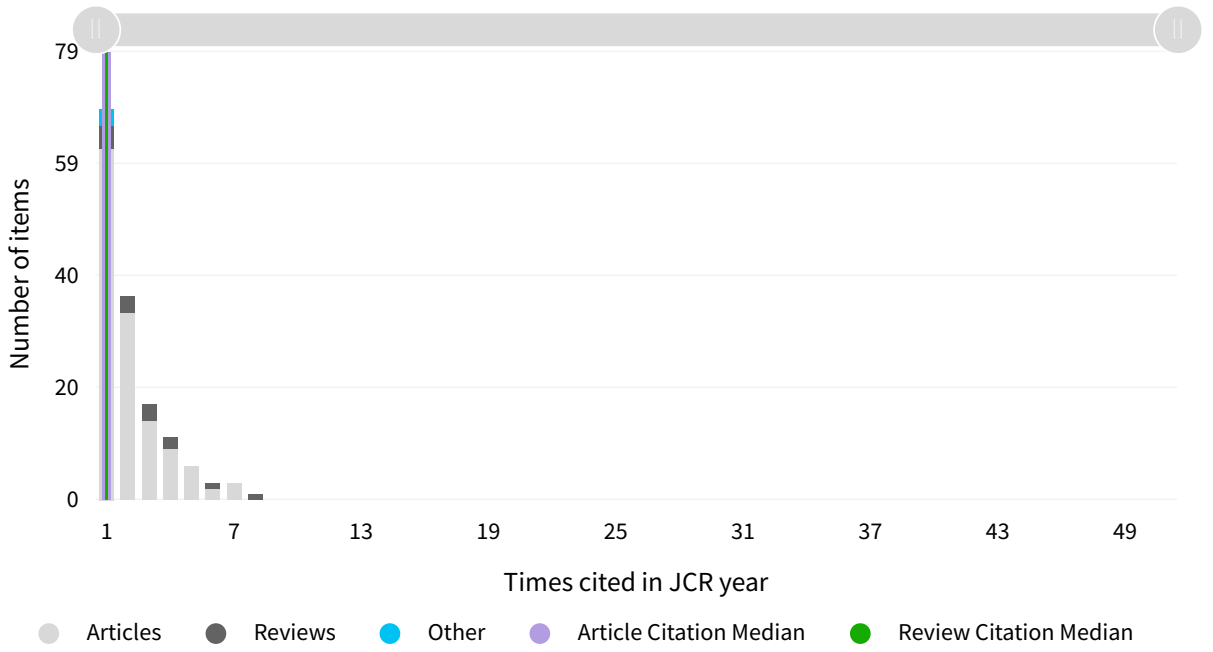
1

REVIEW CITATION MEDIAN

1

UNLINKED CITATIONS

5



TIMES CITED

0

ARTICLES

76

REVIEWS

13

OTHER

20

Open Access (OA)

Export

The data included in this tile summarizes the items published in the journal in the JCR data year and in the previous two years. This three-year set of published items is used to provide descriptive analysis of the content and community of the journal. Learn more

Items

TOTAL CITABLE	% OF CITABLE OA
342	10.23%

Citations*

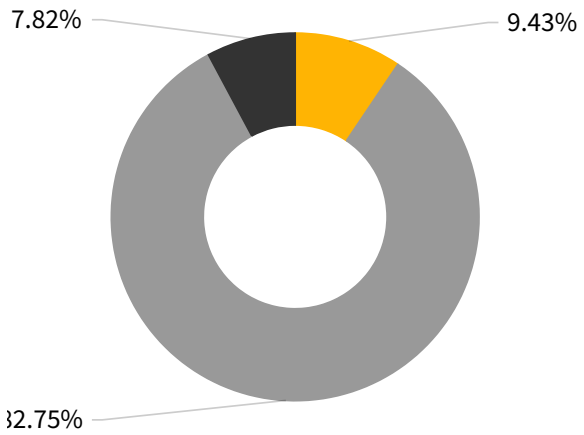
TOTAL CITABLE	% OF CITABLE OA
336	18.45%

15

CITABLE

GOLD OPEN ACCESS
35 / 9.43%

SUBSCRIPTION AND FREE TO READ
307 / 82.75%



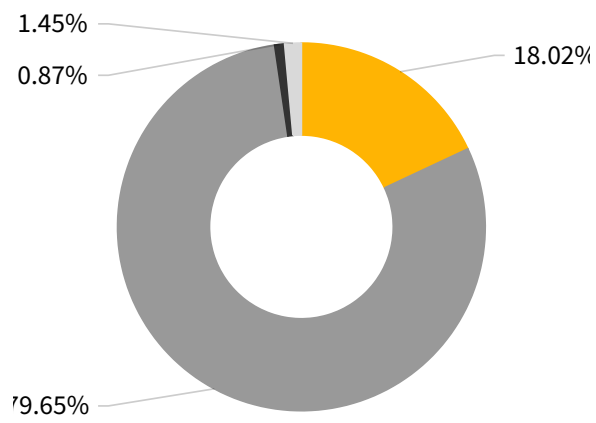
NON-CITABLE

OTHER (NON CITABLE ITEMS)
29 / 7.82%

CITABLE

GOLD OPEN ACCESS
62 / 18.02%

SUBSCRIPTION AND FREE TO READ
274 / 79.65%



NON-CITABLE

OTHER (NON CITABLE ITEMS)
3 / 0.87%

UNLINKED CITATIONS
5 / 1.45%

*Citations in 2024 to items published in [2022 - 2024]

Rank by Journal Impact Factor

Journals within a category are sorted in descending order by Journal Impact Factor (JIF) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Beginning in 2023, ranks are calculated by category.
Learn more

CATEGORY
PATHOLOGY

58/90

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE
2024	58/90	Q3	36.1
2023	56/88	Q3	36.9

Rank by JIF before 2023 for PATHOLOGY

EDITION
Science Citation Index Expanded (SCIE)

JCR YEAR	JIF RANK	JIF QUARTILE	JIF PERCENTILE
2022	47/76	Q3	38.8
2021	51/77	Q3	34.42
2020	51/77	Q3	34.42
2019	47/78	Q3	40.38

Rank by Journal Citation Indicator (JCI)

15

Journals within a category are sorted in descending order by Journal Citation Indicator (JCI) resulting in the Category Ranking below. A separate rank is shown for each category in which the journal is listed in JCR. Data for the most recent year is presented at the top of the list, with other years shown in reverse chronological order. Learn more

CATEGORY

PATHOLOGY

55/90

JCR YEAR	JCI RANK	JCI QUARTILE	JCI PERCENTILE
2024	55/90	Q3	39.44
2023	52/88	Q3	41.48
2022	47/87	Q3	46.55
2021	49/89	Q3	45.51
2020	46/90	Q3	49.44
2019	45/89	Q3	50.00
2018	46/89	Q3	48.88

Citation network

Cited Half-life

6.7 years

The Cited Half-Life is the median age of the items in this journal that were cited in the JCR year. Half of a journal's cited items were published more recently than the cited half-life.

TOTAL NUMBER OF CITES

2,497

NON SELF-CITATIONS

2,468

SELF-CITATIONS

29

Citing Half-life

7.9 years

The Citing Half-Life is the median age of items in other publications cited by this journal in the JCR year.

