

# Innovative uses of large diameter covered stents in the superior vena cava

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## ARTICLE INFO

### Keywords:

Cardiac catheterization  
Partial anomalous pulmonary venous return

## ABSTRACT

We present two cases of off-label use of the covered Cheatham-Platinum stent in the superior vena cava. The first patient was a 35 year old man with superior vena cava obstruction with a superior vena cava to left atrium fistula. Covered stents were used to re-establish superior vena cava to right atrial continuity and close the superior vena cava to left atrium fistula. The second patient was a 25 year old woman with partial anomalous pulmonary venous return of the right upper pulmonary vein to the superior vena cava. A covered stent was placed in the superior vena cava to cover the anomalous right upper pulmonary vein, which then drained to the left atrium via the right middle pulmonary vein.

## 1. Introduction

The covered Cheatham-Platinum stent (NuMed, Inc., Cross Roads, TX) is a large diameter covered stent approved to treat patients with coarctation of the aorta [1] as well as right ventricle to pulmonary artery conduit injury during transcatheter pulmonary valve implantation procedures [2]. Several off-label uses of the device have been described [3–5]. Here we present two cases of off-label use of the covered Cheatham-Platinum stent to treat abnormalities related to the superior vena cava, including placement to re-establish superior vena cava to right atrial continuity while occluding an superior vena cava to left atrial fistula, and treatment of partial anomalous pulmonary venous return of the right upper pulmonary vein to the superior vena cava.

## 2. Case series

**Patient 1:** A 35 year old male with a parachute mitral valve with mitral stenosis and regurgitation, tricuspid regurgitation, and atrial fibrillation underwent mitral valve replacement, tricuspid valve repair, and MAZE procedure at age 31. He developed exertional dyspnea, fatigue, and palpitations and was found to have 2nd degree heart block and so was referred for transvenous pacemaker placement. During that procedure, an angiogram demonstrated obstruction of the superior vena cava at the roof of the right atrium with drainage via the azygous vein to the inferior vena cava, and via a moderate superior vena cava to left atrium fistula. Cardiac MRI confirmed superior vena cava to right atrium discontinuity, revealed a short distance between the two

structures, and also showed the location of the superior vena cava to left atrium fistula and its relationship to the azygous vein. He was thus referred for cardiac catheterization with a plan to re-establish a superior vena cava to right atrium connection and eliminate the superior vena cava to left atrium fistula.

With right femoral and right internal jugular venous access, angiograms were performed in the superior vena cava and right atrium to delineate the relationship between the two structures (Fig. 1). A 10 mm gooseneck snare (Medtronic, Minneapolis, MN) was placed through a 4 French catheter and advanced into the superior vena cava via the internal jugular sheath. Using an 8 French transseptal sheath (Abbott Laboratories, Chicago, IL), a BRK transseptal needle (Abbott Laboratories, Chicago, IL) was used to cross the tissue/septum between the superior vena cava and right atrium. A 0.018" Hi-Torque Steeplecore wire (Abbott Laboratories, Chicago, IL) was advanced through the transseptal needle and the wire snared in the superior vena cava. The transseptal sheath was advanced over the wire into the superior vena cava. After removing the 0.018" wire, a 0.035" Amplatzer super stiff guidewire (Abbott Laboratories, Chicago, IL) was advanced into the superior vena cava, snared, and externalized via the internal jugular sheath. Over this wire, the transseptal sheath was exchanged for a 14 French long Check-Flo sheath (Cook Medical, Bloomington, IN). To first re-establish superior vena cava to right atrium continuity, an 8 zig 4.5 cm covered Cheatham-Platinum stent pre-mounted on a 20 mm balloon was advanced via the long sheath and deployed across the superior vena cava to right atrium junction. An angiogram was performed through the internal jugular sheath showing the stent in

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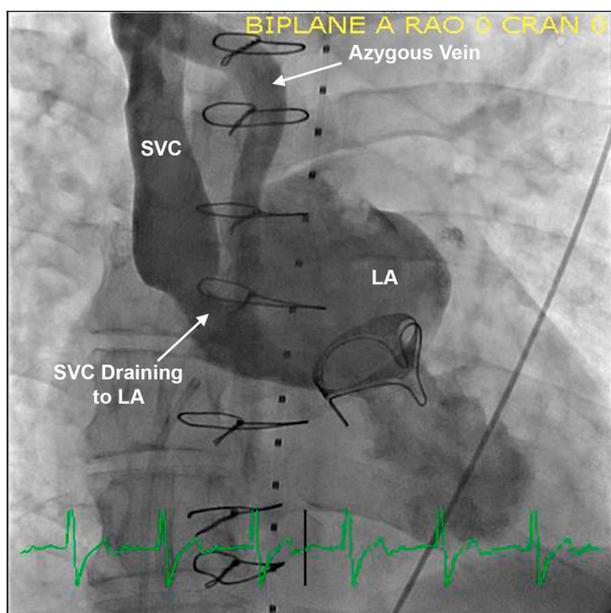
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<https://doi.org/10.1016/j.ppedcard.2019.03.002>

