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ORIGINAL ARTICLE

Catheter-Related Intracardiac Thrombosis in Children: A 10-Year Single-Center Retrospective Study

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Abstract

OBJECTIVES: Central venous catheter–related intracardiac thrombosis is a rare but potentially life-threatening complication in pediatric patients.
MATERIALS AND METHODS: This retrospective single-center study included pediatric patients diagnosed with catheter-related intracardiac thrombosis. Demographic characteristics, thrombus features, inflammatory markers, microbiological findings, treatment strategies, and outcomes were analyzed.
RESULTS: Twenty-two patients were included. Median age was 143 months (range 2–217). Median CRP level was 11.8 mg/L (0.2–190). Underlying disease was predominantly renal (36.4%) and malignancy (27.3%). Catheters were internal jugular venous catheterization (54.5%), tunneled cuffed hemodialysis catheter (27.3%), and totally implantable venous access port (18.2%). Echocardiography was most commonly triggered by infection-related presentations (40.9%) or performed during routine/high-risk surveillance (31.8%). Median thrombus size was 10.5 mm (range 2–35). Right atrial thrombi were present in 20/22 patients (90.9%); one patient had right atrial plus right ventricular thrombi, and one had left ventricular thrombi secondary to myocarditis. Thrombus resolution occurred in 21/22 catheter-related right atrial cases (100% of right-sided thrombi). tPA was used in 45.5%; catheter removal in 40.9%; and surgical thrombectomy in 13.6%. Thrombus resolution occurred in 21/22 (95.5%); one patient with myocarditis and severe heart failure died. Median time to resolution was 8 days (range 1–51). Blood cultures were positive in 40.9% (most commonly coagulase-negative staphylococci). In this small cohort, time to thrombus resolution was similar between patients receiving tPA plus low-molecular-weight heparin and those managed with low-molecular-weight heparin alone, despite larger baseline thrombus size in the tPA group.
CONCLUSION: Catheter-associated intracardiac thrombosis is clinically important complication in children with chronic diseases requiring central venous access. Our findings suggest that intracardiac thrombosis may develop silently in patients with long-term central venous catheters, supporting consideration of routine

echocardiographic screening in high-risk subgroups. However, the optimal screening interval and target populations remain to be defined by prospective studies. While a size- and status-guided treatment strategy achieved high resolution rates, prevention should be prioritized.

INTRODUCTION

Intracardiac thrombosis in pediatric patients with central venous catheters is an increasingly recognized complication linked to the growing use of long-term implantable venous access devices. (Roy & Bansal, 2024) The exact prevalence in children remains variable; a recent systematic review of 262,587 hospitalized children with central venous access devices reported a pooled catheter related thrombosis prevalence of 9.1% (95% CI: 5.7–14.5%), with higher rates in pediatric intensive care units (10.7%) and lower rates in neonatal units (2.9%) (Fu *et al.* 2024). In these patients, thrombus formation is predominantly right atrial. Risk factors include catheter tip position, underlying comorbidities, and the prothrombotic state of critical illness, and have recently been expanded to encompass femoral insertion site, multi lumen catheters, prolonged indwelling time, and elevated D dimer levels. Better characterization of these risk factors is needed to guide prophylactic and therapeutic strategies (Lasagni *et al.* 2022, Jaffray *et al.* 2017). This study reports a decade of single-center experience with catheter-related intracardiac thrombosis in children, focusing on management strategies and outcomes, reported per STROBE guidelines (von Elm *et al.* 2007).

MATERIAL & METHODS

Study design and population

All pediatric patients (age <18 years) diagnosed with intracardiac thrombosis temporally associated with a central venous catheter between January 2014 and December 2024 were eligible for inclusion. Exclusion criteria were: (1) intracardiac thrombi attributable to primary cardiac pathology without catheter association, (2) isolated catheter-tip fibrin sheaths without discrete intracardiac mass on echocardiography, and (3) insufficient imaging data to confirm intracardiac thrombus. No patients were excluded during the study period. The data of the patients were analyzed retrospectively using patient files and the electronic record system.

The echocardiographic images and cardiac images from CT and MRI were reanalyzed from the stored images. Patient demographics, underlying diagnoses, catheter characteristics (type and dwell time), clinical indications for echocardiography, thrombus characteristics (size and location), treatment strategy, microbiological data, and outcomes were extracted from medical records and the electronic hospital information system.

Imaging and thrombus assessment

Transthoracic (TTE) and transesophageal echocardiography (TEE) was used for first diagnosis and CT or MRI imaging was performed on patients deemed necessary to support the diagnosis. Echocardiographic images were stored and features of the existing thrombus were recorded. The effectiveness and options of the treatment were determined by comparing echocardiography images showing changes in thrombus size over time. Transesophageal echocardiography and/or cardiac CT/MRI were performed in selected cases to improve characterization when transthoracic image quality was suboptimal or when additional anatomical detail was required. Stored echocardiographic and cross-sectional images were re-reviewed per current pediatric TTE standards (Lopez-Fernandez *et al.* 2024), and thrombus size was recorded as the maximal diameter on imaging.