TOTAL NUMBER OF CITES

3,480

NON SELF-CITATIONS

3,451

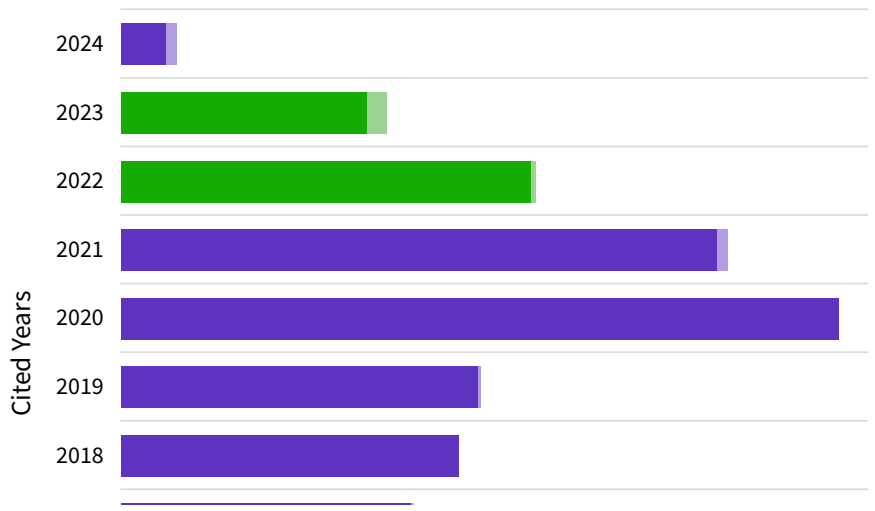
SELF-CITATIONS

29

Cited Half-life Data | Citing Half-life Data

Export

15

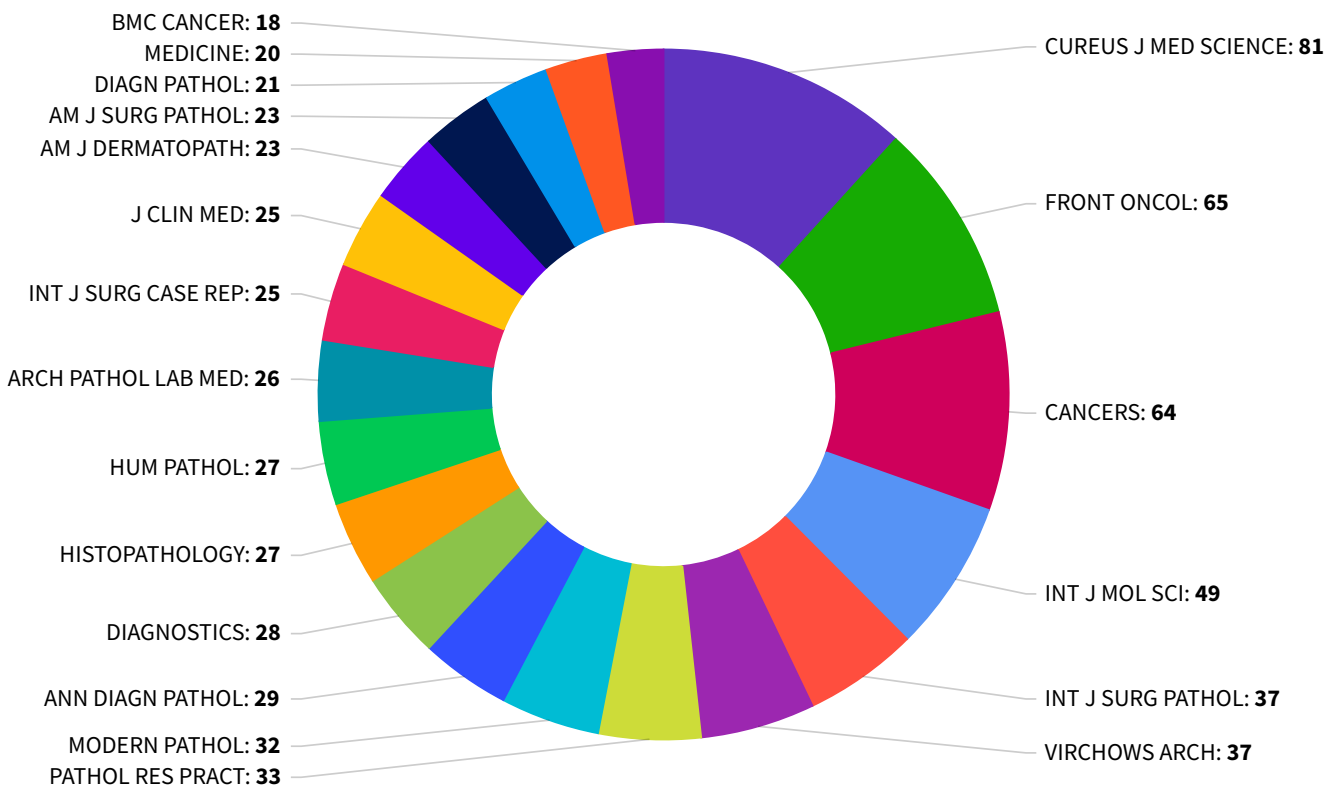


CITED YEAR	# OF CITES FROM 2024	CUMULATIVE %	# OF CITING SOURCES
All years	**2,497 citations**	**100.00%**	**902 sources**
2024	26 citations	1.04%	21 sources
2023	124 citations	6.01%	85 sources
2022	194 citations	13.78%	142 sources
2021	284 citations	25.15%	201 sources
2020	336 citations	38.61%	219 sources
2019	168 citations	45.33%	117 sources
2018	158 citations	51.66%	116 sources

Journal Citation Relationships

Cited Data | Citing Data

Top 20 journals citing ANN DIAGN PATHOL by number of citations



Content metrics

Source data

This tile shows the breakdown of document types published by the journal. Citable Items are Articles and Reviews. For the purposes of calculating JIF, a JCR year considers the publications of that journal in the two prior years. Learn more

Average JIF Percentile

Export

The Average Journal Impact Factor Percentile takes the sum of the JIF Percentile rank for each category under consideration then calculates the average of those values. Learn more

15

110 total citable items

	ARTICLES	REVIEWS	COMBINED(C)	OTHER DOCUMENT TYPES(O)	PERCENTAG
NUMBER IN JCR YEAR 2024 (A)	102	8	110	6	95%
NUMBER OF REFERENCES (B)	3,016	418	3,434	46	99%
RATIO (B/A)	29.6	52.3	31.2	7.7	

ALL CATEGORIES AVERAGE
36.1

PATHOLOGY
36.1

Contributions by organizations

Export

Organizations that have contributed the most papers to the journal in the most recent three-year period. Learn more

RANK	ORGANIZATION	COUNT
1	UNIVERSITY OF TEXAS SYSTEM	22
2	UNIVERSITY SYSTEM OF OHIO	13
3	MAYO CLINIC	12
4	RUTGERS UNIVERSITY SYSTEM	11
5	UNIVERSITY OF CALIFORNIA SYSTEM	10
6	CAPITAL MEDICAL UNIVERSITY	8
-	MEDICAL COLLEGE OF WISCONSIN	8

Contributions by country/region

Export

Countries or Regions that have contributed the most papers to the journal in the most recent three-year period. Learn more

RANK	COUNTRY / REGION	COUNT
1	USA	140
2	CHINA MAINLAND	59
3	TURKIYE	29
4	INDIA	27
5	JAPAN	19
6	BRAZIL	14
7	THAILAND	11
8	PAKISTAN	9
-	SPAIN	9

Additional metrics

Eigenfactor Score

0.00237

The Eigenfactor Score is a reflection of the density of the network of citations around the journal using 5 years of cited content as cited by the Current Year. It considers both the number of citations and the source of those citations, so that highly cited sources will influence the network more than

Normalized Eigenfactor

0.53187

The Normalized Eigenfactor Score is the Eigenfactor score normalized, by rescaling the total number of journals in the JCR each year, so that the average journal has a score of 1. Journals can then be compared and influence measured by their score relative to 1. Learn more

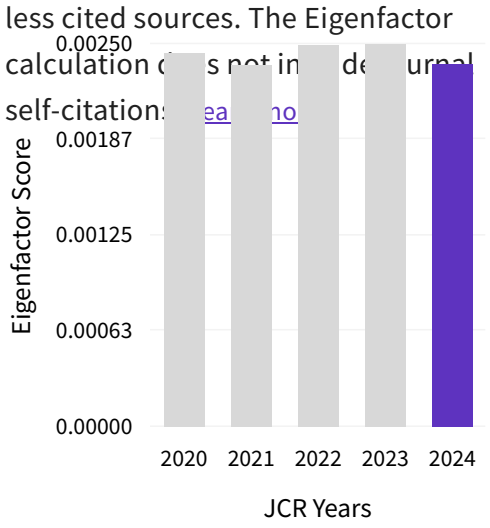
Article influence score

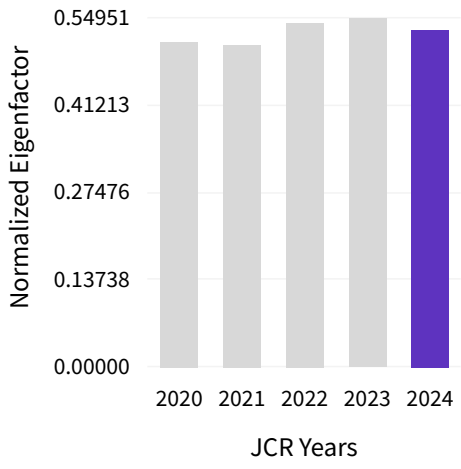
0.458

The Article Influence Score normalizes the Eigenfactor Score according to the cumulative size of the cited journal across the prior five years. The mean Article Influence Score for each article is 1.00. A score greater than 1.00

