

HEART FAILURE AND CARDIOMYOPATHIES

CLINICAL CASE SERIES

Pediatric Transcatheter Atrial Septal Stent Removal Following ECMO Support Including Use of Novel Retrieval Device



John-Anthony Coppola, MD,^{a,b} Yuen Lo Yau, MD,^a Himesh V. Vyas, MD,^a Giles J. Peek, MD,^c Jeffrey P. Jacobs, MD,^c Mark S. Bleiweis, MD,^c James C. Fudge, Jr, MD, MHS^a

ABSTRACT

Left atrial (LA) decompression is often performed in patients on venoarterial extracorporeal membrane oxygenation to help offload the left ventricle. Atrial septal stents may be used to ensure the adequacy of LA decompression; however, if there is cardiopulmonary recovery and extracorporeal membrane oxygenation support is no longer needed, the stents require removal. We describe 3 pediatric patients who required venoarterial extracorporeal membrane oxygenation support and atrial septal stent placement who underwent successful transcatheter removal of the stents after cardiac recovery. In the initial case, snares alone were used to remove the stent. In the 2 subsequent cases, a combination of snares and the $\bar{O}\bar{N}\bar{O}$ retrieval device ($\bar{O}\bar{N}\bar{O}$ COR LLC) were used to remove the stents. Transcatheter removal offers a less invasive approach for atrial septal stent removal after extracorporeal membrane oxygenation support. To our knowledge, this series is the first report of transcatheter removal of a large diameter atrial septal stent and the first report using the $\bar{O}\bar{N}\bar{O}$ retrieval device. (JACC Case Rep. 2025;30:104928) © 2025 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Extracorporeal membrane oxygenation (ECMO) has been used to provide cardiopulmonary support to pediatric patients for decades. One complication of venoarterial (VA) ECMO is inadequate left heart decompression, which can lead to left atrial (LA) hypertension and clinically significant pulmonary edema and hemorrhage.¹ Balloon atrial septostomy for LA decompression has been well documented.^{2,3} In certain cases, an atrial septal stent may be placed to ensure an adequate atrial septal defect for LA decompression. In cases with cardiopulmonary recovery, removal of the atrial septal stent is required. We present 3

TAKE-HOME MESSAGES

- Our cases highlight the use of a novel tool to aid in the assistance of removing atrial stents via a transcatheter approach.
- This technique allows more therapeutic options to help support pediatric patients without requiring sternotomy and further surgical intervention.

pediatric cases who underwent successful atrial stent placement using Palmaz XL 4010 biliary

From the ^aDivision of Pediatric Cardiology, Department of Pediatrics, Congenital Heart Center, University of Florida, Gainesville, Florida, USA; ^bDivision of Pediatric Cardiology, Department of Pediatrics, University of California-Davis, Sacramento, California, USA; and the ^cDivision of Cardiovascular Surgery, Department of Surgery and Pediatrics, Congenital Heart Center, University of Florida, Gainesville, Florida, USA.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

Manuscript received April 9, 2025; revised manuscript received June 2, 2025, accepted June 24, 2025.

ABBREVIATIONS AND ACRONYMS

ECMO = extracorporeal
membrane oxygenation

LA = left atrial

RA = right atrial

RIJ = right internal jugular

VA = venoarterial

stents (Cordis) with subsequent transcatheter removal using novel approaches.

CASE SERIES

CASE 1. A healthy 3-year-old boy developed respiratory failure secondary to respiratory syncytial virus and superimposed methicillin-resistant *Staphylococcus aureus*.

He required venovenous ECMO via the right internal jugular vein (RIJ). He developed cardiogenic shock requiring conversion to VA ECMO (RIJ/right carotid artery) and was treated for myocarditis. He continued with poor cardiac function and showed signs of inadequate LA decompression with development of pulmonary hemorrhage necessitating atrial septal stent placement for atrial decompression (Figures 1A and 1B). He was subsequently transitioned to venovenous ECMO and ultimately had full cardiopulmonary recovery after several weeks of support. He underwent successful transcatheter atrial septal stent removal before decannulation without complications using a double snare technique (Figure 1C). He was discharged after 106 days with normal cardiac function.

