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Original Article

Direct Right Atrial Catheterization in Pediatric Short Bowel Syndrome: A Durable and Technically Advantageous Solution for End-stage Vascular Access

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ABSTRACT

Aim: Children with short bowel syndrome (SBS) frequently require long-term total parenteral nutrition (TPN), which increases the risk of progressive central vein thrombosis. Once conventional venous access is exhausted, direct right atrial catheterization becomes a necessary salvage technique. In addition to bypassing thrombosed veins, it allows for the placement of larger-caliber catheters than percutaneous approaches.

Materials and Methods: This retrospective study included 17 pediatric SBS patients with end-stage vascular access who underwent direct right atrial catheterization via right anterior thoracotomy. Patient characteristics, vein thrombosis patterns, catheter duration, complications, and reinterventions were analyzed.

Results: All patients (100%) had thrombosed jugular veins. Subclavian, hepatic, and femoral vein thrombosis was observed in 41.1%, 29.4%, and 23.6% of the patients, respectively. The median catheter duration was 14.8 months. Four patients (23.6%) developed catheter-related bloodstream infections, including one Candida parapsilosis infection which required complete catheter and port removal with reinsertion. One mechanical complication (5.9%) occurred due to port chamber torsion. Two patients (11.8%) required surgical reintervention. No cases of catheter-related sepsis, tamponade, or mortality were recorded. Larger-bore catheters were successfully implanted in all patients due to the direct atrial route.

Conclusion: Direct right atrial catheterization is a safe, durable, and technically advantageous vascular access option in children with SBS and depleted venous anatomy. Its capacity to accommodate large-caliber catheters supports high-volume TPN delivery. This technique should be considered early in the multidisciplinary management of complex intestinal failure.

Keywords: Short bowel syndrome, vascular access, total parenteral nutrition

Introduction

Short bowel syndrome (SBS) is a common cause of pediatric intestinal failure, typically resulting from extensive bowel resection in the neonatal period due to conditions such as necrotizing enterocolitis, intestinal atresia, or volvulus (1). Children with SBS often require long-term total parenteral nutrition (TPN), which necessitates durable and reliable central venous access (2). Over time, repeated catheter insertions, catheter-related infections, and thrombotic complications frequently lead to the loss of

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usable central veins, resulting in what is termed end-stage central venous access (3,4).

As central veins become progressively unusable, including the internal jugular, subclavian, femoral, and transhepatic veins, clinicians are forced to consider unconventional access strategies. These include transhepatic lines, intercostal vein approaches, or ultimately, direct right atrial catheterization, a rarely performed but potentially life-saving technique (5,6). This approach, typically executed through a right anterior thoracotomy or sternotomy, enables the direct insertion of a tunneled catheter into the right atrium, bypassing the thrombosed venous system entirely (7).

While direct right atrial access has been described in case reports and small series, especially in children with intestinal failure awaiting intestinal transplantation (5,8), data on its mid- to long-term safety, complication rates, and durability remain limited. Reported concerns include catheter dislodgement, infection, and procedural morbidity, but contemporary experiences suggest that with proper technique and multidisciplinary support, outcomes may be favorable (5,9).

In this study, we present our single-center experience with direct right atrial catheterization in 17 pediatric patients with SBS and end-stage vascular access. Unlike previous reports which described only isolated cases or small cohorts such as Rodrigues et al. (5) (n=6) and Detering et al. (7) (a single case report) our study provides one of the largest pediatric series to date. Furthermore, we offer mid-term follow-up data on catheter durability, infectious outcomes, and surgical reinterventions, thereby expanding the limited literature on this approach in non-transplant SBS populations.

Materials and Methods

Study Design and Patient Population

This retrospective single-center study included pediatric patients with a diagnosis of SBS who underwent direct right atrial catheterization between 2020 and 2025 at our institution. The inclusion criteria were: SBS secondary to extensive bowel resection, long-term TPN dependency, and exhaustion of conventional central venous access routes, including jugular, femoral, subclavian, and hepatic veins. Patients with prior cardiac surgery or structural heart defects were excluded.

Demographic data, prior catheterization history, operative details, duration of catheter use, incidence of catheter-related bloodstream infections (CRBSIs), mechanical complications, and the need for surgical reintervention were collected from the medical records.