Received 28 January 2019; Accepted 8 March 2019

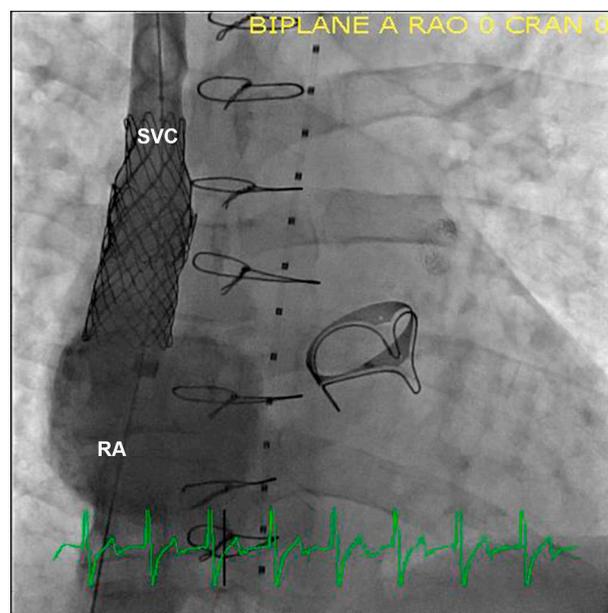
Available online 29 March 2019

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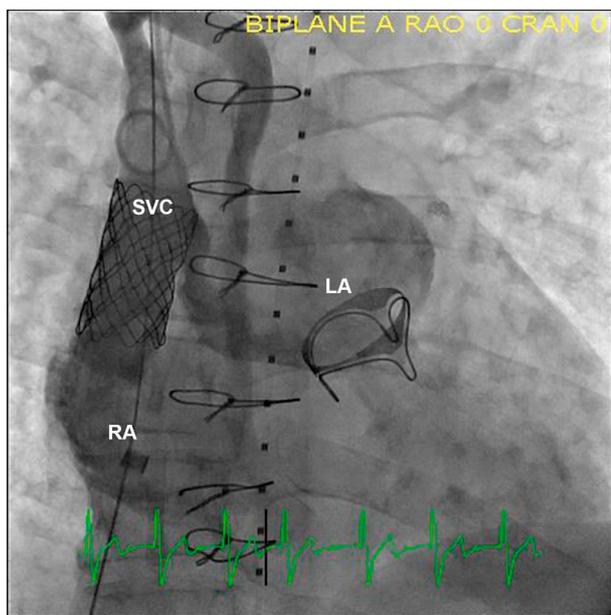
**Fig. 1.** Angiogram showing obstruction from the SVC to RA and an SVC to LA fistula.

SVC - superior vena cava; RA - right atrium; LA - left atrium.



**Fig. 3.** Angiogram showing SVC to RA continuity and no residual SVC to LA fistula.

SVC - superior vena cava; RA - right atrium.



**Fig. 2.** Angiogram showing re-establishment of SVC to RA continuity and a residual SVC to LA fistula.

SVC - superior vena cava; RA - right atrium; LA - left atrium.

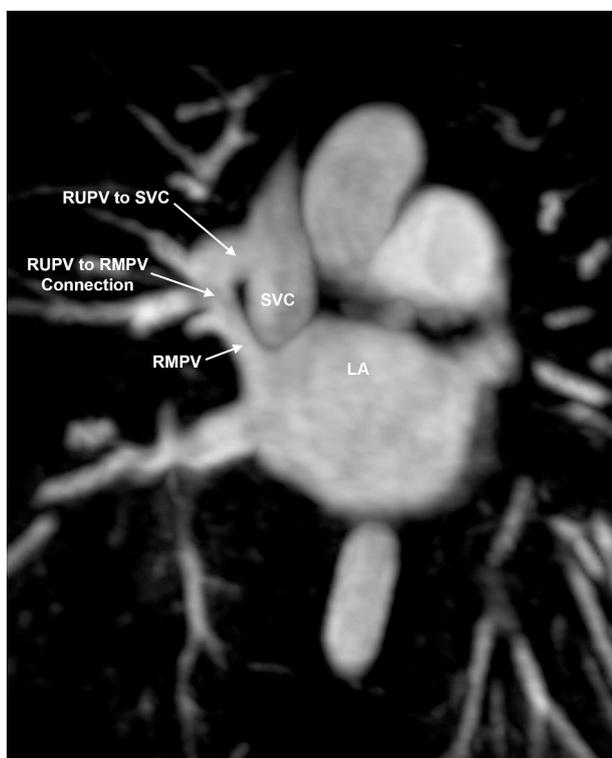
excellent position. The stent was then fully expanded using a 20 mm × 2 cm Atlas Gold balloon (Bard Medical, Covington, GA). A repeat angiogram was performed in the superior vena cava to delineate the residual superior vena cava to left atrium connection (Fig. 2). An 8 zig 4 cm covered Cheatham-Platinum stent pre-mounted on a 20 mm balloon was advanced over the wire until it was positioned to exclude the connection with the left atrium but not obstruct the azygous vein. The stent was then deployed and a repeat angiogram was performed in the superior vena cava showing no residual left atrium connection (Fig. 3). Simultaneous superior vena cava pressure and right atrium pressure were then recorded, showing no gradient across the newly placed superior vena cava stent.

