MARMARA
MEDICAL JOURNAL

Original Article

https://dergipark.org.tr/tr/pub/marumj

Wilms tumor with intravascular extension: Analyzing tumor thrombus characteristics and survival

Kivilcim KARADENIZ CERIT[1], Nursah EKER[2], Ozge KILIC BAYAR[1], Dilek GUL[3], Elif DEMIRBAS[4], Koray AK[4], Ozge YAPICI[5], Gulnur TOKUC[2], Gursu KIYAN[1]

[1] Department of Pediatric Surgery, School of Medicine, Marmara University, Istanbul, Türkiye.
[2] Division of Pediatric Hematology-Oncology, Department of Child Health and Pediatrics, School of Medicine, Marmara University, Istanbul, Türkiye.
[3]Department of Radiation Oncology, School of Medicine, Marmara University, Istanbul, Türkiye.
[4] Department of Cardiovascular Surgery, School of Medicine, Marmara University, Istanbul, Türkiye.
[5] Department of Radiology, School of Medicine, Marmara University, Istanbul, Türkiye.
Corresponding Author: Kivilcim KARADENIZ CERIT
E-mail: kcerit@yahoo.com

Submitted: 25.11.2024 **Accepted:** 27.12.2024

ABSTRACT

Objective: The aim of the study is to review the oncological and surgical strategies for Wilms tumor (WT) with intravascular thrombus extension at our institution.

Patients and Methods: Medical records of patients with WT treated in our institution between June 2012 and June 2024 were retrospectively reviewed. Among these data, patients with intravascular tumor thrombus were identified. Demographics, imaging studies to determine the initial level of thrombus, surgical management and outcomes were analyzed.

Results: During this period 51 patients with WT were treated in our institution. Seven patients (6 male, 1 female) with intravascular tumor thrombus extension were identified (13%). The median age was 46 months (22-67 months). Six patients had unilateral WT (UWT) and one patient had bilateral WT (BWT). Tumor thrombus extension during initial evaluation were: level III (5), level IV (1) and level V (1). Thrombus level in all patients with level III regressed to level II, while, no regression was observed in 2 patients with cardiac thrombus. All patients underwent surgery after neoadjuvant chemotherapy. At a median follow-up of 5 years, the 5-year event-free survival and overall survival rates were 83.3% and 83.3% respectively in patients with intravascular thrombus. In addition, the 5-year event-free survival and overall survival rates were 85% and 94% respectively in patients without intravascular thrombus.

Conclusion: Management of WT with intravascular thrombus is a challenging process. Multidisciplinary approach and an experienced surgical team are the main factors that determine survival in these patients.

Keywords: Wilms tumor, Intravascular extension, Children

1. INTRODUCTION

Wilms tumor (WT) is the most common solid renal tumor in children (70%), and the second most common abdominal tumor in infancy and childhood [1]. Although, different study groups such as National Wilms Tumor Study Group (NWTSG) / Children's Oncology Group (COG) and Societe Internationale d'Oncologie Pediatrique (SIOP) show that survival rates have exceeded 85%, management of intravascular extension is still a difficult aspect in WT [2]. Intravascular extension into the ipsilateral renal vein was reported in 11% of patients, further extension occured into the inferior vena cava (IVC) in 4-10% of patients, while, the extension to the right atrium was only in 1% of patients with WT [3]. COG primarily recommends neoadjuvant chemotherapy in intracaval thrombus extending superior to the level of hepatic veins, since, it would be difficult to control the thrombus with an abdominal approach and these patients may even require cardiopulmonary bypass (CPB) [2].