Surgical Technique

All procedures were performed under general anesthesia by a pediatric cardiovascular surgeon. A right anterior thoracotomy through the fourth or fifth intercostal space was used to access the pericardial cavity. The right atrium was exposed and a tunneled central venous catheter was inserted via a controlled atriotomy. The catheter tip was secured with a purse-string suture, and the line was tunneled to a subcutaneous chest port on the anterior thoracic wall. Proper positioning was confirmed intraoperatively via direct visualization and intraoperative flushing.

A schematic representation of the anterior thoracotomy and the placement of the tunneled catheter through the right clavicular region into the right atrium is illustrated in Figure 1.

Anticoagulation and Infection Prevention

Postoperative anticoagulation was administered in the form of low molecular weight heparin at a dose of 100 IU/kg subcutaneously twice daily for 3 days. The use of taurolidine lock solutions was recorded when applicable; however, due to challenges in supply and inconsistent documentation

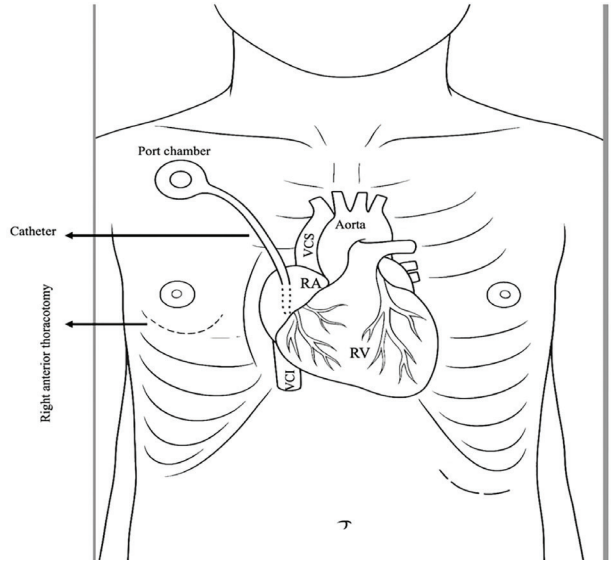

Figure 1. Right anterior thoracotomy and tunneled catheter placement into the right atrium in a pediatric patient. The illustration demonstrates the surgical exposure through the right fourth intercostal space using a retractor. The catheter enters through a subcutaneously placed port under the right clavicle, follows a curved intrathoracic course, and terminates within the right atrium. The cardiac anatomy, rib cage, and port location are anatomically aligned for educational and surgical reference
RA: Right atrium, RV: Right ventricle, VCS: Vena cava superior, VCI: Vena cava inferior

across clinical settings, precise data regarding duration and adherence could not be reliably retrieved for all patients.

Definitions and Outcome Measures

- CRBSI was defined as a positive peripheral blood culture with clinical signs of sepsis and no other identifiable source of infection.
- Mechanical complications included any device-related issues such as port torsion, dislodgement, or subcutaneous migration which interfered with catheter function.
- Reintervention was defined as any surgical procedure required to revise or replace the catheter or port due to infection or mechanical failure.
- End-stage central venous access was defined as thrombosis or anatomic inaccessibility of all major conventional central veins (jugular, subclavian, femoral, and hepatic).

All surgical procedures were performed with written informed consent from the legal guardians. This study was approved by the Non-interventional Clinical Research Ethics Committee of İzmir Bakırçay University (approval no.: 2417, dated: 27.08.2025). The committee confirmed that the study was ethically appropriate and conducted in accordance with the Declaration of Helsinki. Written informed consent for surgical procedures was obtained from the legal guardians of all participants, and the requirement for additional consent for inclusion in this retrospective analysis was waived by the ethics board.

Statistical Analysis

All data were analyzed using IBM SPSS Statistics version 25. Continuous variables, including age, weight, and duration of catheter use, are expressed as medians due to non-normal distribution (assessed using the Shapiro-Wilk test). Categorical variables such as the presence of CRBSI, vein thrombosis status, mechanical complications, and reinterventions are expressed as frequencies and percentages.

Results

Patient Characteristics

A total of 17 pediatric patients with SBS underwent direct right atrial catheterization due to end-stage central venous access. The median age at the time of catheter insertion was 4 years, and the median weight was 10 kg. All patients had previously exhausted conventional central venous access options.

All patients (100%) had documented jugular vein thrombosis. Additionally, thrombosis of the femoral, subclavian, and hepatic veins was observed in 23.6% (n=4), 41.1% (n=7), and 29.4% (n=5) of the patients respectively, highlighting the extent of vascular access compromise in this cohort.