Management strategy and definitions

Thrombus management was guided by a multidisciplinary team including the primary pediatric service and Pediatric Hematology-Oncology specialists. Low-molecular-weight heparin (LMWH) was initiated at 100 IU/kg per dose subcutaneously twice daily. Systemic thrombolysis with tissue plasminogen activator (tPA; alteplase) was administered at 0.2–0.5 mg/kg/h for 6 hours. tPA was generally indicated for thrombi ≥10 mm; however, it was also administered in three patients with smaller thrombi (5–8 mm) who were deemed clinically significant based on concurrent infection (Patients 14 and 15) or hemodynamic considerations (Patient 20). Following thrombolysis, anticoagulation was continued with LMWH, per then-current recommendations (Monagle *et al.* 2012; updated in Monagle *et al.* 2025). Prior to tPA, platelet count, fibrinogen, and PT/aPTT were assessed; laboratory monitoring was repeated after infusion, and the infusion was discontinued in the event of clinically significant bleeding. Asymptomatic thrombi <10 mm were treated with LMWH alone. Catheter removal was primarily considered in the setting of clinical infection with supportive laboratory and microbiological evidence (positive catheter and/or blood cultures and/or elevated acute-phase reactants). However, catheter removal was also performed in selected patients without documented infection when thrombus persistence, large thrombus burden, or catheter dysfunction necessitated device removal (Patients 6, 17, and 20).

Surgical thrombectomy was performed in patients with large thrombi or in those who failed to respond adequately to medical management. Anticoagulant and thrombolytic regimens are detailed in Table 1.

Outcomes

The primary outcome was complete thrombus resolution on follow-up imaging. Secondary outcomes included time to thrombus resolution, microbiologically documented bloodstream infection, and the

Tab. 1. Clinical characteristics, treatment strategies, and outcomes of 22 pediatric patients with catheter-related intracardiac thrombosis (January 2014–December 2024)

Patient No	Primary diagnosis	Catheter type	Thrombus size (mm)	Treatment modalities (chronological order)[b]	Time to thrombus resolution (days)	Blood culture result	CRP (mg/L)
1	Renal Transplantation	TCC	13	2 courses tPA, catheter removal, LMWH	8	Coagulase-negative staphylococci	7.5
2	Congenital Nephrotic Syndrome	TIVAP	10	Catheter removal, LMWH	22	Stenotrophomonas maltophilia	7.0
3	Chronic Renal Failure	IJVC	21	LMWH, surgery	5	No growth	0.2
4	Acute lymphoblastic leukemia	TIVAP	20	LMWH, thrombus removal surgery	2	No growth	25.9
5	Acute lymphoblastic leukemia	TIVAP	6	Catheter removal, LMWH	12	Klebsiella pneumoniae	190.0
6	Acute lymphoblastic leukemia	IJVC	15	tPA, catheter removal, LMWH	30	No growth	2.0
7	Ewing Sarcoma	TIVAP	18	Thrombus removal surgery, LMWH	9	No growth	9.9
8	Sepsis,CPR history	IJVC	15	tPA, LMWH	51	No growth	40.2
9	Arrhythmia CPR history	IJVC	8	LMWH, acetylsalicylic acid	17	No growth	26.6
10	Status Epilepticus-Arrhythmia	IJVC	4	LMWH	6	No growth	6.1
11	Sepsis-CPR history	IJVC	6	LMWH	11	No growth	127.9
12	Myocarditis, Severe Heart Failure	IJVC	35	tPA, LMWH	death (day 3)	No growth	27.8
13	Status Epilepticus	IJVC	2	LMWH	12	No growth	19.8
14	Chronic Renal Failure	TCC	8	tPA, LMWH	6	Coagulase-negative staphylococci	9.9
15	SLE, Chronic Renal Failure	TCC	6	tPA, LMWH	8	Stenotrophomonas maltophilia	35.0
16	Meningomyelocele, Chronic Renal Failure	IJVC	4	Catheter removal	1	Coagulase-negative staphylococci	78.0
17	Down Syndrome, Chronic Renal Failure	TCC	25	tPA, catheter removal + LMWH	17	No growth	11.7
18	Chronic Renal Failure	TCC	7	Catheter removal + LMWH	10	Coagulase-negative staphylococci	11.3
19	Non-Hodgkin Lymphoma, Encephalitis	IJVC	11	Catheter removal + LMWH	7	Candida parapsilosis	51.0
20	Guillain-Barré Syndrome	IJVC	5	Catheter removal + tPA + LMWH	2	No growth	3.7
21	Osteosarcoma	TCC	16	2 courses tPA + LMWH	2	Coagulase-negative staphylococci	12.0
22	Necrotising pancreatitis	IJVC	18	2 courses tPA + LMWH	6	No growth	10.0

Abbreviations: CPR, cardiopulmonary resuscitation; CRP, C-reactive protein; IJVC, internal jugular venous catheter; LMWH,Low-molecular-weight heparin; SLE, Systemic lupus erythematosus; TCC, tunneled cuffed hemodialysis catheter; TIVAP, totally implantable venous access port; tPA, tissue plasminogen activator

[a] Thrombus size recorded as maximal diameter on transthoracic echocardiography at initial detection.

[b] Treatment modalities are listed in the chronological order administered.

[c] "2 courses tPA" denotes two separate tPA infusion cycles (alteplase 0.2–0.5 mg/kg/h for 6 h each).

[d] Patient 12: died before thrombus resolution (myocarditis with ejection fraction <30%, requiring ECMO).

[e] Patient 17: "clexan" refers to enoxaparin (LMWH).