CASE 2. A healthy 3-year-old girl developed progressive respiratory symptoms, dehydration, and altered mental status and was admitted for septic shock. On presentation, her echocardiogram showed hyperdynamic cardiac function. However, she deteriorated requiring inotropic support and VA ECMO (right carotid artery/right femoral vein). Subsequent echocardiogram showed significant left heart dilation with mitral regurgitation, necessitating atrial decompression. She was treated for myocarditis and had rapid recovery of her ventricular function once ECMO was initiated. She underwent decannulation but suffered cardiac arrest on induction for attempted stent removal several days after decannulation requiring extracorporeal cardiopulmonary resuscitation. She then returned to the catheterization laboratory for successful removal of the atrial stent using

a novel approach using a double snare technique and the $\bar{O}\bar{N}\bar{O}$ device ($\bar{O}\bar{N}\bar{O}$ COR LLC) (Figure 1D). She was ultimately decannulated successfully and discharged after 39 days with normal cardiac function.

CASE 3. A 9-year-old boy with history of sickle cell disease developed fever and progressive respiratory symptoms, progressing to acute chest syndrome and admission. On presentation, he developed pulseless electrical activity requiring extracorporeal cardiopulmonary resuscitation and was placed on VA ECMO (RIJ/right carotid artery). Echocardiogram post-cannulation demonstrated severe left-sided dilation, necessitating atrial decompression. Several days later, he had recovery of his ventricular function; however, he still required significant respiratory support. He was converted to venovenous-arterial ECMO with an ongoing decrease of arterial support. While on venovenous-arterial ECMO, the atrial stent was removed using a novel approach with a double snare technique and the $\bar{O}\bar{N}\bar{O}$ device. He was then decannulated from ECMO and discharged after 90 days with normal cardiac function.

DISCUSSION

Transcatheter atrial septal stent placement for creation of an atrial septal defect is a well-known technique used to decompress the left atrium in patients that are supported with VA ECMO dating back to the late 1990s.⁴ Under transesophageal echocardiographic guidance, the Baylis VersaCross system (Baylis) was used to perform transseptal puncture to place an atrial septal stent. As previously published, patients that are older typically benefit from stent placement to maintain an unrestrictive atrial septal communication.⁵ We used a Palmaz XL 4010 biliary stent (Cordis) mounted on a 12- or 14-mm NuMed BIB balloon (NuMed) for creation of an unrestrictive atrial septal defect in our cases within 24 hours of initiating ECMO.

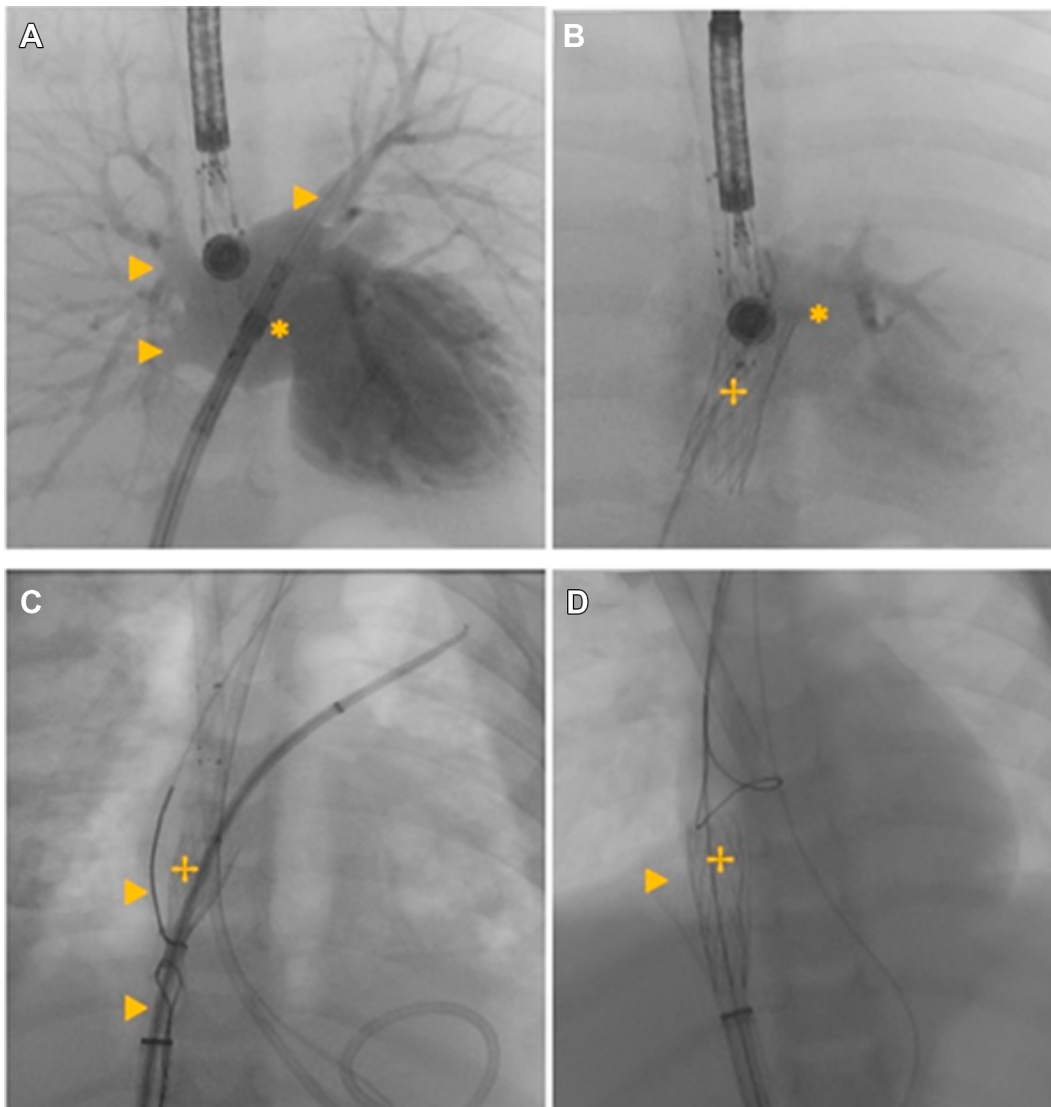
Atrial septal stent removal was performed using the following technique. Venous access was obtained from the neck and groin in all cases. Jugular venous access consisted of a 7- to 8-F sheath in the left internal jugular vein, which was used for introduction of a snare from above. Each patient had a venous cannula in the RIJ which prohibited us from using this vessel. Femoral venous access consisted of a 20-F GORE Dryseal sheath (W.L. Gore and Associates) in either the right or left femoral vein dependent on which vessel was already used for venous ECMO cannulation. The tip of the GORE Dryseal sheath was positioned at the inferior vena cava and right atrial (RA) junction. In each case, a 25- to 35-mm Amplatz