Catheter Duration and Use

The median duration of catheter use following direct right atrial insertion was 14.8 months (7-22 months). All patients were successfully managed with TPN via the intra-atrial catheter during this period, with no early postoperative catheter failures. Taurolidine lock solutions were selectively used in a minority of cases, depending on availability and clinician preference.

Catheter-related Bloodstream Infections

A total of 4 patients (23.5%) developed CRBSIs during the follow-up period. The isolated pathogens included *Staphylococcus aureus*, *Staphylococcus epidermidis*, and Candida parapsilosis. Time to first CRBSI ranged from 1 to 6 months following catheter placement. Three cases were successfully managed with antimicrobial therapy alone. In one case, a Candida parapsilosis bloodstream infection necessitated complete catheter and port system removal. No patients developed sepsis-related complications or endocarditis.

Mechanical Complications

Mechanical complications were rare. Only 1 patient (5.9%) experienced a complication, which was identified as subcutaneous port chamber torsion, resulting in difficult access and requiring repositioning. No cases of catheter migration, pericardial effusion, or tamponade were observed.

Reinterventions

Two patients (11.8%) required surgical reintervention. One underwent catheter revision due to subcutaneous port torsion. The second patient required complete catheter and port removal with subsequent reinsertion due to persistent Candida parapsilosis associated infection. Both patients recovered without further complications and resumed TPN through the new catheter.

A summary of the patient demographics, thrombotic profiles, catheter-related infections, mechanical complications, and reintervention rates is presented in Table I.

Table I. Summary of patient characteristics and outcomes: CRBSI: catheter-related bloodstream infections	
Parameter	Value
Total number of patients	17
Median age at catheter insertion (range)	4 (2-7) years
Median weight (range)	10 (4-15) kg
Median catheter duration (range)	14.8 (7-22) months
Jugular vein thrombosis	17 (100%)
Femoral vein thrombosis	4 (23.6%)
Subclavian vein thrombosis	7 (41.1%)
Hepatic vein thrombosis	5 (29.4%)
Catheter-related bloodstream infections (CRBSI)	4 (23.6%)
Microorganisms identified	*Staphylococcus aureus* 2 (11.8%) *Staphylococcus epidermidis* 1 (5.9%) Candida parapsilosis 1 (5.9%)
CRBSI requiring catheter removal	1 (5.9%) Candida infection
Mechanical complications (e.g., port torsion)	1 (5.9%)
Surgical reintervention required	2 (11.8%)
Mortality	0 (0%)

Discussion

This study presents a single-center experience of direct right atrial catheterization in pediatric patients with SBS and end-stage central venous access. Our findings demonstrate that this technique can be safely performed with relatively low rates of mechanical complications and infectious events, even in a high-risk cohort with extensive venous thrombosis and long-term parenteral nutrition dependence.

Central venous access is critical for maintaining TPN in children with SBS, but it often becomes compromised over time due to catheter-related thrombosis, mechanical failure, and/or infection (4,10). Multiple prior studies have reported progressive loss of venous access in this population, especially among those with prolonged survival and repeated catheter insertions (11,12). In our series, 100% of patients had thrombosed jugular veins, while thrombosis of subclavian, femoral, and hepatic veins was present in 41.1%, 23.6%, and 29.4%, respectively. These data highlight the severity of vascular depletion in this cohort and the necessity of alternative access strategies.

Direct intra-atrial catheterization has historically been reserved for patients in whom all conventional central veins are unavailable. Previous reports, such as those by Rodrigues et al. (5) and Detering et al. (7), described the technique in small series and case reports, typically as a last-resort measure in children awaiting intestinal transplantation. In our series of 17 patients, the median catheter duration was 14.8 months, with no early failures or procedure-related deaths, demonstrating the durability and safety of this approach when performed in experienced hands.

Our findings add to existing evidence by demonstrating the feasibility of this technique outside of transplant-focused cohorts. While Rodrigues et al. (5) reported its use mainly as a bridge to small bowel transplantation, our patient population included those undergoing long-term TPN for intestinal adaptation as well. Compared to the prior literature, our series offers longer follow-ups and a detailed evaluation of complications, and so it supports a broader application of this approach in selected pediatric SBS patients.

Our CRBSI rate of 23.6% is comparable to or lower than reported rates in pediatric patients with long-term central lines (13,14). One case of Candida parapsilosis CRBSI required complete catheter and port removal. Fungal infections involving long-term venous devices often demand more aggressive management, including device explantation, due to the risk of persistent bloodstream infection and biofilm formation (15). While rare, this complication underscores the importance of early diagnosis and organism-specific management strategies in patients with TPN dependence and device-related infections.