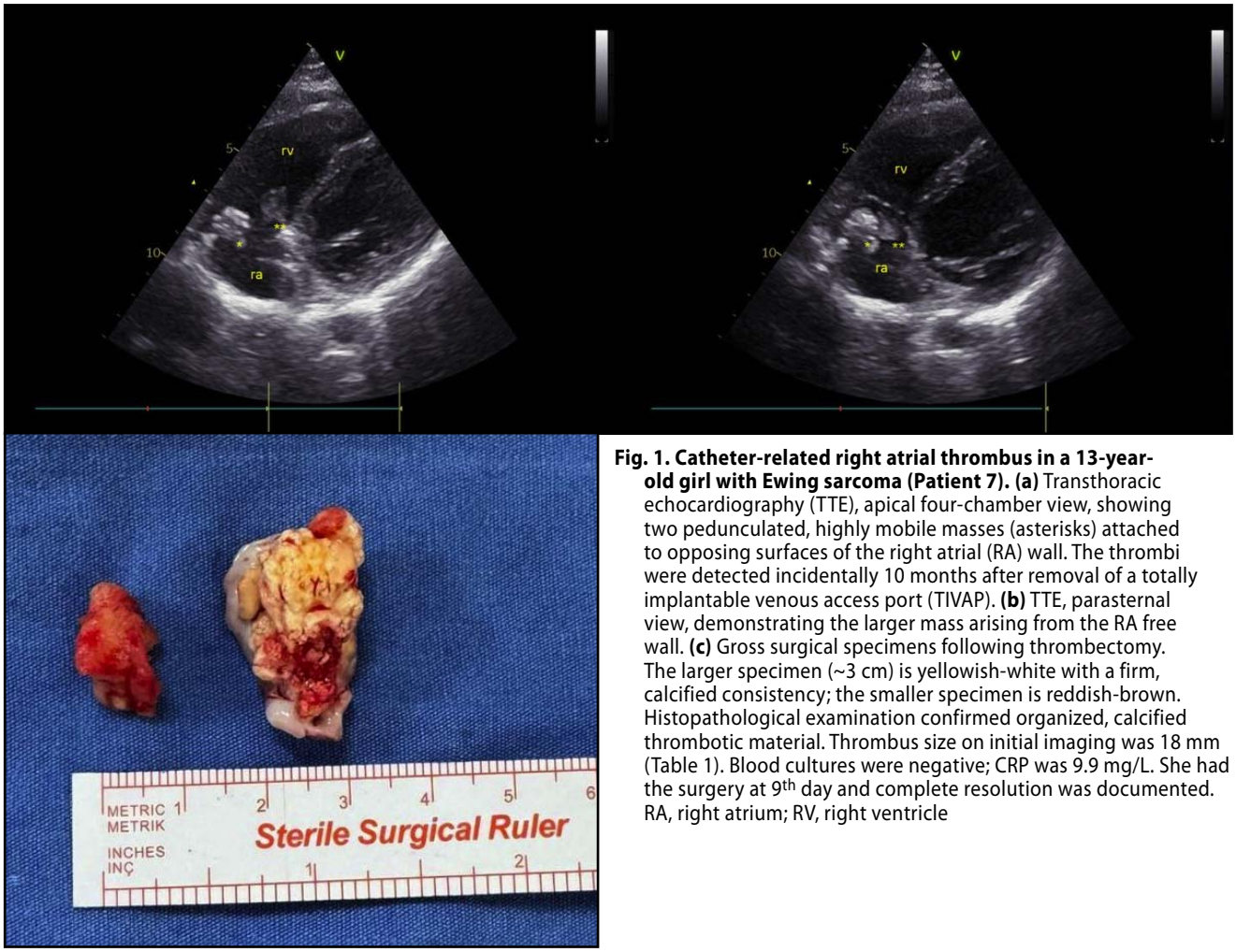

Fig. 1. Catheter-related right atrial thrombus in a 13-year-old girl with Ewing sarcoma (Patient 7). (a) Transthoracic echocardiography (TTE), apical four-chamber view, showing two pedunculated, highly mobile masses (asterisks) attached to opposing surfaces of the right atrial (RA) wall. The thrombi were detected incidentally 10 months after removal of a totally implantable venous access port (TIVAP). **(b)** TTE, parasternal view, demonstrating the larger mass arising from the RA free wall. **(c)** Gross surgical specimens following thrombectomy. The larger specimen (~3 cm) is yellowish-white with a firm, calcified consistency; the smaller specimen is reddish-brown. Histopathological examination confirmed organized, calcified thrombotic material. Thrombus size on initial imaging was 18 mm (Table 1). Blood cultures were negative; CRP was 9.9 mg/L. She had the surgery at 9th day and complete resolution was documented. RA, right atrium; RV, right ventricle

need for thrombolysis, catheter removal, or surgical thrombectomy.