Determining the extent of intravascular thrombus before surgery is important as it will completely affect the surgical strategy. Depending on the level of thrombus, CPB or cavatomy may be preferred to achieve complete resection, while cavectomy should also be considered as a surgical option in cases where there is no blood flow around it [4]. In previous publications during presurgical planning Doppler ultrasonography (US), computed tomography (CT), magnetic resonance imaging

How to cite this article: Karadeniz Cerit K, Eker N, Bayar OK, et al. Wilms tumor with intravascular extension: Analyzing tumor thrombus characteristics and survival. Marmara Med J 2025;38(2): doi: 10.5472/marumj. 1707972

© 2025 Marmara University Press, All Rights Reserved
ISSN: 1309-9469

http://doi.org/10.5472/marumj.1707972
Marmara Med J 2025;38(2): 114-120

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

(MRI), venography were used to determine the extent of vascular tumor thrombus; in addition echocardiography was recommended in the evaluation of cardiac thrombus [5]. In the latest recommendations of the American Pediatric Surgical Association (APSA) Cancer Committee, it was emphasized that if triphasic CT scan was performed for the evaluation of cavoatrial thrombus, there is no need to perform routine Doppler US [2,6]. Furthermore, Abdullah et al., decribed the decrease in cardiac volume caused by reduced venous return with positive pressure ventilation under anesthesia [7]. Considering the risk of sudden arrest, the authors emphasized the importance of echocardiographic examination before surgery [7].

Due to the rarity of WT with intravascular extension, the oncological management and surgical strategies to be applied in these patients are still a challenge and a controversial topic. Although, survival rates in WT with intravascular extension following neoadjuvant chemotherapy are expected to be similar to uncomplicated WT cases, the main factor in determining survival in these patients are multidisciplinary approach and an experienced surgical team [8]. The aim of this study is to review our institutional experience in complicated WT with intravascular tumor thrombus extension that have been managed based on current knowledge and recommendations in the latest published studies.

2. PATIENTS and METHODS

Ehical approval for this study was obtained from the Marmara University School of Medicine Non-Interventional Clinical Research Ethics Committee (approval number: 09.2024.361). Consent for study participation was obtained from all patients or their guardians. We conducted a retrospective review of the medical records of patients with the diagnosis of WT treated in our institution between June 2012 and June 2024. Among these data, patients with intravascular tumor thrombus extension were identified and included in the study. Patient demographics, imaging studies, chemotherapy/radiotherapy protocols, operative details, stage/histology, viability of tumor thrombus, patency of IVC were analyzed. Triphasic CT scan was performed to determine the initial tumor thrombus extension and was categorized according to Abdullah's classification which is a modification of the original staging proposed by Daum [7,9]. In addition, echocardiography was performed in patients with intracardiac tumor thrombus. All patients received neoadjuvant chemotherapy in accordance with NWTSG-5/AREN0534 protocols [2].

Statistical Analysis

Statistical analysis was done using SPSS software version 25 for data management and analysis. Kaplan-Meier plots were drawn using the software for event-free survival (EFS) and overall survival (OS). A p – value <0.05 was considered statistically significant.

3. RESULTS

During this period, 51 patients with WT were treated in our institution. Forty-four patients (35 UWT, 8 BWT, 1 horseshoe kidney) had no intravascular thrombus during initial evaluation. We identified 7 patients (6 male and 1 female) who had intravascular tumor thrombus (13%). The median age was 46 months (22-67 months). Six patients had unilateral UWT, and one patient had BWT. Triphasic CT scan was performed for the evaluation of cavoatrial thrombus in all of our patients. The level of tumor thrombus extension during initial evaluation were as follows according to the Abdullah's classification: level III (5), level IV (1) and level V (1) (Figure 1). In two patients who had intracardiac tumor thrombus, echocardiography was also performed. Three out of seven cases received 3 drug neoadjuvant chemotherapy (vincristine, dactinomycin, doxorubicin) according to the NWSTG-5 protocol (6-8 weeks), while four cases received it according to the AREN0534 protocol (4-12 weeks). In two cases under the AREN0534 protocol, two cycles of ICE therapy (ifosfamide, carboplatin, etoposide) were given due to inoperability after 12 weeks of chemotherapy. Regression of trombus level after neoadjuvant chemotherapy was observed in 5 patients. All patients with level III thrombus regressed to level II, while, two patients with cardiac thrombus no regression occurred in 2 cases with cardiac thrombus. All patients underwent surgery after neoadjuvant chemotherapy. Different surgical tecniques were used for various levels of intravascular tumor thrombus.



