Cardiology in the Young

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Use of a modified microvascular plug to modify fenestration flow in a rapidly failing Fontan

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Abstract

We report a case of an alternative transcatheter use of the modified Medtronic microvascular plug to modify fenestration stent flow in a patient with a rapidly deteriorating clinical condition. This four-year-old boy developed severe cyanosis following fenestration stent insertion, initially placed due to prolonged drainage post-Fontan with extra-cardiac conduit. In April 2023, he underwent urgent cardiac catheterisation and had partial occlusion of fenestration stent with a modified 9Q microvascular plug. His oxygen saturations improved from 50 to 89% in room air with no re-emergence of raised cavopulmonary pressures.

Brief Report

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Case report

The modified Medtronic microvascular plug has been reported as the transcatheter alternative to the surgical pulmonary artery band, used to restrict pulmonary blood flow in the setting of pulmonary over-circulation.[1–5]

We report a case of an alternative transcatheter use of the modified microvascular plug to modify fenestration stent flow in a patient with a rapidly deteriorating clinical condition.

The patient is a four-year-old boy with right atrial isomerism, unbalanced atrioventricular septal defect, hypoplastic left ventricle, transposed great vessels and severe pulmonary stenosis. His previous procedures include transcatheter patent ductus arteriosus stenting at day 8 of life and bidirectional Glenn at 6 months.

Pre-Fontan cardiac catheterisation in March 2022 was reassuring with a mean SVC pressure of 11 mmHg pre- and post-occlusion of a large veno-venous collateral from the innominate vein. The catheter was performed under general anaesthetic with the patient disconnected from the ventilator to try and nullify the effect of positive airway pressure during cavopulmonary pressure measurement. He underwent Fontan with fenestrated extra-cardiac conduit in October 2022. Fontan is performed with a fenestration in all patients in our surgical centre independently of their pre-Fontan catheterisation data.

Post-operatively, our patient was extubated on day 1 but was noted to have early closure of his fenestration, raised cavopulmonary pressures and high chest drain output at 9 ml/kg/hr. He subsequently underwent fenestration stenting on day 8 post-Fontan with Cook F535 6 × 12 mm stent. It was hoped that the GORE-TEX material in the extra-cardiac conduit would achieve a degree of constriction in the stent creating a diabolo shape. Unfortunately, the stent ended up being fully expanded throughout its length to 6 mm diameter. He was discharged home 18 days following his Fontan procedure with saturations in the 70s.

At follow-up, his saturations remained in the low 70s and walk testing revealed desaturation to the 50s.

In April 2023, he was then admitted for an urgent cardiac catheterisation to assess cavopulmonary pressures and for fenestration stent reduction. The patient arrested post-anaesthetic induction with significant desaturation and low cardiac output. The loss of cardiac output associated with severe hypoxia was attributed to pre-existing impaired ventricular function and loss of spontaneous ventilation which was likely an important part of his Fontan circulation with a large fenestration resulting in severe hypoxia. He was resuscitated with adrenaline, and after a period of stabilisation in the cardiac catheterisation lab, we proceeded with the intervention. Angiography confirmed no re-emergence of veno-atrial collaterals and that the desaturation was secondary to the fenestration stent.

A modified 9Q microvascular plug was made by creation of a 4 mm hole to create a flow restrictor device. Perforation of the polytetrafluoroethylene covering was achieved with an ophthalmic cautery tool, which allowed the creation of a circular perforation, which was subsequently balloon dilated with 4 × 12 mm Maverick balloon through one of the covered diamonds (Figure 1).

The 9Q modified microvascular plug was delivered via a 5Fr non-tapered coronary catheter to the previously placed fenestration stent. Initial deployment resulted in device deformation, incomplete expansion, and an unstable position. The device was subsequently removed. We felt the use of the 5Fr non-tapered catheter caused compression of the device, resulting in

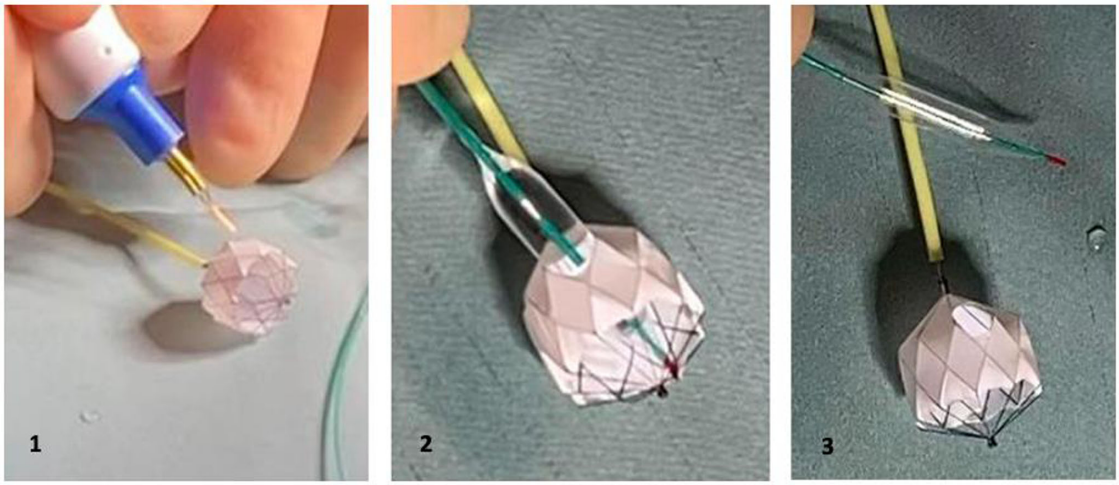

Figure 1. 1. Use of an ophthalmic cautery tool to create a hole in the PTFE covering of the microvascular plug. 2. The hole was balloon dilated with a 4 × 12 mm Maverick balloon. 3. A modified 9QMVP was made by the creation of a 4 mm hole to create a flow restrictor device.