Statistical analysis

Continuous variables are summarized as median (interquartile range, IQR) and range, and categorical variables as number (percentage). Between-group comparisons were performed using the Mann–Whitney U test for continuous variables and the Kruskal–Wallis test for comparisons across catheter types. Time to thrombus resolution was analyzed as a time-to-event outcome: complete resolution on follow-up imaging was defined as the event, and the single death prior to documented resolution was treated as a censored observation at the time of death. Kaplan–Meier curves were used to estimate time to resolution, and groups (tPA vs non-tPA) were compared using the log-rank test. As a sensitivity analysis, time to resolution among survivors was also compared using the Mann–Whitney U test. All tests were two-sided and a p value < 0.05 was considered statistically significant. Because of the retrospective design and rarity of catheter-related intracardiac thrombosis, no a priori sample size or power calculation was performed. Given the small cohort size, subgroup analyses were considered exploratory, confidence intervals were not routinely reported, and no multivariable adjustment for potential confounders (e.g., age, underlying disease, catheter factors, or infection status) was undertaken to avoid model overfitting. Statistical analyses were performed using SPSS software version 20.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Between January 2014 and December 2024, 22 children were diagnosed with catheter-related intracardiac thrombosis at our institution. The median age was 143 months (range: 2–217 months, interquartile range: 104.3–190.8 months). The most commonly used central venous access devices were internal jugular venous catheters (IJVC; n = 12, 54.5%), tunneled cuffed hemodialysis catheters (TCC; n = 6, 27.3%), and totally implantable venous access ports (TIVAP; n = 4, 18.2%). Median thrombus size differed across catheter types: IJVC 9.5 mm, TCC 10.5 mm, TIVAP 14.0 mm (Kruskal–Wallis, p = 0.704). Median time to resolution by catheter type was IJVC 7 days, TCC 8 days, TIVAP 10.5 days (Kruskal–Wallis, p = 0.866)Table 1 summarizes patient

diagnoses, catheter types, thrombus dimensions, treatment sequences, blood culture results, and CRP levels.

Among the 9 patients with positive blood cultures, catheter removal was performed in 6 (66.7%), compared with 3/13 (23.1%) patients with negative cultures (Fisher's exact test, $p = 0.079$). Median CRP was higher in culture-positive patients (35.0 mg/L, IQR 9.9–78.0) than in culture-negative patients (10.0 mg/L, IQR 3.7–26.6; Mann–Whitney U, $p = 0.333$). Median time to thrombus resolution was 8 days in culture-positive patients versus 10 days in culture-negative patients (Mann–Whitney U, $p = 0.476$).

Echocardiography was requested for diverse clinical indications. The most frequent triggers were infection-related presentations in 9/22 (40.9%) (persistent fever in a patient with acute leukemia, fever during hemodialysis in 3 patients with chronic renal failure, fever-related tachycardia in 2 patients, positive blood cultures in 3 patients). Asymptomatic evaluation requested as cardiac follow-up accounted for 7/22 (31.8%): renal transplanted patients (n = 1), patients with hemodialysis (n = 3), and oncology patients undergoing pre-chemotherapy cardiac screening (n = 3). In all seven cases, the intracardiac thrombus was an incidental finding, as none of these patients had symptoms or laboratory findings suggestive of thrombosis at the time of echocardiography.

Right atrial (RA) involvement was the predominant location in patients diagnosed with intracardiac thrombus. A 3-month-old patient who had a jugular catheter inserted due to septic shock one day prior and experienced a brief cardiopulmonary arrest was found to have multiple thrombi in both the right atrium and right ventricle. Patient 12, a 9-year-old girl with an internal jugular catheter and severe left ventricular dysfunction due to myocarditis, had multiple thrombi in the left ventricle. She required extracorporeal membrane oxygenation for refractory heart failure but died. Notably, this patient's thrombi were considered secondary to severe cardiomyopathy-related stasis rather than to the right-sided catheter itself, and she represents the only case of left-sided intracardiac thrombosis in this cohort. Thrombus resolution was documented in 21/22 patients (95.5%), the median time to thrombus resolution was 8 days (IQR 6-12; range 1-51 days). Blood cultures were positive in 9/22 cases (40.9%), with coagulase-negative staphylococci being the most frequent pathogen (n = 5, 22.7%), followed by Stenotrophomonas maltophilia (n = 2, 9.1%), Klebsiella pneumoniae (n = 1, 4.5%), and Candida parapsilosis (n = 1, 4.5%). The median C-reactive protein (CRP) level was 11.85 mg/L (IQR 8.1-33.2; range 0.2-190.0 mg/L).

The median thrombus size was 10.5 mm (IQR 6.0-17.5; range 2-35 mm). Low-molecular-weight heparin was used in 21/22 patients (95.5%), while catheter removal was performed in 9/22 (40.9%). Systemic thrombolysis with tissue plasminogen activator (tPA) was administered in 10/22 (45.5%), and surgical thrombus removal was required in 3/22 (13.6%). One patient underwent catheter removal alone without anticoagulation. The patients who received tPA had larger thrombi than those managed with anticoagulation alone. Median thrombus size was 15.0 mm (IQR 9.25–17.50) in the tPA group (n = 10) versus 7.5 mm (IQR 5.50–12.75) in the non-tPA group (n = 12; Mann–Whitney U, $p = 0.137$). In time-to-event analysis accounting for one censored observation (death), Kaplan–Meier estimated median time to thrombus resolution was 8 days in the tPA group and 9 days in the non-tPA group; the log-rank test showed no statistically significant difference between groups ($p = 0.444$). These comparisons should be interpreted as exploratory given the limited sample size. In a sensitivity analysis restricted to the 21 survivors, median time to thrombus resolution was 8 days (IQR 6–17) in the tPA group versus 9.5 days (IQR 5.75–12.0) in the non-tPA group (Mann–Whitney U, $p = 1.000$), consistent with the primary Kaplan–Meier analysis.