Figure 1. *CT image showing intracaval thrombus*

http://doi.org/10.5472/marumj.1707972
Marmara Med J 2025;38(2): 114-120

In patients with level II intracaval tumor thrombus, cavatomy was performed to remove the intravascular thrombus (4 patients with UWT). In this approach, initially IVC and all branches were controlled. The main right renal vein, left renal vein, suprarenal and infrarenal vena cava were controlled with vessel loops (Figure 2). The vessel was examined to detect the healthy segment without tumor thrombus. It is one of the most important steps of surgery since clamping at the wrong level can cause proximal embolization of the thrombus. Following systemic heparinization proximal and distal healthy segments were clamped. Through a vertical venotomy, the thrombus was resected en bloc with renal tumor specimen and lymph node samples. Antegrad and retrograd blood flow were examined. Robust bleeding and backbleeding were noted from the renal vein and IVC. The venotomy was closed with 6/0 prolene suture following air expelling. In one of these patients, the thrombus was also present in the right iliac vein. Tumor thrombus in IVC was adherent to the vessel wall, and it was removed piece by piece. In addition, the macroscopic examination of tumor thrombus in the right iliac vein was different from intracaval thrombus, in fact a chronic thrombus appearance was observed in the removed specimen. As estimated, no tumor cells were detected in the pathological examination of the thrombus removed from the iliac vein. It was concluded that the tumor thrombus in IVC caused stasis, resulting in the development of chronic thrombus at the level of right iliac vein. In one patient with BWT who had intracaval thrombus, the same surgical steps were followed as in patients with UWT. After a vertical venotomy the thrombus was resected en bloc with renal tumor specimen in one kidney, afterwards lymph node sampling and contralateral enucleation was performed on the other side. Excision of the vascular wall was not performed in any of the patients and none of the patients required a vascular greft.