The patient was extubated in the catheterization laboratory without

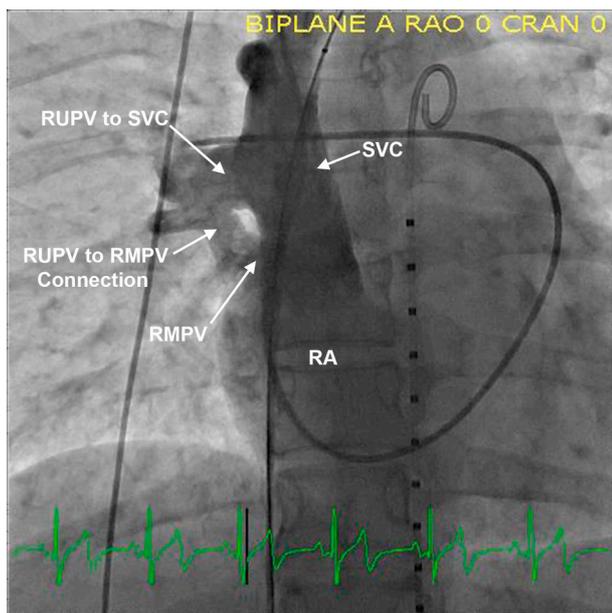
complication. He was monitored overnight and discharged home the following day. His exertional dyspnea improved and 3 ½ months later he underwent successful transvenous pacemaker implantation. One year following the procedure, his symptoms had significantly improved and echocardiography showed no gradient across the superior vena cava stent.

**Patient 2:** A 25 year old asymptomatic young woman being evaluated for heart murmur with associated right heart dilation underwent a cardiac MRI which showed partial anomalous pulmonary venous return with connection of the right upper pulmonary vein to the superior vena cava. By MRI, Qp:Qs was 2:1 (on cardiac catheterization, Qp:Qs was 1.8:1). The MRI also showed right ventricular dilation with an indexed right ventricular end diastolic volume of 124 mL/m<sup>2</sup>. Although initially referred for surgical correction, after review of the MRI a connection between the right upper pulmonary vein and right middle pulmonary vein was noted (Fig. 4). Therefore, she was referred for cardiac catheterization with possible covered stent placement to exclude the right upper pulmonary vein to superior vena cava connection as it was felt her right upper pulmonary vein would drain through her right middle pulmonary vein.

Right femoral and right internal jugular venous access and femoral arterial access was obtained. Angiography confirmed drainage of the right upper pulmonary vein to the superior vena cava (Fig. 5). We elected to temporarily balloon occlude the superior vena cava at the level of the anomalous right upper pulmonary vein to ensure persistent right upper lung pulmonary venous drainage without worsening pulmonary artery pressures. A balloon wedge catheter (Teleflex, Inc., Wayne, PA) was advanced into the right upper pulmonary artery via the internal jugular vein. From the femoral venous approach, a 0.035" guidewire was placed into the left innominate vein and an 18 mm Amplatzer sizing balloon II (Abbott Laboratories, Chicago, IL) was advanced over the wire into the superior vena cava. The balloon was inflated, while simultaneously measuring a right pulmonary artery pressure, which remained unchanged. An angiogram performed via the wedge catheter showed the right upper lobe draining via the right middle pulmonary vein and no residual flow through the right upper pulmonary vein into the superior vena cava. After additional superior vena cava angiography, an 8 zig 4.5 cm covered Cheatham-Platinum stent pre-mounted on a 22 mm balloon was selected and advanced via a