Patient 7, a 13-year-old girl with a history of Ewing sarcoma, previously managed with a totally implantable venous access port during oncologic therapy, was evaluated 10 months after device removal. Although she was asymptomatic, transthoracic echocardiography revealed two distinct pedunculated, highly mobile thrombi attached to opposing surfaces of the right atrial wall. The patient underwent surgical thrombectomy, and histopathological examination of the excised material confirmed a calcified thrombotic mass (Figure 1).

Thrombus sizes varied among patients, with measured dimensions ranging from small (<10 mm) to larger masses exceeding 20 mm. Multimodal imaging, including transthoracic echocardiography, transesophageal echocardiography, and cardiac MRI, was used in selected cases to further characterize thrombus morphology and localization.(Figure 2)

The interval between catheter insertion and thrombus detection ranged widely, indicating both early and late thrombotic events. Left-sided intracardiac thrombi appear to reflect underlying cardiac pathology or severe hemodynamic compromise, whereas right atrial thrombi are predominantly catheter-related.

Management strategies included catheter removal, low-molecular-weight heparin, and thrombolytic therapy (tPA), either alone or in combination. In several patients, follow-up imaging demonstrated complete thrombus resolution, whereas others required prolonged anticoagulation. A small number of patients experienced severe complications, including intracranial hemorrhage and mortality, which were associated with significant comorbid conditions.

DISCUSSION

The diverse clinical presentations and outcomes observed in this cohort underscore the heterogeneity of intracardiac thrombosis in pediatric patients with