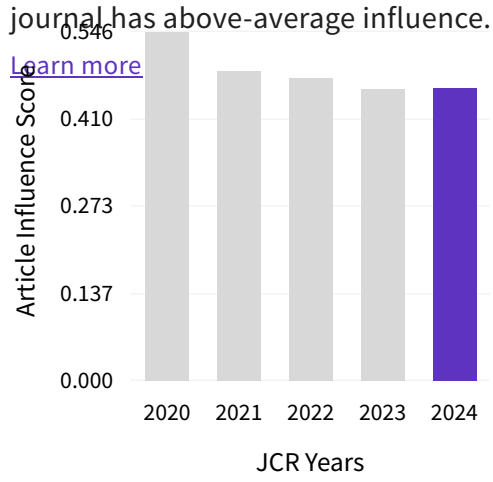
15

less cited sources. The Eigenfactor calculation does not include journal self-citations. Learn more





indicates that each article in the journal has above-average influence. Learn more

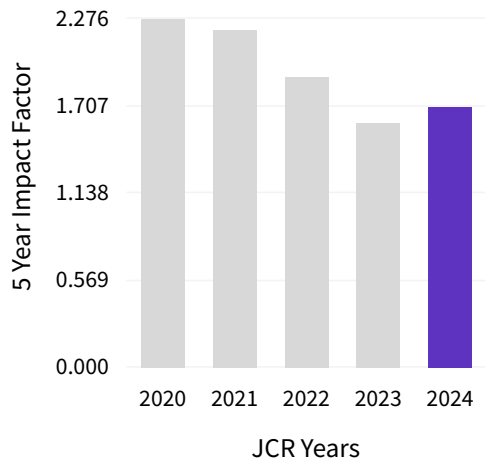


5 Year Impact Factor

1.7

View Calculation

The 5-year Impact Factor is the average number of times articles from the journal published in the past five years have been cited in the JCR year. It is calculated by dividing the number of citations in the JCR year by the total number of articles published in the five previous years. Learn more

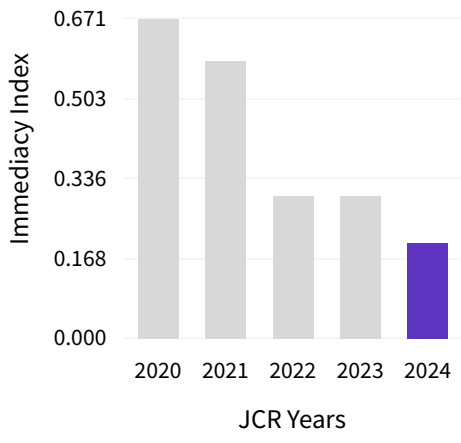


Immediacy Index

0.2

View Calculation

The Immediacy Index is the count of citations in the current year to the journal that reference content in this same year. Journals that have a consistently high Immediacy Index attract citations rapidly. Learn more



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Original Contributions

Primary intrarenal hemangioma – A series of 39 cases

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ARTICLE INFO

Keywords:
Intrarenal hemangioma
Anastomosing
Cavernous
Capillary
Synchronous tumors

ABSTRACT

Intrarenal hemangiomas lack concise clinicopathologic information, due to the predominance of single case reports and inclusion of other vascular neoplasms and hemangiomas of perirenal, hilar, and renal vein origin. Herein, in this multi-institutional study we evaluate clinicopathologic features of 39 intrarenal hemangiomas. The median age was 62 years (range = 27–94 years; 2:1 male to female ratio), with left-sided predominance (left = 21, right = 13; one case was bilateral). The median tumor size was 1.5 cm (0.2-10 cm). Two cases arose from transplanted kidneys. Most were asymptomatic (n = 30, 86 %), even though most surgical interventions (19 partial, 19 radical, 1 biopsy) were due to hemangiomas (n = 24, 62 %). Synchronous renal neoplasms were present in 9 (23 %) patients, including clear cell renal cell carcinoma (RCC) (n = 4), angiomyolipoma (n = 2), oncocytoma (n = 2), and chromophobe RCC (n = 1). Multifocal hemangiomas (n = 5) were seen in cases with end stage renal disease. Intrarenal hemangiomas were mostly anastomosing (n = 18; 46 %), followed by capillary (n = 15; 38 %), and cavernous (n = 6; 16 %) subtypes. Fibrin thrombus (n = 9; 23 %) and extramedullary hematopoiesis (n = 4; 10 %) were occasionally present, the latter being only in the anastomosing subtype. Immunohistochemistry was performed on a majority (n = 33, 84 %) of hemangiomas, with vascular markers CD31 and CD34 and lack of PAX8 were most used for diagnosis. 30 patients had follow-up (median 48 months, range 1–241 months), none showed disease progression/recurrence. This study provides comprehensive observation of the largest intrarenal hemangioma cohort, highlighting their frequent cause of surgical intervention

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when present, predominance of anastomosing subtype, multifocality in end stage kidney disease, and occasional concurrent ipsilateral neoplasms.

1. Introduction

Vascular lesions encompass a broad spectrum, ranging from non-neoplastic arteriovascular malformations (AVM) to highly aggressive malignant angiosarcomas [1]. Hemangioma, benign vascular neoplasm in this spectrum, is the most common vascular neoplasm and can be seen in any organ and tissue type, including but not limited to skin, synovium, skeletal muscle, vascular wall, visceral organs, and central nervous system [1]. Age and gender predisposition, along with the tumor location, are somewhat determined by the various subtypes of hemangioma such as capillary, anastomosing, venous, or epithelioid [1]. For instance, infantile hemangioma is mostly seen in the skin of head and neck region and trunk of the infants with female predilection, whereas intramuscular hemangioma, with equal age distribution in young adults, are observed within the skeletal muscle of lower extremities [1]. Involvement of the genitourinary system may occur in the setting of systemic angiomatosis, such as in Sturge–Weber and Klippel–Trénaunay syndromes [1].

Hemangiomas can rarely be seen in any organ in the urinary tract and male genital system; the kidney involvement was first identified as an autopsy finding by Virchow in 1867 [2]. Only scattered case reports and small case series have been reported thus far in the literature, often with the series including multiple types of vascular tumors arising from the kidney or hemangiomas from different sites of genitourinary tract [3,4]. Approximately 220 examples of renal hemangioma have been reported in the literature. Herein, we conducted an international collaboration to gather a large cohort of primary intrarenal hemangiomas to overview their distinct clinicopathologic features.

2. Materials and method

An international cohort of intrarenal hemangiomas were collected from Hungary, Spain, Turkiye, India, and the United States and were re-evaluated histologically. Authors from each participating institution (MA, AS, SRW, SH, MAA, MGM, AP, KY, LK, BYB, SK, SKM) were asked to review their archival material using hematoxylin and eosin-stained slides and supporting immunohistochemical (IHC) assays, and relevant available clinicopathologic data. Hemangiomas that were arising from renal vein or renal sinus adipose tissue were excluded; only hemangiomas arising in the renal parenchyma were included in the study. Age and gender of the patients with concurrent relevant clinical conditions (if any), pre-surgical clinical symptoms (if any), surgical procedure (i.e. biopsy, partial nephrectomy, or radical nephrectomy), laterality of the involved kidney, tumor characteristics (size, number of hemangiomas, hemangioma type, synchronous renal tumors), presence of vascular thrombus and extramedullary hematopoiesis, and immunoprofile were recorded. Follow-up were recorded from the time of diagnosis and either the death of the patient or lost-to-follow up. In addition to our cohort, a comprehensive review of the English literature on intrarenal hemangiomas was performed.