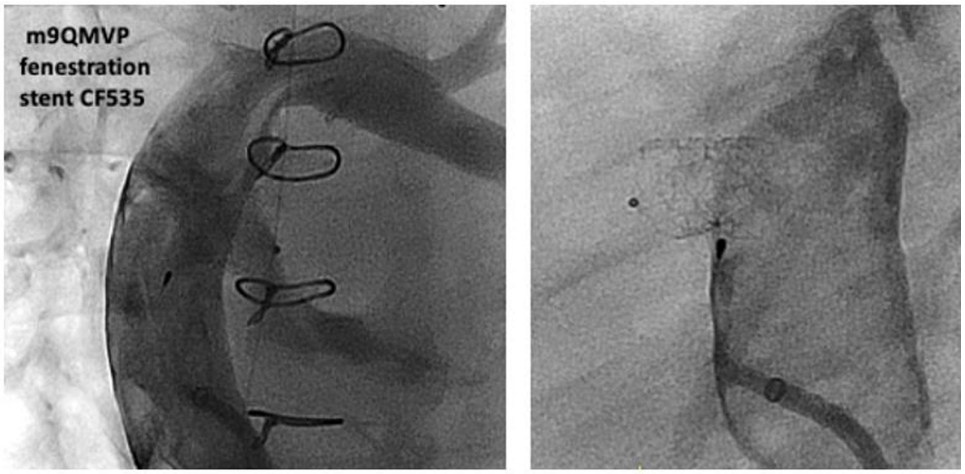

Figure 2. m9QMVP in Cook F535 6 × 12 mm fenestration stent seen in AP and lateral angiographic images taken from the extra-cardiac conduit.

incomplete expansion of the device when pushed out of the catheter within the fenestration. A second modified 9Q microvascular plug was delivered via 6Fr Destination sheath within the fenestration stent. Stable position and adequate expansion were confirmed within the lumen of the stent prior to release (Figure 2).

After 15 minutes of observation, device position remained stable. Repeat haemodynamic testing confirmed IVC pressure 22 mmHg (pre-procedure IVC pressure 19 mmHg) and a sustained increase in oxygen saturation from 65 to 85% in 30% oxygen.

Post-procedure, the patient was observed in the paediatric intensive care unit with an intravenous infusion of heparin ongoing, prior to extubation and discharge to the ward the next day. The patient demonstrated an improvement in saturations from low 50s to high 80s prior to discharge home with no clinical evidence of re-emergence of raised cavopulmonary pressures.

His post-procedure course was complicated at day two procedure, following return to the ward; he was noted to have loss of peripheral vision, and a subsequent MRI brain confirmed occipital infarction. The patient remained on prophylactic heparin post-procedure, and due to the complications, he was subsequently transitioned to warfarin, rather than aspirin.

The patient has clinically improved following the initial insult and is being closely followed up by ophthalmology and neurology.

In May 2023, he had an episode of supraventricular tachycardia that was managed with one dose of adenosine and maintenance bisoprolol. Saturations remained stable, and bloods were noted to be normal at the time of this brief re-admission with an Albumin of 41.

At the follow-up in July 2023, the patient demonstrated a sustained improvement in saturations to high 80s with no clinical evidence of re-emergence of raised cavopulmonary pressures or protein-losing enteropathy.

Discussion

Clinical use of the modified microvascular plug has been previously reported in the branch pulmonary arteries in the setting of a pulmonary over-circulation [1,3,5] and as a transcatheter stage 1 procedure in hypoplastic left heart syndrome in addition to patent ductus arteriosus stent insertion.[3,4]

This case highlights the versatility and the capability of a modified Microvascular plug to modify flow in our Fontan patients where small changes in flow and pressure can have a significant clinical impact.

The clinical success of modifying fenestration flow in this patient who had hypoxia with a fenestration stent and raised

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cavopulmonary pressures without, highlights the need for further development of flow-modifying devices to enable safe placement in a variety of clinical conditions.

Our patient developed occipital infarction post-procedure, and this highlights the importance of thromboprophylaxis in patients with flow-modifying devices. A different approach should be considered in a patient with a right-left shunting condition compared to a left-to-right shunt. Flow-modifying devices used with right to left shunts carry a much greater risk with thromboembolism and therefore perhaps should routinely be accompanied by a more aggressive thromboprophylaxis strategy such as the use of dual anti-platelet therapy or warfarin.

Follow-up of our patient will further enable us to understand the capabilities of this modified device over the medium and long term. The time constraints placed on pulmonary artery flow restrictors do not apply in this case due to the in-stent placement of the modified device.

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Competing interests. None.

Ethical standards. Fully informed written consent by Patient's parents prior to case report submission.

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