VISUAL SUMMARY Hospitalization Timeline for Cases

	Case 1	Case 2	Case 3
Admission	Day 0	Day 0	Day 0
ECMO initiation	Day 1	Day 0	Day 1
Atrial stent placement	Day 1	Day 1	Day 1
First ECMO decannulation attempt	N/A	Day 3	N/A
Atrial stent removal	Day 34	Day 24	Day 9
Final ECMO decannulation	Day 42	Day 29	Day 9
Discharge	Day 106	Day 39	Day 90

ECMO = extracorporeal membrane oxygenation; N/A = not applicable.

FIGURE 1 Fluoroscopy During Atrial Septal Stent Placement and Retrieval



(A) Case 1 before stent placement demonstrating dilated left atrium (*) with backflow into the pulmonary veins (arrowhead). (B) Case 1 after left atrial decompression (*) and atrial septal stent placement (+). (C) Case 1 demonstrating retrieval of stent (+) using 2 snares technique (arrowhead). (D) Case 2 demonstrating retrieval of stent (+) using ONO retrieval device (arrowhead).

gooseneck snare (Medtronic) was advanced from the left internal jugular and positioned at the tip of the GORE sheath and a second 25- to 35-mm gooseneck snare was advanced through the GORE sheath and positioned at its tip just below the snare from above. An 0.035-in guidewire (Terumo) and 4-F angle glide catheter (Terumo) were then advanced through the GORE sheath, the center of the 2 snares, and the atrial septal stent, taking care to ensure we were not through any of the side cells of the stent. The angle glide catheter was positioned in the left upper

pulmonary vein using the guidewire, and the wire was exchanged for an 0.035-in $\times$ 260-cm Amplatzer superstiff wire (Boston Scientific). In the first case, the glide catheter was then exchanged for an 8-F 85-cm Cook Flexor sheath (Cook Medical), and in the subsequent cases, the glide catheter was exchanged for a deflectable sheath (Integer) which proved to be more useful. A 6.5-F OSCOR deflectable sheath (Abbott) was used in the second case, and an 8.5-F Agilis NXT small curl sheath was used in the third case based on sheath availability. In all cases, the