3. Results

3.1. Clinical presentation and demographics

The clinicopathologic features of 39 patients with intrarenal hemangioma are summarized in Table 1. The cohort included 26 men and 13 women (male-to-female ratio is 2), with a median age 62 years (range 27–94 years) at the time of the diagnosis. None of the patients had a personal or family history of syndromes. The diagnostic specimens comprised of 19 radical nephrectomies, 19 partial (bilateral nephrectomies in a single patient) nephrectomies, and one biopsy. In patients with known laterality ($n = 35$), left kidney was more affected than the right (21 vs 13), in addition to one patient with bilateral involvement. Intrarenal hemangiomas occurred in transplant kidneys in two patients. In cases with known history of initial presentation (n = 35), most were asymptomatic ($n = 30$, 86 %); documented symptoms were flank or abdominal pain ($n = 4$), gross hematuria ($n = 2$), or both ($n = 1$). A total of six patients (15 %) had end stage renal disease (ESRD), with additional four patients with a variety of pathologic processes including glomerulonephritis, glomerulosclerosis, AL-type amyloidosis, oxalosis with staghorn calculi, and chronic pyelonephritis.

3.2. Tumor characteristics

Intrarenal hemangiomas were the main reason for planned nephrectomies in 24 patients (62 %), whereas in 15 (38 %) patients, intrarenal hemangiomas were microscopically identified in nephrectomies performed for other renal neoplasms ($n = 8$, 21 %) or non-neoplastic ($n = 7$, 18 %) renal conditions, such as the removal of non-functional kidney due to ESRD or staghorn calculus. Hemangioma size was ranging from 0.2 to 10 cm, and the median size was 1.5 cm. Multifocal intrarenal hemangiomas were seen in 5 (13 %) patients, and interestingly, all multifocal hemangiomas arose in the background of ESRD, only one patient with ESRD had solitary hemangioma. Grossly, tumors showed somewhat well circumscribed solid nodules mottled with brown-red foci of hemorrhage, larger tumors exhibited apparent cystic changes with hemorrhage (Fig. 1A). Concurrent ipsilateral renal neoplasms were present in 9 (23 %) patients, and clear cell renal cell carcinoma (RCC) was the most common concurrent renal neoplasm ($n = 4$), followed by angiomyolipoma (AML, $n = 2$), oncocytoma (n = 2), and chromophobe RCC ($n = 1$). Contralateral oncocytoma was present in one case. Only one patient had a concomitant extra-renal hemangioma, consistent with retroperitoneum origin.

3.3. Histological features and immunohistochemical assays

Microscopically, intrarenal hemangiomas formed somewhat well-circumscribed unencapsulated masses (Fig. 1B) with frequent entrapment of renal tubules (Fig. 1C). Low-grade endothelial cell proliferation with absent mitotic activity and minimal or no cytologic atypia were present in all neoplasms. No mitotic activity was present. Most cases were anastomosing ($n = 18$; 46 %, Fig. 1B-G) subtype, characterized by the interconnected vascular network in sinusoidal pattern (Fig. 1C – D), with frequent microcystic changes (Fig. 1E). Fibrin thrombus ($n = 9$; 23 %, Fig. 1F) and extramedullary hematopoiesis ($n = 4$; 10 %, Fig. 1G) were occasionally present, the latter being only in the anastomosing subtype (n = 4). It was followed by capillary ($n = 16$; 38 %) subtype with ill-delineated mass (Fig. 2A) formed by tightly packed capillary lumina (Fig. 2B) with flattened to enlarged epithelioid endothelial cells (Fig. 2C). Seamless intertubular infiltration was also present (Fig. 2D). Least common subtype was cavernous ($n = 6$; 16 %, Fig. 3A-D), identified by the conglomeration of large cystic and congested vascular spaces with fibrovascular septa and inconspicuous endothelial lining. Majority of cass ($n = 33$, 84 %) had immunohistochemical (IHC) assays; vascular markers ERG (Fig. 1H), CD31 (Figs. 1I, 2D) and CD34 and lack of PAX8 were most commonly used (See Table 1 for the summary of IHC assays).

3.4. Follow-up data

Follow-up data was available for 30 patients, with a median follow-

Table 1
Clinicopathologic features of 39 intrarenal hemangioma.

Case number	Age/ gender	Laterality/ procedure	Incidental/ symptomatic	Primary cause of surgery/ biopsy*	Tumor size (cm)	Focality (unifocal or multifocal)	Diagnosis (subtype, if applicable)	Extramedullary hematopoiesis	Fibrin thrombi	Additional renal lesions	IHC work up	Hemangioma at the non-renal sites	Follow-up (months)
1	52 M	Left/Partial	Incidental	Hemangioma	2.8	Unifocal	Anastomosing	Absent	Present	None	(+) CD31, FVIII, SMA,	None	DWOD (81)
2	71F	Left/ Radical	NA	Hemangioma	2.8	Unifocal	Anastomosing	Present	Present	None	(+) CD31, SMA, CD34, FLI1	None	NED (83)
3	72F	Left/ Radical	Incidental	Hemangioma	1.5	Unifocal	Cavernous	Absent	Absent	None	None	None	DWOD (59)
4	69 M	Left/Partial	Incidental	Hemangioma	1.1	Unifocal	Anastomosing	Absent	Absent	None	(+) ERG	None	NED (35)
5	94 M	Right/ Biopsy	Incidental	Hemangioma	4.7	Unifocal	Anastomosing	Absent	Absent	None	(+) ERG	None	NED (31)
6	47F	Left/ Radical	Incidental	Hemangioma	3.5	Unifocal	Anastomosing	Present	Absent	None	(+) CD34, HHF-35	None	NED (161)
7	75 M	NA/Radical	Incidental	Non-neoplastic**	2,5	Unifocal	Capillary	Present	Absent	GN, GS	(+) CD31, CD34, Factor VIII (−) HMB45, CK, HHV8	None	NA
8	69F	Right/ Radical	Right abdominal pain	Non-neoplastic**	1,5 (largest)	Multifocal	Capillary	Absent	Absent	AL amyloidosis, GN, GS	(+) CD31, CD34, Factor VIII (−) HMB45, CK, HHV8	None	NA
9	76 M	NA/Partial	Incidental	Hemangioma	1.3	Unifocal	Anastomosing	Absent	Present	None		None	NA
10	45 M	Left/ Radical	incidental	Hemangioma	2.9	Unifocal	Anastomosing	Absent	Present	None	(+) CD31, CD34, (−) D2–40, AE1/3, HHV8	None	NED (156)
11	59 M	Left/Partial	incidental	Hemangioma	2.2	Unifocal	Anastomosing	Absent	Present	None	None	Retroperitoneal	NED (108)
12	56F	Left/ Radical	incidental	AMLEC	0.5 (largest)	Multifocal	Anastomosing	Absent	Absent	AMLEC, AML, cortical cysts	(+) ERG; (−) PAX8, CA9, cathK, inhibin, ER	None	NED (24)
13	32 M	NA/Radical	Incidental	Non-neoplastic**	0.3	Unifocal	Cavernous	Absent	Absent	Oxalosis + staghorn calculi	None	None	NED (144)
14	67F	Right/ Partial	incidental	CCRCC	0.2	Unifocal	Anastomosing	Absent	Absent	CCRCC	(+) CD31, ERG; (−) CA9, keratin 7, AE1/3	None	NED (9)
15	73 M	Right/ Partial	incidental	CCRCC	1.4	Unifocal	Cavernous	Absent	Absent	CCRCC	(+) ERG, CD31	None	NA
16	41 M	Right/ Partial	incidental	CCRCC	1	Unifocal	Anastomosing	Absent	Absent	CCRCC, ESRD	(+) ERG, CD31	None	NED (81)
17	62 M	Left/ Radical	Incidental	Non-neoplastic**	0.8 (largest)	Multifocal	Anastomosing	Absent	Absent	ESRD	(+) ERG, CD31	None	NED (46)
18	50F	Left/ Radical	Incidental	Non-neoplastic**	1.2 (largest)	Multifocal	Anastomosing	Absent	Absent	ESRD	(+) ERG, CD31	None	NA
19	81 M	Left/ Radical	Incidental	ChRCC	N/A	Unifocal	Capillary	Absent	Absent	ChRCC	None	None	NED (120)
20	80 M	Right/ Partial	Incidental	Hemangioma	4	Unifocal	Anastomosing	Absent	Absent	Contralateral Oncocytoma	(+) CD31; (−) CKAE1/AE3	None	NED (24)
21	55F	NA/Radical	Incidental	Non-neoplastic**	1.5	Unifocal	Capillary	Absent	Absent	ESRD, transplant kidney	(+) CD31; (−) AE1/ AE3, HMB45	None	NA
22	43 M	Left/ Radical	Incidental	Non-neoplastic**	1.2	Unifocal	Capillary	Absent	Absent	ESRD	(+) CD31, (−) AE1/ AE3	None	NED (48)
23	56 M	Right/ Partial	Incidental	Hemangioma	1.8	Unifocal	Capillary	Absent	Absent	None	(+) ERG, CD31, FLI1; (−) HHV8,	None	NED (21)