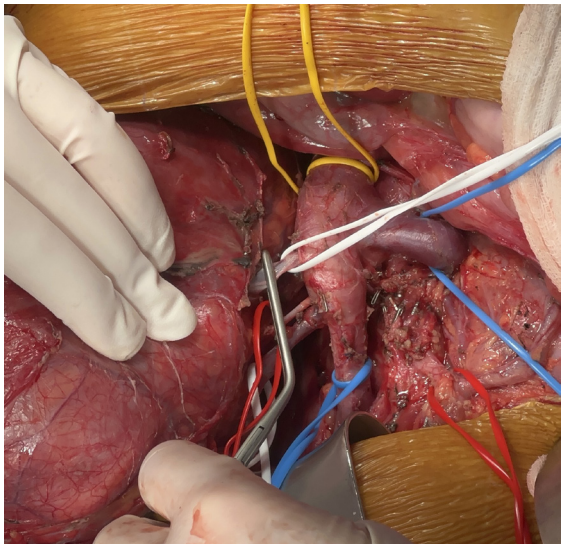


Figure 2. *Operative view: Controlling the IVC and all branches*

Another type of surgical approach was used in 2 patients who had thrombus extending into the atrium and ventricle during presentation. Since, no regression in thrombus were observed after neoadjuvant chemotherapy and decrease in ejection fractions was determined in one of them, performing CPB surgery were decided in these patients. Through a laparotomy incision, exploration of the tumor and controlling the main right renal vein, left renal vein, suprarenal and infrarenal vena cava with vessel loops was the first step of surgery. Afterwards sternotomy, aortic and bicaval cannulation were performed (Figure 3). Subsequently, CPB circuit was started. While, reaching the requisite temperature for total circulatory arrest, tumor was completely removed. Vertical cavotomy was performed and tumor thrombus was mobilized from abdomen as much as possible. Then aortic cross clamp was replaced. Cardioplegia delivery was performed antegrad via aortic root cannula. Under total circulatory arrest, both the tumor thrombus in the atrium and primarily mobilized intracaval tumor thrombus were removed through the right atriotomy. Afterwards, the patient was weaned from CPB. No operative mortality nor complications occurred. All patients received adjvant chemotherapy and radiotherapy according to current protocols. Patients were also evaluated for vascular patency in surveillance imaging. In 6 patients, stenosis in IVC or recurrent thrombus were not identified during the postoperative oncological follow-up. However, in one patient partial stenosis in IVC was detected. The same patient died in intensive care conditions due to sepsis. Patient was in 14th month of complete remission after unilateral nephroureterectomy and removal of the atrioventricular thrombus with CPB surgery. While, complete remission was observed in 5 patients, adjuvant treatment of one patient is still ongoing. At a median follow-up of 5 years, the 5-year event free survival and overall survival rates were 83.3% and 83.3% respectively in patients with intravascular thrombus (Figure 4). In addition, the 5-year event free survival and overall survival rates were 85% and 94% respectively in patients without intravascular thrombus (Figure 5). The overall survival rate of patients without intravascular thrombus was higher than the survival rate of patients with intravascular thrombus. However, the statistical comparison could not be performed due to the nonhomogeneous distribution of groups with and without intravascular thrombus. Neoadjuvant/adjuvant chemotherapy protocols, operative details, stage distribution, tumor histology and viable tumor cells within thrombus and radiotherapy protocols are presented in Table I.

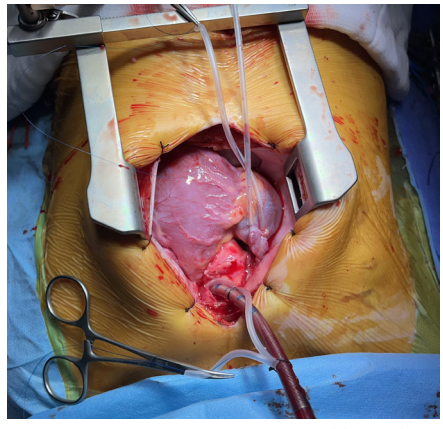


Figure 3. *Operative view: Sternotomy, aortic and bicaval cannulation*

http://doi.org/10.5472/marumj.1707972
Marmara Med J 2025;38(2): 114-120

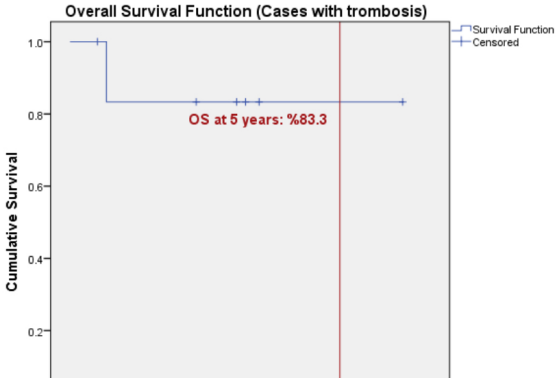


Figure 4. *Event-free survival and overall survival of patients*

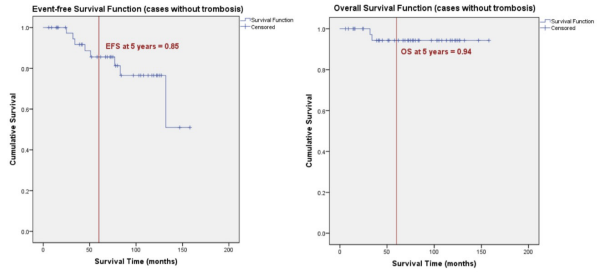


Figure 5. *The 5-year event-free survival and overall survival in patients without intravascular thrombus*

Table I. *Patient demographics, chemotherapy protocols, surgical management, and outcomes*