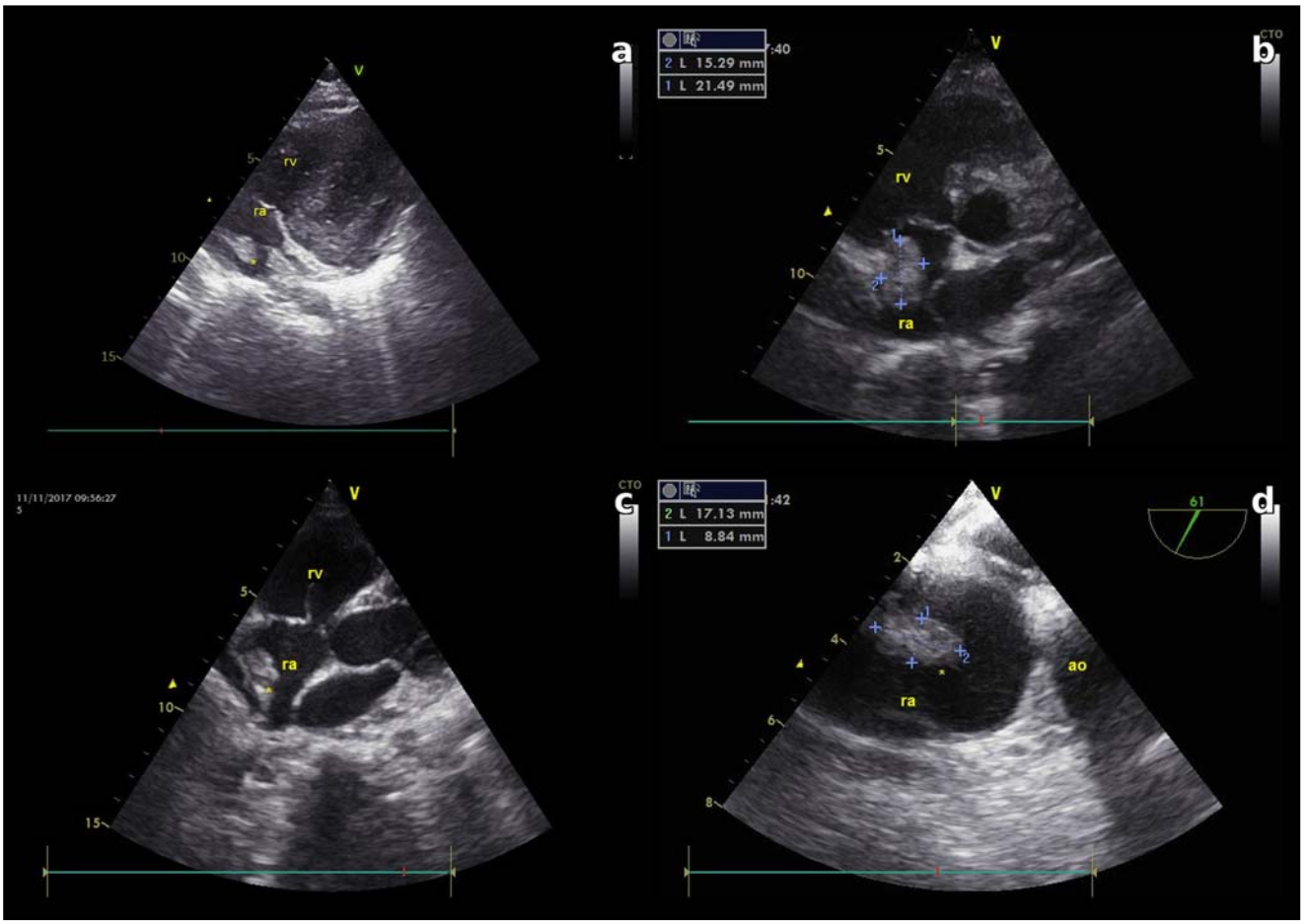

Fig. 2. Multimodal echocardiographic assessment of a right atrial catheter-related thrombus in a 12-year-old girl with Chronic Renal Failure (Patient 3). (a) Transthoracic echocardiography (TTE), parasternal short-axis view at the aortic valve level, showing an echogenic mass in the right atrium (RA) adjacent to the tricuspid valve. **(b)** TTE with caliper measurements of the mass: 21.5 × 15.3 mm. **(c)** TTE, apical four-chamber view, demonstrating the mass (asterisk) in the RA. RV, right ventricle. **(d)** Transesophageal echocardiography (TEE) at 61° providing improved spatial resolution; mass measurements 8.8 × 17.1 mm. Ao, aorta; RA, right atrium. Thrombus size on initial imaging was 21 mm (Table 1). Blood cultures were negative; CRP was 0.2 mg/L.She had the surgery at 5th day and complete resolution was documented. This case illustrates the complementary role of TEE when TTE image quality is suboptimal or when detailed anatomical characterization is required (Tamaki, 2024).

central venous catheters, necessitating individualized therapeutic approaches. The high prevalence of catheter-related right atrial thrombosis in this demographic, often identified via routine echocardiographic surveillance, highlights the importance of early detection and tailored management strategies (Garcia-Nicoletti *et al.* 2021). The observed asymptomatic nature of many catheter related intracardiac thrombi in children further complicates diagnosis, with a substantial proportion detected incidentally during imaging performed for other indications. These 'silent' thrombi, despite their often asymptomatic presentation, carry a significant risk of pulmonary embolism, systemic embolization, and catheter dysfunction, underscoring the need for routine echocardiographic surveillance in high-risk populations such as children on chronic hemodialysis (Gong *et al.* 2022). Consistent with our findings, Agarwal *et al.* reported that catheter-related intracardiac thrombi in 58 children required a median 3–6 months of anticoagulation, with CVC presence independently delaying resolution (Agarwal *et al.* 2024).

In our renal subgroup (8/22, 36.4%), catheter removal was performed in 4 patients, aligning with recent evidence that device removal combined with anticoagulation may be preferable for hemodialysis-associated right atrial thrombi (Chen *et al.* 2024).

From a clinical perspective, the factors that predominantly determine the risk of thrombosis are frequently not the type of catheter employed, but rather the tip position (cavoatrial junction), the number and diameter of lumens, left-sided placement, insertion trauma, infection, the patient's thrombophilia-inflammation status, and catheter dwell time (Lassandro *et al.* 2020), a finding prospectively confirmed by *et al.* (Narayan *et al.* 2024).

While echocardiography serves as the primary diagnostic tool for initial evaluation, definitive diagnosis often necessitates histological confirmation, particularly given the potential for misdiagnosis with other intracardiac masses. Furthermore, distinguishing true thrombi from catheter-related fibrin sleeves or vegetations, which can mimic thrombotic lesions on imaging,

presents a persistent diagnostic dilemma, particularly in critically ill or septic patients (Odaman *et al.* 2022). Odaman Al *et al.* reported a comparable single-center experience with 24 pediatric patients with intracardiac thrombosis; our cohort extends this evidence with a longer observation period (10 vs. 5 years), an explicit size-guided tPA threshold (≥10 mm), inclusion of surgical thrombectomy with histopathological confirmation (3/22, 13.6%), and multimodal imaging characterization including transesophageal echocardiography and cardiac MRI. Cardiac CT achieves 96% sensitivity and 99% specificity for intracardiac thrombus detection and was used adjunctively in our cohort (Ghozy *et al.* 2024).. Moreover, the increasing incidence of venous thromboembolism in pediatric patients, driven by greater exposure to central venous access devices and improved diagnostic techniques, further emphasizes the critical need for accurate and timely diagnosis (McLaughlin *et al.* 2019).

Using a size and clinical status guided approach, most patients in this retrospective cohort achieved thrombus resolution, but the non randomized treatment allocation and small subgroup sizes preclude firm conclusions about the comparative effectiveness of thrombolysis, anticoagulation alone, catheter removal, or surgery.

Catheter related thrombosis has been increasingly recognized over the last decades, with a meta analysis of pediatric CVC studies reporting a pooled thrombosis frequency of approximately 20% (95% CI: 16–24%; Vidal *et al.* 2014), with case reports documenting CRAT even in infants (Sharara-Chami *et al.* 2020), consistent with the youngest patient in our cohort (age 2 months). Future collaborative studies addressing this critical knowledge gap are essential to inform risk stratified thromboprophylaxis trials in pediatric patients with central venous catheters, particularly in light of recent evidence quantifying device related thrombosis incidence and modifiable risk factors (Vidal *et al.* 2014).

The absence of established guidelines for anticoagulation in pediatric patients with long-term catheter use, particularly in the context of hemodialysis, necessitates further research into surveillance programs for thrombi detection and risk-stratified management protocols. Such protocols could incorporate advanced imaging modalities, including compression ultrasonography and CT venography, which have demonstrated high diagnostic accuracy for venous thrombosis in children when compared with venography as a reference standard (McLaughlin *et al.* 2019). Notably, while discussions surrounding prophylactic anticoagulation in high-risk pediatric cohorts are ongoing, current guidelines primarily favor secondary prophylaxis over primary preventive measures (Hanuna *et al.* 2023).