(*continued on next page*)

Table 1 (*continued*)

Case number	Age/ gender	Laterality/ procedure	Incidental/ symptomatic	Primary cause of surgery/ biopsy*	Tumor size (cm)	Focality (unifocal or multifocal)	Diagnosis (subtype, if applicable)	Extramedullary hematopoiesis	Fibrin thrombi	Additional renal lesions	IHC work up	Hemangioma at the non-renal sites	Follow-up (months)
											PAX8, AE1/3, low Ki67		
24	41F	Right/ Partial	Incidental	Hemangioma	1.3	Unifocal	Capillary	Absent	Absent	None	(+) ERG, CD31, FLI1; AE1/3, low Ki67	None	NED (36)
25	59F	Right/ Partial	Incidental	Hemangioma	2	Unifocal	Capillary	Absent	Present	None	(+) ERG, CD31, FLI1; (−) HHV8, PAX8, AE1/3, low Ki67	None	NA
26	62F	Left/Partial	Abdominal Pain	Hemangioma	3.5	Unifocal	Capillary	Absent	Absent	None	(+) ERG, CD31, FLI1; (−) HHV8, PAX8, AE1/3, low Ki67	None	NED (37)
27	66 M	Left/ Radical	Incidental	Hemangioma	2.5	Unifocal	Capillary	Absent	Absent	Multilocular benign cysts	(+) CD31, CD34; (−) PAX8	None	NED (90)
28	70 M	Right/ Partial	Incidental	Hemangioma	2.5	Unifocal	Anastomosing	Absent	Absent	None	(+) CD31, CD34; (−) CD10, PAX8	None	NED (4)
29	59F	Left/ Radical	Incidental	Hemangioma	4.5	Unifocal	Cavernous	Absent	Yes	PN	None	None	NED (40)
30	66 M	Left/Partial	NA	Hemangioma	2.5	Unifocal	Capillary	Absent	Absent	Benign simple cortical cysts	(+) CD34, (−) PAX8, CAM5.2 and CD68	None	NA
31	66 M	Left/Partial	Incidental	Hemangioma	1.5	Unifocal	Capillary	Absent	Absent	None	(+) CD34, SMA and Vimentin; (−) CD10, PAX8, CK7, AMACK and Chromogranin	None	NED (120)
32	48 M	Left/Partial	Left flank pain	Hemangioma	3	Unifocal	Cavernous	Absent	Present	None	(+) CD31	None	NED (241)
33	71 M	Left/Partial	Gross hematuria	Hemangioma	8	Unifocal	Cavernous	Absent	Present	None	(+) CD31	None	NED (167)
34	59 M	Right/ Radical	Incidental	Oncocytoma	1.3	Unifocal	Capillary	Absent	Absent	Oncocytoma	(+) CD31	None	NED (1)
35	54 M	Right/ Radical	Incidental	Oncocytoma	1.4	Unifocal	Capillary	Absent	Absent	Oncocytoma	(+) CD31	None	NED (147)
36	33F	Left/ Radical	Left flank pain and gross hematuria	Hemangioma	10	Unifocal	Anastomosing	Present	Present	None	(+) CD31, CD34, ERG	None	NA
37	64 M	Right/ Radical	Incidental	CCRCC	0.4	Unifocal	Capillary	Absent	Absent	CCRCC	(+) CD31	None	NED (2)
38	34 M	Bilateral/ Partial	NA	Hemangioma	1.1 (largest)	Multifocal	Anastomosing	Absent	Absent	ESRD, AML, transplant kidneys	(+) ERG, (−) PAX8	None	NED (5)
39	50 M	Left/Partial	Incidental	Hemangioma	2.5	Unifocal	Anastomosing	Absent	Absent	None	(+) CD31, ERG; (−) KRT7, PAX8, PanCK	None	NED (72)

AML: Angiomyolipoma; AMLEC: Angiomyolipoma with epithelial cysts; CCRCC: clear cell renal cell carcinoma; ChRCC: Chromophobe renal cell carcinoma; DWOD: died without disease; ESRD: end stage renal disease; GN: glomerulonephritis; GS: glomerulosclerosis; NA: Not applicable; NED: alive with no evidence of disease; PN: pyelonephritis.

* In cases that are not hemangioma as the primary cause of surgery/biopsy; hemangioma is microscopically identified.