sheaths were advanced over the wire and through the atrial septal stent. The left internal jugular snare was then advanced over the atrial stent as distal as possible followed by the snare from the femoral venous sheath. The snares were used to both secure and crimp the RA portion of the stent onto the sheath within the stent. Once the RA portion of the stent was thought to be adequately crimped, the snares were used to secure the stent and retract it into the right atrium with the sheath through the stent remaining in position. With the stent entirely within the right atrium, the dilator of the sheath through the stent was removed and the angle glide catheter was advanced through the sheath over the wire. The sheath, catheter, and wire were carefully retracted into the right atrium using the snares to ensure control of the stent. The glide catheter was then used to guide the wire toward the superior vena cava, and the snare from above was then retracted off the stent and sheath and used to snare the tip of the Amplatzer wire. The wire was externalized through the left internal jugular sheath and created a venovenous rail from the left internal jugular to the femoral vein, thereby securing the stent to prevent embolization. The snare from above was then advanced over the wire to assist with stent crimping as needed, and the sheath through the stent was removed to allow for tighter crimping of the stent. At this juncture in the cases, the technique for removal of the stent varied between the first and subsequent cases.

In the first case, the snares alone were used to crimp the stent until it could be retracted into the GORE sheath. In the subsequent cases, we used the novel $\bar{O}\bar{N}\bar{O}$ device for removal of the stent. The snare from the femoral vein was removed and the $\bar{O}\bar{N}\bar{O}$ retrieval device was prepped and advanced over the wire through the GORE sheath without difficulty to the RA and inferior vena cava junction. The $\bar{O}\bar{N}\bar{O}$ device was then carefully advanced over the stent and wire until the stent was almost completely

within the $\bar{O}\bar{N}\bar{O}$ device. With simultaneous retraction of the $\bar{O}\bar{N}\bar{O}$ device and advancement of the sheath, the stent was easily pulled into the GORE sheath using the $\bar{O}\bar{N}\bar{O}$ device (Figure 1D). The $\bar{O}\bar{N}\bar{O}$ device and stent were removed without difficulty, and the wire was removed using the 4-F angle glide catheter. Echocardiography was performed after stent removal in each case demonstrating a small atrial level communication with left to right flow.

Complications that can arise when removing the stents include embolization, inability to entrap the device in the chosen sheath because of size, and the technical challenge of serial snaring of the stent; the duration of fluoroscopy is also important. Crimping the stent to fit in the GORE sheath took a considerable amount of time. The $\bar{O}\bar{N}\bar{O}$ device allowed almost complete entrapment of the stent essentially in its native formation decreasing the amount of technical time significantly. The venovenous rail system provided safety controlling the stent and provided the ability to position the $\bar{O}\bar{N}\bar{O}$ device. Importantly, all patients underwent stent removal while on ECMO support.

To our knowledge, this case series is the first to discuss transcatheter removal of a large diameter atrial septal stent after cardiopulmonary ECMO support in pediatric patients and is the first case report using the ONOCOR $\bar{O}\bar{N}\bar{O}$ retrieval device to successfully perform this procedure.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr John-Anthony Coppola, Division of Pediatric Cardiology, Department of Pediatrics, University of California-Davis, Suite 210 2516 Stockton Blvd, Sacramento, California 95817, USA. E-mail: jcoppola@health.ucdavis.edu.

REFERENCES

1. Zampi JD, Alghanem F, Yu S, et al. Relationship between time to left atrial decompression and outcomes in patients receiving venoarterial extracorporeal membrane oxygenation support: a multicenter pediatric interventional cardiology early-career society study. *Pediatr Crit Care Med*. 2019;20:728-736.
2. Baruteau AE, Barnette T, Morin L, et al. Percutaneous balloon atrial septostomy on top of venoarterial extracorporeal membrane oxygenation results in safe and effective left heart decompression. *Eur Heart J Acute Cardiovasc Care*. 2018;7:70-79.
3. Sperotto F, Polito A, Amigoni A, Maschietto N, Thiagarajan RR. Left atrial decompression in pediatric patients supported with extracorporeal membrane oxygenation for failure to wean from cardiopulmonary bypass: a propensity-weighted analysis. *J Am Heart Assoc*. 2022;11:e023963.
4. Koenig PR, Ralston MA, Kimball TR, Meyer RA, Daniels SR, Schwartz DC. Balloon atrial septostomy for left ventricular decompression in patients receiving extracorporeal membrane oxygenation for myocardial failure. *J Pediatr*. 1993;122:595-599.
5. Veeram Reddy SR, Guleserian KJ, Nugent AW. Transcatheter removal of atrial septal stent placed to decompress left atrium with VA ECMO. *Catheter Cardiovasc Interv*. 2015;85:1021-1025.

KEY WORDS atrial septal stent, cardiac catheterization, ECMO, left atrial decompression, $\bar{O}\bar{N}\bar{O}$ COR, pediatrics