In patients with a central venous catheter, echocardiography should be considered to evaluate for catheter-associated intracardiac thrombus when there is persistent or recurrent bacteremia/fungemia, sepsis without an alternative source, or elevated inflammatory markers with clinical infection, particularly if cultures (catheter or blood) are positive. Additional indications include new or unexplained cardiopulmonary findings (new murmur, tachyarrhythmia/tachycardia out of proportion to fever, dyspnea, hypoxemia, respiratory deterioration, suspected pulmonary embolism, or hemodynamic instability), catheter-related problems (dysfunction, difficult aspiration/infusion, suspected catheter-tip malposition), and high-risk prothrombotic settings (known thrombophilia, malignancy, chronic kidney disease/dialysis, prolonged catheter dwell time, or prior thrombosis). Repeat echocardiography is also essential for treatment monitoring, particularly after thrombolysis or during anticoagulation, to document regression/resolution and guide duration of therapy.

LIMITATIONS

This study is limited by its retrospective single-center design, modest sample size, and heterogeneous underlying diagnoses. Treatment selection was not randomized and reflected clinical decision-making, which may limit causal inference regarding comparative effectiveness. Standardized screening intervals were not applied across all patient groups. Additionally, catheter dwell time - a recognized risk factor for CVC-related thrombosis - was not systematically analyzed as a predictor variable, although it was recorded as part of catheter characteristics. One patient (Patient 12) had left ventricular thrombi attributable to myocarditis rather than catheter-related right atrial thrombosis, introducing pathophysiological heterogeneity into the cohort. Finally, the tPA versus non-tPA comparison was underpowered (n=10 vs. n=12), and observed p-values should not be interpreted as evidence of equivalence.

CONCLUSION

In conclusion, the retrospective analysis highlights the persistent challenges in managing intracardiac thrombosis associated with central venous catheters in pediatric populations, emphasizing the urgent need for standardized diagnostic and therapeutic protocols. Future research should focus on prospective, multicenter trials to establish evidence-based guidelines for risk stratification, optimal anticoagulation strategies, and novel thromboprophylactic interventions in this vulnerable patient group. Additionally, a deeper understanding of the molecular mechanisms underlying pediatric catheter-related thrombosis could lead to the development of targeted pharmacological interventions (van Ommen &Luijnenburg,2024). This would also involve exploring the interplay of developmental hemostasis and specific catheter materials in promoting thrombus formation, thereby informing the design of more biocompatible devices. Furthermore, investigations into the efficacy of various lock solutions, such as ethanol or low-dose heparin infusions,

for preventing CVC-related thrombosis in pediatric patients are warranted (Jaffray *et al.* 2017; Onyeama *et al.* 2016). Notably, all patients in our cohort received parenteral anticoagulation (LMWH); however, recent network meta-analysis evidence supports DOACs as non-inferior alternatives with favorable safety profiles in pediatric VTE (Fu *et al.* 2024). A recent comparative study demonstrated that rivaroxaban achieved intracardiac thrombus resolution rates comparable to warfarin in children, offering an oral alternative to the injectable LMWH regimen used in this series (Cappelletti *et al.* 2025). Practical frameworks for transitioning pediatric patients from parenteral to oral anticoagulation are now available (Bhat *et al.* 2024).

Conflicts of Interest

The authors declare no conflicts of interest.

Informed Consent

Was waived by the IRB due to the retrospective design.

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Ethical approval

Ethical approval was granted by the Baskent University Institutional Review Board (Project No: KA 25/248).

REFERENCES

1 Agarwal S, Abdelghani E, Stanek JR, Sankar A, Cua CL, Kerlin BA, et al. (2023). Intracardiac thrombi in pediatrics: anticoagulation approach and treatment outcomes. Res Pract Thromb Haemost. **7**(8): 102266. doi: 10.1016/j.rpth.2023.102266.

2 Bhat RV, Young G, Sharathkumar AA (2024). How I treat pediatric venous thromboembolism in the DOAC era. Blood. **143**(5): 389–403. doi: 10.1182/blood.2022018966.

3 Cappelletti D, Bianco F, Bucciarelli V, Raffaelli E, Bordignon L, Di Cesare G et al.(2025). Comparison of rivaroxaban with warfarin for intracardiac thrombosis in the pediatric population at different cardiac sites: Early experience of anticoagulation approach and treatment outcomes. Thromb Res. Sep; **253**: 109397. doi: 10.1016/j.thromres.2025.109397

4 Chen L, Chen B, Lai Q, Gao X, Zhou Y, Li W et. Al. (2024. Management of catheter-related right atrial thrombus in hemodialysis: a systematic review. BMC Cardiovasc Disord. 2024 Nov 20; **24**(1): 656. doi: 10.1186/s12872-024-04330-y. PMID: 39563254; PMCID: PMC11577792.

5 Fu M, Yuan Q, Yang Q, Yu Y, Song W, Qin X et al. (2024) Risk factors and incidence of central venous access device-related thrombosis in hospitalized children: a systematic review and meta-analysis. Pediatr Res. 2024 Dec; **96**(7): 1568–1593. doi: 10.1038/s41390-024-03225-0.

6 Garcia-Nicoletti M, Sinha MD, Savis A, Adalat S, Karunanithy N, Calder F (2021). Silent and dangerous: catheter-associated right atrial thrombus (CRAT) in children on chronic haemodialysis. Pediatric Nephrology. **36**(5): 1245–1256. doi: 10.1007/s00467-020-04743-9.