** Additional renal lesions column indicates the reason for surgery.

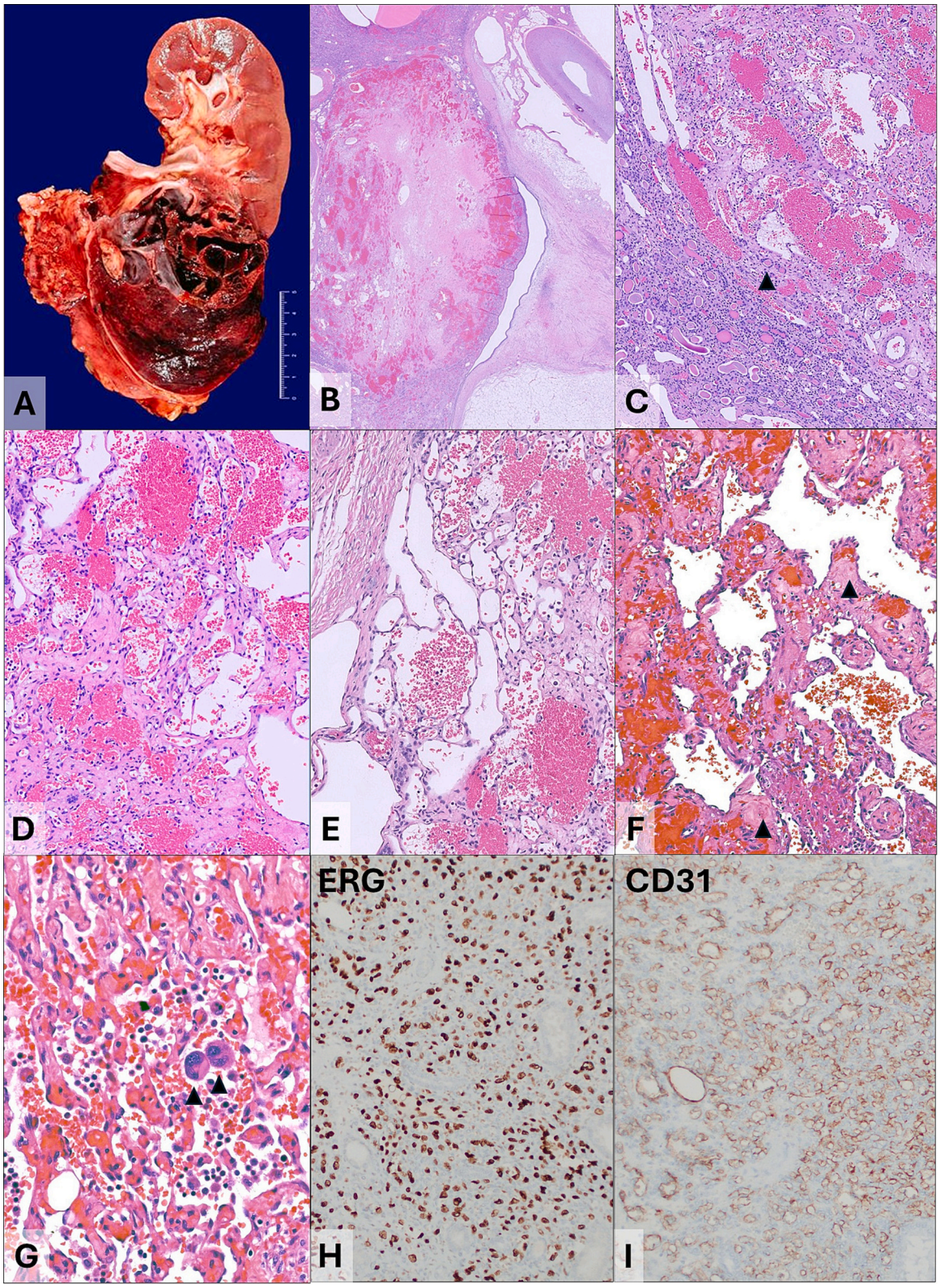


Fig. 1. Cross section of nephrectomy specimen with large hemorrhagic and necrotic cut surface (**A**) (microscopic evaluation revealed cavernous hemangioma). Intrarenal hemangioma is most commonly of anastomosing subtype, microscopically forming unencapsulated well-circumscribed masses (**B, 20**×) with focal hyalinization in this case. Frequent entrapment of renal tubules (arrowhead indicate renal tubule, **C, 40**×) is present. Anastomosing hemangioma is characterized by interconnected vessels with sinusoidal pattern (**D, 100**×) Extravasated blood and microcystic changes are common (**E, 100**×). Fibrin thrombi (arrowheads indicate fibrin thrombi, **F, 200**×) and extramedullary hematopoiesis (arrowheads indicate macrophages, **G, 200**×) were occasionally seen. Markers that are specific for endothelium, such as ERG (**H, 200**×) and CD31 (**I, 200**×) can be used as supporting immunohistochemical assays.

up period of 48 months (range 1–241 months). All nephrectomy patients were postoperatively free of disease, while the single biopsied hemangioma patient was stable after 31 months.

3.5. Literature review

A detailed literature review from the largest case series [3,5-7,16] (Table 2) summarizes intrarenal hemangioma in 49 patients, including three pediatric patients (<1, 15, and 17 years, respectively). These large cohorts were intermixed. Montgomery et al. [7] highlighted anastomosing hemangioma and its predilection to genitourinary tract, including cases from kidney, renal hilum, perinephric fat, and testis, whereas Brown et al. [6] and Mehta et al. [3] included various other vascular neoplasms such angiosarcoma, lymphangioma, or intravascular papillary endothelial hyperplasia. In addition, hemangiomas arising from peri-renal soft tissue, i.e. renal hilum or perinephric adipose tissue were frequent in these reports. Male to female ratio (32:16) and tumor size (median 2.0 cm) were comparable to our cohort. Moreover, anastomosing subtype ($n = 25$) was the most common similar to our cohort, followed by capillary ($n = 9$), AVM ($n = 8$), and cavernous (n = 2), with four cases without any subtype documentation. Hemangioma subtyping was occasionally missing [3,5], moreover subtype characterization could differ between reports. For instance, most reports [5,7,16] described anastomosing subtype as a distinct category, whereas Brown et al. [6] considered it in the morphologic spectrum of capillary hemangioma. Multifocality was more common than our cohort (8/48, 17 %), particularly due to Kryvenko et al. [16] observation on hemangiomas arising in the setting of ESRD, and 75 % of multifocal cases arose from kidneys with ESRD. Unlike our cohort, median age (52.5 years) was relatively younger than our cohort (62 years), and both kidneys were similarly involved (left/right: 19/18) with few bilateral presentations ($n = 4$). Extramedullary hematopoiesis and fibrin thrombi were occasional similar to our cohort, and extramedullary hematopoiesis were only seen in anastomosing hemangioma. No progression or recurrence were reported following surgery.

4. Discussion

Renal hemangiomas exclusively arising from the renal parenchyma lack concise clinical and pathologic information despite ample documentation of the vascular lesions arising from or around this organ with >200 cases reported in the literature. This is due to 1) reports of single cases in the vast majority of publications, 2) mixed cohorts including a) perinephric, renal sinus, or renal vein hemangiomas or b) other vascular neoplasms including angiosarcomas or lymphangiomas, and 3) lack of consistent documentation of the coexistence with other neoplasms in the ipsi- or contralateral kidney. Our cohort, which is largest to date, aims to address these shortcomings.

Median age, male predominance, most commonly anastomosing subtype, and unanimously non-progressing non-recurring outcomes after surgery were comparable to the cases of intrarenal hemangioma in the literature. Moreover, occasional extramedullary hematopoiesis was identified only in anastomosing subtype in cases with known subtype, similar to the literature. Unique findings that are somewhat overlooked in the literature are as follows:

A) Most hemangiomas were asymptomatic and were considered RCC by imaging and were the cause of the nephrectomies in most cases despite their benign clinical nature. It indicates that intrarenal hemangioma is a mimicker of malignant renal neoplasms, particularly RCC by imaging [8,9]; furthermore, intrarenal hemangiomas can also microscopically mimic low-grade clear cell renal cell carcinoma [10], hemangioblastoma [11], hemangioblastoma-like RCC [12], and unclassified hemangioma-

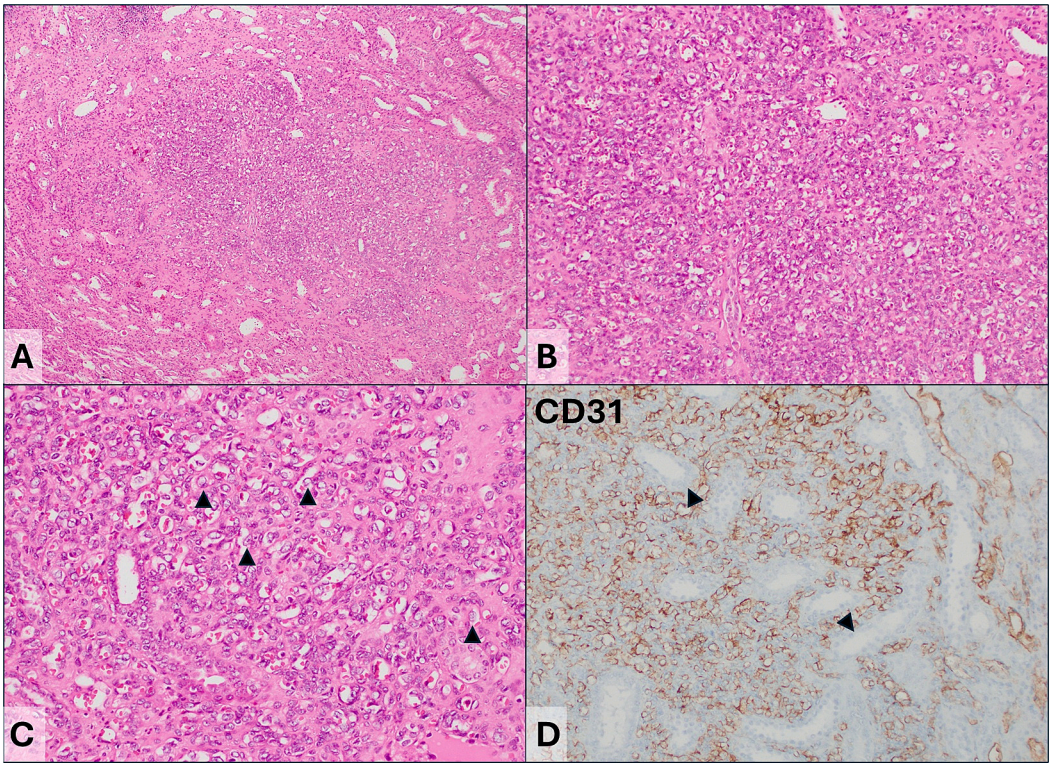


Fig. 2. Capillary hemangiomas form nodules within the intrarenal parenchyma with no capsulation (**A, 40**×), hemangiomas and are formed by closely packed delicate round vascular spaces (**B, 100**×). Endothelial cells can be flat, although prominent epithelioid changes can be present (arrowheads indicate plump endothelial cells, **C, 200**×). Capillary hemangiomas seamlessly infiltrate renal parenchyma, CD31 immunohistochemical assay (**D, 200**×) highlights endothelial cells, whereas entrapped renal tubules (arrowheads, D) can be appreciated with lack of CD31.

like RCC [13,14]. Regardless to say, angiosarcomas can rarely be seen and can be distinguished by cytologic atypia, mitotic activity, and increased Ki67 proliferation index [7].