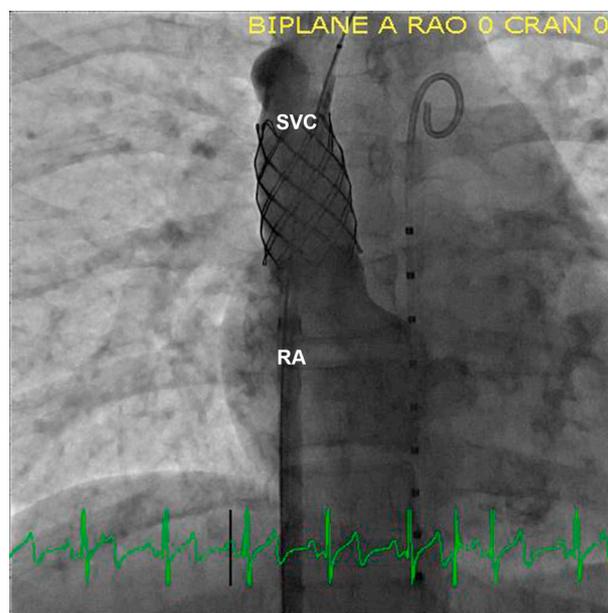


**Fig. 4.** MRI showing partial anomalous pulmonary venous return of the RUPV to the SVC and a connection between the RUPV and RMPV. SVC - superior vena cava; RUPV - right upper pulmonary vein; RMPV - right middle pulmonary vein; LA - left atrium.



**Fig. 5.** Angiogram showing partial anomalous pulmonary venous return of the RUPV to the SVC and a connection between the RUPV and RMPV. SVC - superior vena cava; RUPV - right upper pulmonary vein; RMPV - right middle pulmonary vein; RA - right atrium.

14 French long Check-Flo sheath from the femoral vein. The stent was then deployed in the superior vena cava at the entrance of the right upper pulmonary vein. A repeat angiogram in the superior vena cava was performed using a 6/8 French multitrack angiographic catheter (B. Braun Melsungen AG, Melsungen, Germany) and showed a well-positioned stent with no flow seen into the RUPV, no obstruction of the



**Fig. 6.** Angiogram showing the stented SVC draining into the RA with no flow into the RUPV. SVC - superior vena cava; RA - right atrium.

azygous vein, and a widely patent superior vena cava draining into the right atrium (Fig. 6). Repeat right pulmonary artery pressures were measured and were unchanged from baseline. A right upper pulmonary artery wedge angiogram was then performed showing all contrast returning to the left atrium through the right middle pulmonary vein with no return of contrast to the superior vena cava.

The patient was extubated in the catheterization laboratory without complication. She was monitored overnight and discharged home the following day. An echocardiogram on the day of discharge showed unobstructed flow through the superior vena cava stent. She remains asymptomatic at 6 month follow-up with echocardiography showing an unobstructed superior vena cava with improving (now top normal) right ventricular dilation.

### 3. Discussion

Covered Cheatham-Platinum stent use is now common in the management of aortic coarctation and right ventricle to pulmonary artery conduit rehabilitation. We describe the off-label use of the covered Cheatham-Platinum stent within the superior vena cava to correct intra-cardiac shunts in two adult patients with very differing anatomic abnormalities. The first patient was incidentally found to have superior vena cava to right atrium discontinuity with a superior vena cava to left atrium fistula. This right to left shunt lesion was possibly iatrogenic and related to prior surgery with mitral valve replacement. Interestingly, the patient was noted several years before to have a lower oxygen saturation during a 6 minute walk. We were able to re-establish a connection from the superior vena cava to right atrium and exclude the superior vena cava to left atrium fistula using two covered Cheatham-Platinum stent, allowing restoration of normal superior vena cava drainage. These both improved the patient's symptoms and allowed for successful transvenous pacemaker placement due to 2nd degree heart block.

In the second patient with partial anomalous pulmonary venous return, cardiac MRI was essential in planning this procedure as this patient would typically have undergone surgical intervention at our center. The MRI showed the connection between the right upper pulmonary vein and the right middle pulmonary vein, making a transcatheter approach potentially feasible. Although a low-risk surgical

candidate, the ability to provide a physiologic correction without the morbidity of cardiac surgery was appealing.

#### 4. Conclusion

In these two adult patients, we were able to establish physiologically correct systemic and pulmonary venous drainage and eliminate intra-cardiac shunts using the covered Cheatham-Platinum stent. Both cases had immediate and short term success with no complications. In select patients, the covered Cheatham-Platinum stent offers an appealing minimally-invasive approach to re-establish normal physiology and avoid cardiac surgery. Pre-operative cross sectional imaging was essential in planning for these cases.

#### Acknowledgements

The authors would like to acknowledge Dr. Jimmy Lu for his assistance with preparing the cardiac MRI image.

#### Funding

This research did not receive any specific grant from funding

agencies in the public, commercial, or not-for-profit sectors.

#### Conflicts of interest

None.

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