P	Presentation	Age Gender	Neoadjuvant therapy	Operation	Stage, histology, viability of tumor thrombus	Adjuvant therapy	Outcome
1	BWT (level III)	46 months M	AREN 0534, 12 weeks, ICE 2 weeks	UNU (L), NSS (R) cavatomy, thrombectomy	L I, R I, FH, margin (-) viable tumor thrombus (-)	AREN 0534 Right flank XRT pulmonary XRT	CR
2	UWT (level IV)	56 months M	NWTSG-5 6 weeks	UNU (L), CPB	L IV, FH, margin (-) viable tumor thrombus (-)	NWTSG-5, WART	CR
3	UWT (level V)	24 months F	NWTSG-5 8 weeks	UNU (R), CPB	R III, UFH, diffuse anaplasia, margin (-) viable tumor thrombus (-)	NWTSG-5 Right flank XRT	Exitus
4	UWT (level III)	35 months M	NWTSG-5 6 weeks	UNU (L), cavatomy, thrombectomy	L III, FH, margin (+) viable tumor thrombus (+)	NWTSG-5 Left flank RT	CR
5	UWT (level III)	48 months M	AREN 0534 9 weeks	UNU (R), cavatomy, thrombectomy	L IV, FH, margin (-) viable tumor thrombus (-)	AREN0534 Right flank XRT pulmonary XRT	CR
6	UWT (level III)	22 months M	AREN0534 12 weeks, ICE 2 weeks	UNU (R), cavatomy, thrombectomy	R III, FH, margin (-) viable tumor thrombus (+)	AREN 0534, Right flank XRT	CR
7	UWT (level III) (right iliac vein thrombus)	67 months M	AREN 0534 4 weeks	UNU (R), cavatomy, thrombectomy	R III, FH, margin (-) viable tumor thrombus (-)	AREN 0534 WART	Ongoing adjuvant chemotherapy

BWT:Bilateral Wilms tumor/UWT:Unilateral Wilms tumor, M:male/F:female, IVC: Inferior vena cava, UNU: Unilateral nephroureterectomy, NSS: Nephron-sparing surgery, ICE: Ifosfamide, Carboplatin, Etoposide, FH: Favorable histology, UFH: Unfavorable histology, XRT: Radiotherapy, WART: Whole abdomen RT, CR: Complete remission

http://doi.org/10.5472/marumj.1707972
Marmara Med J 2025;38(2): 114-120

4. DISCUSSION

Significant improvements in the management of pediatric WT have been observed due to the advances in diagnostic methods, surgical techniques, chemotherapy and radiotherapy protocols [10]. Although, there has been gradual improvement in long-term survival rates of WT based on prospective studies and multimodal treatment, surgical difficulties continue in a special subgroup classified as complex WT such as patients with intravascular tumor thrombus [2,8,11].

The most controversial issue in WT with intravascular thrombus is the administration and duration of neoadjuvant chemotherapy. In earlier studies, histological type and stage were reported as the most significant factors affecting survival [11]. Moreover, surgical removal of the tumor thrombus was recommended without receiving chemotherapy or radiotherapy before surgery in technically suitable patients [11]. However, in their next study the same authors observed that nephrectomy could be performed in 93% of the patients after neoadjuvant treatment who were considered inoperable or unresectable initially [12]. In the subsequent NWTS-4 study, regression rates of tumor thrombus extending to IVC (86%) and atrium (58%) after preoperative chemotherapy were reported [13]. Although, increased complication rates were observed in atrial thrombus compared to caval thrombus (36% vs 17%), no significant difference was observed between groups in terms of complication rates comparing primary surgery and surgery after preoperative chemotherapy [13]. Reviewing the data in the literature, intracardiac thrombus in some patients decreased to the infrahepatic/infradiaphragmatic IVC level or complete thrombus resolution were observed with neoadjuvant chemotherapy, thus eliminating the need for aggressive surgery [3,7]. Furthermore, significant difference was reported comparing neoadjuvant chemotherapy response and the initial anatomical level of intracaval thrombus ($p<0.001$) as a result of the analysis of largest cohort patient series with malignant tumor thrombus in IVC [14]. On the other hand, an urgent surgical approach may be required during neoadjuvant chemotherapy in some circumstances: if the tumor thrombus grows, risk for pulmonary embolism occurs or cardiac malfunction develops [3,7,14]. In our study, regression of the intracaval tumor thrombus from suprahepatic to infrahepatic level was observed in 5 patients; thus, due to this improvement less aggressive surgeries were applied in these patients. Neverthless, no regression in tumor thrombus was observed in patients who had extension into the atrium or ventricle. Moreover, urgent surgery was decided in one of the patients due to the deterioration in cardiac functions while neoadjuvant chemotherapy was ongoing.