B) Compared to prior intrarenal hemangioma reports, frequent synchronous renal neoplasms were present in our cohort (almost one quarter of cases) and were strongly associated with capillary subtype. Moreover, two other intrarenal hemangiomas were associated with renal cysts. Why our cohort had more synchronous tumors with intrarenal hemangiomas or why synchronous tumors were common in capillary subtype is unclear, although presence of RCC with capillary hemangioma is previously reported in the literature [15].

C) Multifocality had a strong association with ESRD. A subset of our patients had ESRD and/or distinct non-neoplastic pathologies involving renal parenchyma, and all but one cases (5/6) had multifocal hemangioma. The association of ESRD with hemangiomas is well known, particularly underscored by Kryvenko et al. [16], and multifocal hemangiomas are frequently reported in these cohorts [16,17]. One meta-analysis suggested the association of anastomosing hemangioma with ESRD [18].

Limitations of this study includes retrospective nature of the observation. Moreover, arteriovenous malformation, considered under vascular tumors, were not represented in our cohort. Additionally, as this was a retrospective study from multiple institutions, consisting recording of the precise epicenter of the hemangiomas in the renal parenchyma (i.e. renal cortex vs medulla) were not recorded in our cohort. Finally, therapeutic interventions other than surgery, such as ablation techniques [19] were not present in the treatment of our cohort.

In conclusion, intrarenal hemangiomas are rare mostly asymptomatic benign vascular neoplasms, radiologically mimicking malignancy and thereby causing nephrectomies. Anastomosing subtype is the most common, moreover capillary subtype can be associated with synchronous tumors. Intrarenal hemangiomas can present in native or transplant kidneys and tend to be multifocal in patients with ESRD. It is non-progressive and non-recurring after surgery.

CRediT authorship contribution statement

Maria Faraz: Writing – original draft. **Andrew Rosenzweig:** Conceptualization. **Angel Panizo:** Data curation. **Sabina Hajiyeva:** Data curation. **Nusret B. Subasi:** Writing – original draft. **Mohammed A. Alghamdi:** Data curation. **Andrea A. Lightle:** Writing – review & editing. **Levente Kuthi:** Data curation. **Dora Kelemen:** Data curation. **Ankur R. Sangoi:** Writing – review & editing, Data curation, Conceptualization. **Luiz M. Nova-Camacho:** Data curation. **Mehrnaz Movassaghi:** Data curation. **Anandi Lobo:** Writing – review & editing, Data curation. **Shilpy Jha:** Data curation. **Kutsal Yörükoğlu:** Data curation. **Busra Yaprak Bayrak:** Data curation. **Sean R. Williamson:** Writing – review & editing, Data curation, Conceptualization. **Swati Bhardwaj:** Data curation. **Shivani Kandukuri:** Data curation. **Seema Kaushal:** Data curation. **Sambit K. Mohanty:** Data curation. **Mahmut Akgul:** Writing – review & editing, Project administration, Data curation, Conceptualization.

Patient consent

This study is conducted on a retrospective cohort, therefore patient

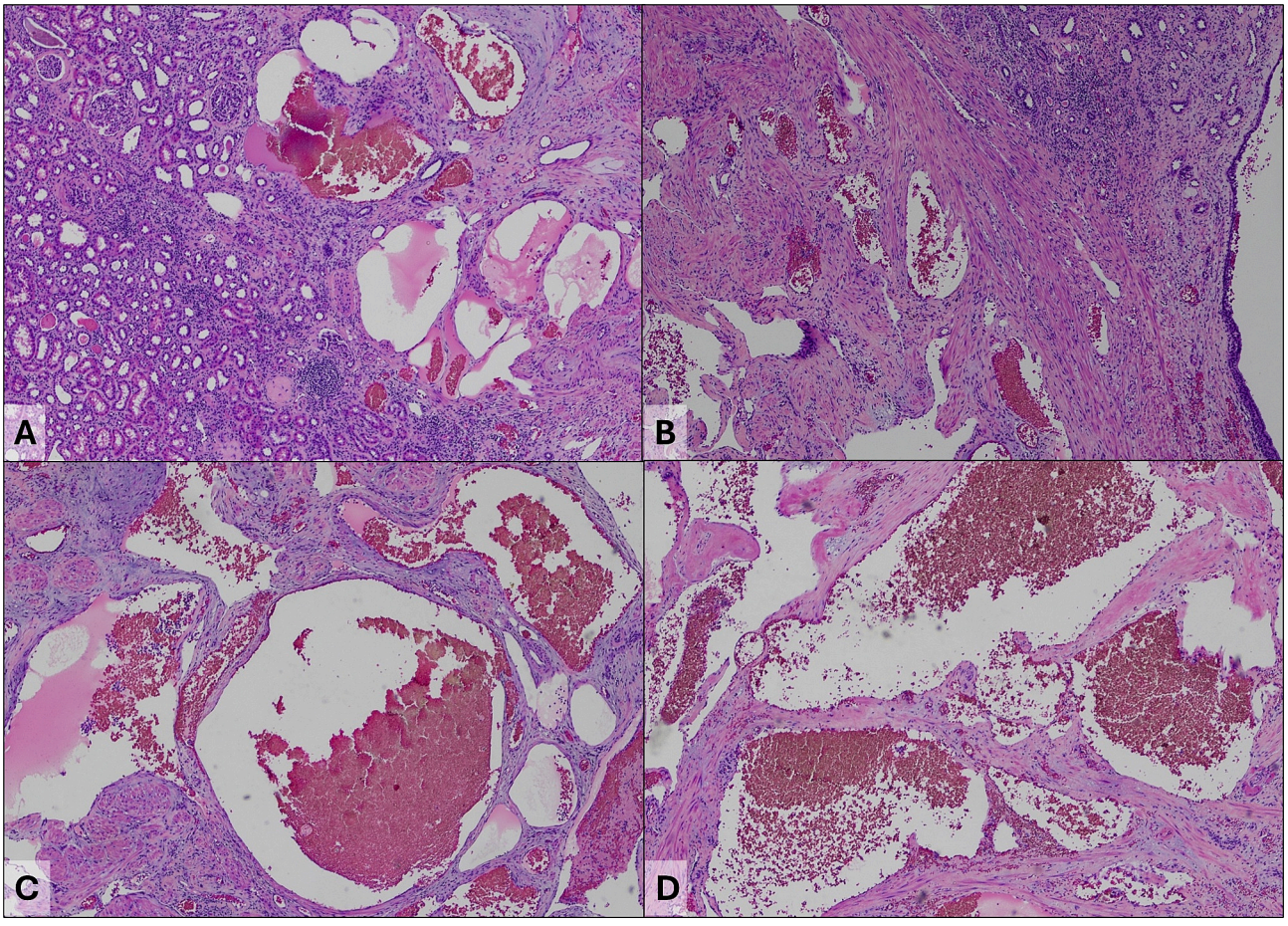


Fig. 3. Least common intrarenal hemangioma subtype in our cohort is cavernous, forming large cystic pools of hemorrhage (**A, B, 40**×) with thick fibromuscular septa and flattened and inconspicuous endothelial cells (**C, D, 100**×).

Table 2
Summary of selected cohorts of intrarenal hemangiomas in the literature.