7 Ghozy S, Liu M, Kobeissi H, Mortezaei A, Amoukhteh M, Abbas AS, et al. (2024). Cardiac CT vs echocardiography for intracardiac thrombus detection in ischemic stroke: a systematic review and meta-analysis. Neurology. **103**(10): e209771. doi: 10.1212/WNL.0000000000209771.

8 Gong S, Yang Y, Tan M, Chen J (2022). Effective treatment for massive neonatal catheter-related right atrial thrombosis. Interact Cardiovasc Thorac Surg. **35**(1): ivac055. doi: 10.1093/icvts/ivac055.

9 Hanuna M, Abuakke M, Abu-Harb M, Alhasan K, Albaroudi O, Alkhateeb A, et al. (2023). Case report: central venous catheter thrombosis complicated by chronic thromboembolic disease/pulmonary hypertension in two children requiring parenteral nutrition. Frontiers in Cardiovascular Medicine. **10**: 1198204. doi: 10.3389/fcvm.2023.1198204.

10 Jaffray J, Bauman M, Massicotte P (2017). The impact of central venous catheters on pediatric venous thromboembolism. Frontiers in Pediatrics. **5**: 5. doi: 10.3389/fped.2017.00005.

11 Lasagni D, Nosadini M, Molinari AC, Saracco P, Pelizza MF, Piersigilli F, et al (2022). Systemic Catheter-Related Venous Thromboembolism in Children: Data From the Italian Registry of Pediatric Thrombosis. Front Pediatr. **10**: 843643. doi: 10.3389/fped.2022.843643.

12 Lassandro G, Palmieri VV, Palladino V, Amoruso A, Faienza MF, Giordano P (2020). Venous thromboembolism in children: from diagnosis to management. International Journal of Environmental Research and Public Health. **17**(14): 4993. doi: 10.3390/ijerph17144993.

13 McLaughlin CM, Barin EN, Fenlon M, Azen C, Deakers TW, Stein JE et al. (2019) Symptomatic catheter-associated thrombosis in pediatric trauma patients: Choose your access wisely. Surgery. Dec; **166**(6): 1117–1121. doi: 10.1016/j.surg.2019.05.018.

14 Monagle P, Azzam M, Bercovitz R, Betensky M, Bhat R, Biss T, et al. (2025). American Society of Hematology/International Society on Thrombosis and Haemostasis 2024 updated guidelines for treatment of venous thromboembolism in pediatric patients. Blood Adv. **9**(10): 2587–2636. doi: 10.1182/bloodadvances.2024015328.

15 Monagle P, Chan AKC, Goldenberg NA, Ichord RN, Journeycake JM,Nowak-Gottl U et al. (2012) Antithrombotic therapy in neonates and children: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest; **141**: (2 Suppl): e737S–e801S

16 Narayan AS, Ramamoorthy JG, Parameswaran N, RamKumar G, Kayal S (2024). Central Venous Catheter-associated Venous Thromboembolism in Children: A Prospective Observational Study. J Pediatr Hematol Oncol. Oct 1; **46**(7): e544–e549. doi: 10.1097/MPH.0000000000002923.

17 Odaman Al I, Oymak Y, Erdem M, Tahta N, Okur Acar S, Mese et al. (2022) Assessment of clinical characteristics and treatment outcomes of pediatric patients with intracardiac thrombosis: a single-center experience. Blood Coagul Fibrinolysis. Jan 1; **33**(1): 34–41. doi: 10.1097/MBC.0000000000001100. PMID: 34799505.

18 Onyeama SJN, Hanson SJ, Dasgupta M, Hoffmann RG, Faustino EVS (2016). Factors associated with continuous low-dose heparin infusion for central venous catheter patency in critically ill children worldwide. Pediatric Critical Care Medicine. **17**(8): e367–e374. doi: 10.1097/PCC.0000000000000854.

19 Roy PS, Bansal D (2024). Thromboembolism in children: unveiling risk-factors. The Indian Journal of Pediatrics. **91**(7): 655–656. doi: 10.1007/s12098-024-05155-5.

20 Sharara-Chami R, Arabi M, Hassanieh a J, Hamideh D, Zaghal A (2020). Catheter related atrial thrombosis in an infant: a case report and review of the literature. J Pediatr Surg Case Rep. **63**: 101673. https://doi.org/10.1016/j.tru.2020.100003.

21 Tamaki N, Manabe O, Hirata K. Cardiovascular imaging in cardio-oncology(2024). Jpn J Radiol. 2024 Dec; **42**(12): 1372–1380. doi: 10.1007/s11604-024-01636-x.

22 van Ommen CH, Luijnenburg SE (2024). Anticoagulation of pediatric patients with venous thromboembolism in 2023. Thrombosis Research. **235**: 186–193. doi: 10.1016/j.thromres.2023.12.019.

23 Vidal E, Sharathkumar A, Glover J, Faustino EV (2014). Central venous catheter-related thrombosis and thromboprophylaxis in children: a systematic review and meta-analysis . J Thromb Haemost. Jul; **12**(7): 1096–109. doi: 10.1111/jth.12598. Epub 2014 Jun 19. PMID: 24801495; PMCID: PMC4107177.

24 von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. PLoS Med. **4**(10): e296. doi: 10.1371/journal.pmed.0040296.