Another controversial issue is duration of neoadjuvant chemotherapy. Recently, Morris et al., reviewed the data on this topic to analyze the optimal duration of neoadjuvant chemotherapy [16]. In their study, standard duration (4 weeks) and extended duration (longer than 6 weeks) of chemotherapy were compared according to the patient groups in the literature. As a result of their analysis disease-free survival rates were increased significantly in standard duration of chemotherapy (78% vs 54%, $p=0.04$). Furthermore, they compared patient groups according to standard duration and extended duration of chemotherapy relying the data of SIOP. While, increased disease-free survival rates and significantly increased complete survival rates were observed in standard duration of chemotherapy (95% vs 79%, $p=0.02$), no significant difference was observed in terms of tumor regression, complete resection or cavectomy [16]. In our patients, it was also observed that intensifying or extending the duration of chemotherapy did not change the treatment approach, especially for patients who had intracardiac tumor thrombus.

The rare presentation of BWT accompanied by intravascular tumor thrombus creates a very challenging situation. The main goal in BWT is to prevent long-term renal insufficiency by using a renal tissue-preserving approach as much as possible without compromising long-term oncological outcomes [17]. The need for CPB was avoided in 80% of patients with regression of tumor thrombus above the hepatic vein level or atrium after neoadjuvant chemotherapy. Furthermore, complications that may develop during surgery were prevented [18]. However, bilateral nephron-sparing surgery may not be possible due to tumor thrombus and radical nephroureterectomy may be necessary due to difficult anatomic circumstances [18]. Similarly, in our patient, although nephron-sparing surgery was performed in one kidney, the other kidney had to be removed en bloc due to tumor thrombus.

Another debatable topic is whether incomplete thrombectomy increases the risk of relapse. When the tumor thrombus is mobile within the vessel, cavatomy and thrombectomy procedures are performed; whereas in cases thrombus is adherent to the vessel wall, it may be necessary to peel the intima and remove the thrombus piece by piece. It is a controversial issue whether such an incomplete thrombectomy increases the risk of relapse. Since, the tumor thrombus is mostly not viable after neoadjuvant chemotherapy, the necessity of a complicated vascular surgery is questioned recently [18]. Unfortunately, there is no imaging method which can determine the viability of tumor thrombus preoperatively. Therefore, surgical techniques with undefined long-term effects such as thrombectomy, partial or complete cavectomy, and repair of the IVC with sutures or patch/synthetic grafts are still performed during the removal of the thrombus [18].

Considering the viability of tumor thrombus, results of the IMPORT study were published recently [19]. According to their analysis, while OS and EFS were significantly associated with histological risk group ($p<0.05$); no significant association was shown with the viability of the tumor thrombus [19]. Furthermore, a significant association was observed between completeness of surgical resection and EFS ($p<0.05$) [19]. Based on these results, the authors emphasized the importance of complete resection and recommended extensive surgical approach in the form of artificial IVC replacement [19]. They also drew attention to the necessity of radiotherapy as an adjuvant treatment in case of necrotic tumor thrombus, due to the nonsignificant association between viability of the tumor thrombus and survival [19]. However, Ehrlich critisized the results of this study in which regression of intravascular tumor