First author/ publication year	PMID	Age (years)/ gender	Diagnosis	Laterality	Procedure type	Concurrent renal disease/neoplasm	Tumor size (cm)	Focality	Extramedullary hematopoiesis	Presence of fibrin thrombi	Follow-up
Mitchell et al. 1982	7131,472	NA /Female	Hemangioma *	Right	Partial Nephrectomy	Not Specified	2	Unifocal	No	Not specified	NED 5 years
		15/Female	Cavernous	Right	Partial Nephrectomy	Not Specified	NA	Unifocal	No	Present	NA
		25/Male	Cavernous	Left	Partial Nephrectomy	Not Specified	NA	Unifocal	No	Present	NED 4mo
Brown et al. 2010	20534992	58/Female	AVM	Right	Radical Nephrectomy	None	2.5; 1.5	Multifocal	No	Not specified	NA
		61/Male	AVM	Right	Radical Nephrectomy	None	2	Unifocal	No	Not specified	NA
		55/Male	AVM	Left	Radical Nephrectomy	None	NA	Unifocal	No	Not specified	NED 60
		64/Male	Capillary	Left	Partial Nephrectomy	None	3.5	Unifocal	No	Not specified	NA
		58/Male	Capillary	Left	Radical Nephrectomy	None	2	Unifocal	No	Not specified	NA
		56/Male	Anastomosing	Right	Partial Nephrectomy	None	1.3	Unifocal	No	Not specified	NA
		40/Male	Capillary	Left	Radical Nephrectomy	Lupus,ESRD, CRCC, PRCC, ACKD-RCC	0.2	Unifocal	No	Not specified	NED 2mo
		33/Female	Anastomosing	Left	Radical Nephrectomy	None	3.2	Unifocal	No	Not specified	NA
		69/Male	Capillary	Right	Nephroureterectomy	Urothelial Carcinoma	0.4	Unifocal	No	Not specified	Developed lung CA at 108 months
		21/Male	Anastomosing	Right	Radical Nephrectomy	ESRD, transplant	2.2	Unifocal	No	Not specified	NED 24mo
		49/Female	Capillary	Left	Radical Nephrectomy	ESRD, renal cortical papillary neoplasm	NA	Unifocal	No	Not specified	NA
		59/Male	Capillary	Right	Radical Nephrectomy	Oncocytoma	0.5	Unifocal	No	Not specified	NED 2mo
		60/Female	Capillary	Left	Radical Nephrectomy	None	2.1	Unifocal	No	Not specified	NED 36mo
		40/Male	Capillary	Left	Radical Nephrectomy	None	3	Unifocal	No	Not specified	NED 84mo
		44/Female	Anastomosing	Left	Radical Nephrectomy	None	2	Unifocal	No	Not specified	NED 72mo
		83/Female	Anastomosing	Left	Radical Nephrectomy	None	3.5	Unifocal	No	Not specified	NED 24mo
Mehta et al., 2012	23090628	58/Female	AVM	Right	Radical Nephrectomy	None	4	Unifocal	Not specified	Not specified	NED 36mo
		33/Female	AVM	Left	Radical Nephrectomy	Renal infarct	9.2	Unifocal	Not specified	Not specified	NED 68mo
		74/Female	AVM	Left	Partial Nephrectomy	PRCC	3.4	Unifocal	Not specified	Not specified	NED 12mo
		47/Male	AVM	Right	Partial Nephrectomy	None	2.4	Unifocal	Not specified	Not specified	NED 9mo
		61/Male	AVM, Hemangioma	Right	Nephroureterectomy	None	2 (AVM); 0.9 (Hemangioma)	Multifocal	Not specified	Not specified	NED 112mo
		60/Male	Hemangioma*	NA	Radical Nephrectomy	CCRCC contralateral kidney	0.5	Unifocal	Not specified	Not specified	NED 3mo
		39/Female	Hemangioma*	Right	Partial Nephrectomy	None	1.8	Unifocal	Not specified	Not specified	NED 3mo
		63/Male	Hemangioma*	NA	Laparoscopic drainage of renal cyst	Renal stones	9	Unifocal	Not specified	Not specified	NED 12mo
		49/Male	Anastomosing	NA	Radical Nephrectomy	ESRD	2	Unifocal	Present	Not specified	NED 58mo
		55/Male	Anastomosing	NA	Radical Nephrectomy	ESRD; papillary adenoma	0.6	Unifocal	Present	Not specified	NED 144mo
		45/Male	Anastomosing	NA	Radical Nephrectomy	ESRD	1.9	Unifocal	Present	Not specified	NED 132mo
Montgomery et al. 2009	19606014	74/Male	Anastomosing	NA	Radical Nephrectomy	Renal sinus fat hemangioma	1.5	Unifocal	Present	Not specified	NED 36mo
		75/Female	Anastomosing	NA	Radical Nephrectomy	Renal sinus fat and periureter hemangioma	2	Unifocal	Present	Not specified	NA
Kryvenko et al. 2014	24548339	68/Female	Anastomosing	Right	Nephrectomy**	ESRD	0.1, 1.5	Multifocal	Present	Not specified***	NA
		51/Female	Anastomosing	Right	Nephrectomy**	ESRD	1	Unifocal	Present	Not specified***	NA
		54/Female	Anastomosing	Bilateral	Nephrectomy**	ESRD; CCRCC, PA	0.6, 1.1	Multifocal	Present	Not specified***	NA
		29/Male	Anastomosing	Bilateral	Nephrectomy**	ESRD	1.3, 0.5	Multifocal	Present	Not specified***	NA

(*continued on next page*)

Table 2 (*continued*)

First author/ publication year	PMID	Age (years)/ gender	Diagnosis	Laterality	Procedure type	Concurrent renal disease/neoplasm	Tumor size (cm)	Focality	Extramedullary hematopoiesis	Presence of fibrin thrombi	Follow-up
		40/Male	Anastomosing	Left	Nephrectomy**	Lupus, ESRD; CCPRT, ACKD RCC, PA	0.25	Unifocal	Present	Not specified***	NA
		34/Male	Anastomosing	Right	Nephrectomy**	Lupus, ESRD; ACKD RCC	0.25–1.3	Multifocal	Present	Not specified***	NA
		62/Male	Anastomosing	Left	Nephrectomy**	ESRD; ACKD RCC, ACKD RCC precursor	1	Unifocal	Present	Not specified***	NA
		40/Male	Anastomosing	Left	Nephrectomy**	Lupus, ESRD; renal sinus fat hemangioma	8	Unifocal	Present	Not specified***	NA
		46/Male	Anastomosing	Left	Nephrectomy**	IgA nephropathy, ESRD	1.6	Unifocal	Present	Not specified***	NA
		60/Male	Anastomosing	Left	Nephrectomy**	Hereditary nephritis, ESRD; PA; ACKD RCC precursor	3.5	Unifocal	Present	Not specified***	NA
		49/Male	Anastomosing	Right	Nephrectomy**	FSGS, ESRD; renal sinus fat hemangioma	3.5	Unifocal	Present	Not specified***	NA
		49/Male	Anastomosing	Left	Nephrectomy**	ESRD;	1.3	Unifocal	Present	Not specified***	NA
		66/Male	Anastomosing	Right	Nephrectomy**	ESRD; ACKD RCC precursor, PA	3	Unifocal	Present	Not specified***	NA
		15/Male	Anastomosing	Bilateral	Nephrectomy**	ESRD; renal sinus fat hemangioma	0.2, 0.7	Multifocal	Present	Not specified***	NA
		<1/Male	Capillary	Right	Nephrectomy**	ESRD, Congenital nephrotic syndrome, Wilms Tumor	1	Unifocal	Present	Present***	NA
		17/Male	Anastomosing	Bilateral	Nephrectomy**	ESRD, ACKD; RCC NOS, PA	0.1–2.8	Multifocal	Present	Not specified***	NA

ACKD: acquired cystic kidney disease; CCRCC: clear cell renal cell carcinoma; ESRD: end stage renal disease; FSGS: focal segmental glomerulosclerosis; NOS: not otherwise specified; RCC: renal cell carcinoma; PA: papillary adenoma; PRCC: papillary renal cell carcinoma.

* Hemangioma subtpye was not documented.

** Whether radical or partial nephrectomy was performed in each case was not documented.

*** Fibrin thrombus was present in 10 hemangiomas, however, which specific case had fibrin thrombus was not documented.

consent was not applicable at the time of the study. Patients' anonymity was meticulously protected throughout the manuscript.

Ethical statement

This study was conducted under Albany Medical Center Local Ethics Committee's approval (IRB #GU-5781). This study adhered to Declaration of Helsinki (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/). All other contributors shared de-identified data from archival tissue specimens and were adhered to their local ethics committee approval.

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Declaration of competing interest

None.

Data availability

Additional de-identified data is available upon request.

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