The selective use of taurolidine locks may have contributed to this favorable outcome. Although taurolidine locks were selectively used in some patients, limitations in supply and non-standardized clinical documentation precluded accurate quantification of usage patterns. Consequently, a definitive analysis of its effect on CRBSI incidence could not be performed in this study.

Mechanical complications were rare in our cohort. Only one patient (5.9%) experienced a complication, identified as subcutaneous port torsion, resulting in difficult access and requiring repositioning. No cases of catheter migration, pericardial effusion, or tamponade were observed. These findings compare favorably with prior reports, in which mechanical issues such as dislodgement or tamponade have been described as serious complications (7,8). We attribute our low rate to the consistent use of a right anterior thoracotomy approach, secure atrial fixation, and careful subcutaneous tunneling.

While alternative approaches such as transhepatic or intercostal venous access have been described (6), these techniques are often technically demanding, and catheter longevity is typically limited. Direct atrial catheterization, by contrast, offers a central, stable, and durable route for TPN in patients with no other options.

In addition to providing durable access, direct atrial insertion allows for the use of larger-diameter catheters compared to percutaneous techniques. This facilitates improved flow rates, reduced catheter occlusion risk, and more effective long-term parenteral nutrition delivery, which is a critical advantage in children with increasing nutritional demands (16).

Our experience supports the early consideration of direct atrial access in select children with SBS and severely compromised vascular access. In patients awaiting intestinal transplantation or those with the potential for enteral adaptation, this technique may serve as a vital bridge, provided that meticulous surgical technique, anticoagulation, and infection prevention measures are applied.

Study Limitations

This study has several limitations. First, its retrospective design and single-center nature may limit the generalizability of the findings. While the surgical technique and postoperative protocols were consistent, institutional practices (e.g., the use of taurolidine locks or the timing of reintervention) may differ across centers.

Second, the sample size was relatively small (n=17), which limits the statistical power to detect rare complications or perform subgroup analysis (e.g., comparing catheter duration in patients with vs. those without reintervention). Additionally, we did not include a comparison group (e.g., transhepatic access or tunneled central catheters via alternative veins), which would have strengthened the interpretation of catheter longevity and complication rates.

Third, the follow-up period, while sufficient to assess short- to mid-term outcomes, may not fully capture long-term complications such as right atrial thrombus formation, late infections, or impacts on future transplant eligibility. No routine echocardiography or surveillance imaging was performed unless clinically indicated, which may have led to an underestimation of subclinical atrial changes.

Lastly, heterogeneity in infection prevention strategies, particularly the non-uniform use of taurolidine or ethanol locks, limits our ability to draw firm conclusions about CRBSI prevention. Standardized infection control protocols may further improve the understanding of outcomes in future studies.

Despite these limitations, our findings provide meaningful insights into a rarely described yet increasingly important surgical option for children with end-stage venous access.

Conclusion

In pediatric patients with SBS and exhausted central venous access, direct right atrial catheterization via anterior thoracotomy represents a safe and effective salvage strategy for maintaining long-term parenteral nutrition. Our experience demonstrates low rates of mechanical complications and manageable CRBSI incidence, with a median catheter duration of 14.8 months.

This technique, though historically considered a last resort, should be repositioned as a proactive option in selected patients with confirmed multi-site venous thrombosis. With proper surgical execution, perioperative anticoagulation, and infection surveillance, direct atrial access may serve as a bridge to intestinal adaptation or transplantation. The ability to insert larger-caliber catheters through this route further enhances its utility for long-term use.

Future multicenter, prospective studies are needed in order to define the long-term safety, ideal timing for intervention, and standardized postoperative management of this increasingly relevant vascular access approach in complex intestinal failure populations.

Ethics

Ethics Committee Approval: This study was approved by the Non-interventional Clinical Research Ethics Committee of İzmir Bakırçay University (approval no.: 2417, dated 27.08.2025).

Informed Consent: All surgical procedures were performed with written informed consent from the legal guardians.

Footnotes

Authorship Contributions

Surgical and Medical Practices: O.N.T., M.A., Y.A., Concept: O.N.T., E.K.T., Design: O.N.T., E.K.T., Y.A., Data Collection or Processing: O.N.T., M.A., Analysis or Interpretation: O.N.T., Y.A., Literature Search: M.A., E.K.T., Writing: O.N.T., E.K.T., Y.A.

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