http://doi.org/10.5472/marumj.1707972
Marmara Med J 2025;38(2): 114-120

thrombus was observed only in 22% of patients when compared with Shamberger's study [14]. Ehrlich believed that low regression rate might be related to application of neoadjuvant chemotherapy containing two drugs [20]. Furthermore, Ehrlich recommended increasing upfront therapy which might improve regression ration and complete tumor resection [20]. He also emphasized that aggressive surgery and artificial vascular stents might have unexpected long-term consequences and concluded that avoiding radiation therapy in patients with necrotic tumor thrombus should be decided based on the results of prospective studies [20]. In our study, complete resection of tumor thrombus was achieved in all patients. Since, viable tumor thrombus was observed only in one patient, nevertheless all patients received postoperative radiotherapy.

Contributing to this debate, Loh et al., analyzed treatment approaches and long-term results of solid abdominal tumors with intracaval tumor thrombus previously [21]. In this study; Hinman level, viability of the tumor thrombus and completeness of surgical thrombectomy were not associated with OS [21]. However, OS had a significant association between IVC patency and histologic type [21]. In addition, no relation with short-term morbidity and vascular component of tumors was observed [21]. However, incomplete resection causing caval occlusion and long-term morbidity were emphasized by authors [21]. Similarly, in our study the only patient who died in intensive care unit of another center, had partial stenosis in the IVC. Although, the patient was in complete remission, sepsis was declared as the cause of death. Therefore, we believe that close follow-up is required after these complicated procedures. Since, we know that this was the only patient who had partial stenosis in IVC, in our current approach we recommend that surgeons should have low threshold in performing diagnostic tests in terms of vascular patency after surgery in these patients.

Conclusion

Wilms tumor with extension of intravascular tumor thrombus requires detailed oncological evaluation and follow-up. Therefore, complicated cases should be managed by experienced surgical teams with multidisciplinary approach. Although, the retrospective design and small number of patients are the limitations of our study, we believe that it is important to share our experiences in these rare, complicated cases which can only be applied in centers with the requisite expertise.

Acknowledgement: The authors are grateful to Gizem Tanıl for her support in statistical analysis of data and preparation Kaplan-Meier plots of event-free survival (EFS) and overall survival (OS).

Compliance with Ethical Standards

Ethical approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by Marmara University School of Medicine Non-Interventional Clinical Research Ethics Committee (approval number: 09.2024.361). Consent for study participation was obtained from all patients or their guardians.

Conflict of interest: The authors declare that there is no conflict of interest.

Financial support: This study received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Author contributions: KKC and NE: Concept and design, NE, OKB, DG, ED and OY: Data collection and processing, KKC, NE, KA, GT and GK: Analysis or interpretation, KKC, NE, DG and ED: Literature search, KKC, NE, DG and ED: Writing the manuscript. All authors approved the final version of the manuscript.

REFERENCES

[1] Lopyan NM, Ehrlich PF. Surgical management of Wilms tumor (nephroblastoma) and renal cell carcinoma in children and young adults. Surg Oncol Clin N Am 2021;30:305-23. doi:10.1016/j.soc.2020.11.002

[2] Aldrink JH, Heaton TE, Dasgupta R, et al. Update on Wilms tumor. J Pediatr Surg 2019;54:390-7.

[3] Naik-Mathuria B, Utria AF, Ehrlich PF, et al. Management and outcomes of Wilms tumor with suprarenal intravascular extension: A pediatric surgical oncology research collaborative study. Ann Surg 2024;279:528-35. doi: 10.1097/SLA.000.000.0000005921

[4] Pio L, Abib S, Guerin F, et al. Surgical management of Wilms tumors with intravenous extension: A multicenter analysis of clinical management with technical insights. Ann Surg Oncol 2024;31:4713-23. Available from: https://doi.org/10.1245/s10434.024.15232-w

[5] Szavay P, Luithle T, Semler O, Graf N, Fuchs J. Surgery of cavoatrial tumor thrombus in nephroblastoma: A report of the SIOP/GPOH study. Pediatr Blood Cancer 2004;43:40-5.

[6] Khanna G, Rosen N, Anderson JR, et al. Evaluation of diagnostic performance of CT for detection of tumor thrombus in children with Wilms tumor: A report from the Children's Oncology Group. Pediatr Blood Cancer 2012;58:551-5.

[7] Abdullah Y, Karpelowsky J, Davidson A, et al. Management of nine cases of Wilms' tumour with intracardiac extension: A single centre experience. J Pediatr Surg 2013;48:394-9. doi:10.1016/j.jpedsurg.2012.11.024

[8] Cox S, Büyükünal C, Millar AJW. Surgery for the complex Wilms tumour. Pediatr Surg Int 2020;36:113-27. doi: 10.1007/s00383.019.04596-w

[9] Daum R, Roth H. Tumor infiltration of the vena cava in nephroblastoma. Pediatr Surg Int 1992;7:16-20.

[10] Bader MI, Abdelaal K, Rogers T, Arul SG. A surgical approach to Wilms' tumour with retrohepatic vena caval extension. Pediatr Surg Int 2013;29:229-32.

[11] Ritchey ML, Kelalis PP, Breslow N, Offord KP, Shochat SJ, D'Angio GJ. Intracaval and atrial involvement with nephroblastoma: Review of National Wilms Tumor Study-3. J Urol 1988;140(5 Pt 2):1113-8. doi: 10.1016/S0022-5347(17)41975-6

[12] Ritchey ML, Pringle KC, Breslow NE, et al. Management and outcome of inoperable Wilms tumor: A report of National Wilms Tumor Study-3. Ann Surg 1994;220:683-90.

[13] Shamberger RC, Ritchey ML, Haase GM, et al. Intravascular extension of Wilms tumor. Ann Surg 2001;234:116-21.

[14] Elayadi M, Hammad M, Sallam K, et al. Management and outcome of pediatric Wilms tumor with malignant inferior vena cava thrombus: Largest cohort of single-center experience. Int J Clin Oncol 2020;25:1425-31. doi:10.1007/s10147.020.01667-0

[15] Morris L, Squire R, Sznajder B, van Tinteren H, Godzinski J, Powis M. Optimal neoadjuvant chemotherapy duration in Wilms tumour with intravascular thrombus: A literature review and evidence from SIOP WT 2001 trial. Pediatr Blood Cancer 2019;66:e27941.

[16] Sutthatarn P, Gomez Quevedo O, Gleason J, Davidoff AM, Murphy AJ. Management of intravascular thrombus in cases of bilateral Wilms tumor or horseshoe kidney. J Pediatr Surg 2022;57:166-73. doi: 10.1016/j.jpedsurg.2021.07.025

[17] Qureshi SS, Bhagat M, Smriti V, et al. Intravascular extension of Wilms tumor: Characteristics of tumor thrombus and their impact on outcomes. J Pediatr Urol 2021;17:69.e1-69.e8. doi:10.1016/j.jpurol.2020.10.003

[18] Boam TD, Gabriel M, Shukla R, Losty PD. Impact of neoadjuvant chemotherapy on thrombus viability in patients with Wilms tumour and caval extension: Systematic review with meta-analysis. BJS Open 2021;5:zrab036.

[19] Dzhuma K, Powis M, Vujanic G, et al. Surgical management, staging, and outcomes of Wilms tumours with intravascular extension: Results of the IMPORT study. J Pediatr Surg 2022;57:572-8. doi: 10.1016/j.jpedsurg.2021.08.023

[20] Ehrlich P. Commentary on surgical management, staging, and outcomes of Wilms tumours with intravascular extension: Results of the IMPORT study. J Pediatr Surg 2022;57:579-80. doi:10.1016/j.jpedsurg.2021.09.009

[21] Loh A, Bishop M, Krasin M, Davidoff AM, Langham MR. Long-term physiologic and oncologic outcomes of inferior vena cava thrombosis in pediatric malignant abdominal tumors. J Pediatr Surg 2015;50:550-5. doi: 10.1016/j.jpedsurg.2014.11.044