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CASE SERIES

Extrinsic outflow graft flow obstruction in patients with HeartMate3 LVAD

Silvia Ajello[1] | **Marina Pieri**[1] | **Luca Bertoglio**[2] | **Savino Altizio**[1] | **Pasquale Nardelli**[1] | **Anna Mara Scandroglio**[1]

[1]Department of Anesthesia and Intensive Care, IRCCS San Raffaele Scientific Institute, Milan, Italy

[2]Department of Vascular Surgery, IRCCS San Raffaele Scientific Institute, Milan, Italy

Correspondence
Anna Mara Scandroglio, MD, Department of Anesthesia and Intensive Care, IRCCS San Raffaele Scientific Institute, Via Olgettina 60, Milan 20132, Italy.
Email: scandroglio.mara@hsr.it

Abstract

Blood flow obstruction at the level of the outflow graft is a rare but severe complication of LVAD support. We present a series of five patients supported with HeartMate3 LVAD (Abbott Labs, Chicago, IL) that developed an outflow graft obstruction after 607–1250 days of support, during prolonged antithrombotic therapy. Three patients presented with severe symptoms of heart failure, were treated with endovascular stenting and experienced full recovery. Preoperative computed tomography angiography and intraoperative angiography together with intravascular ultrasound provided diagnosis and guided treatment. In two patients, outflow obstruction was an occasional finding at imaging without heart failure symptoms and a "watchful waiting" approach was adopted: delayed treatment in one of them was futile. This late adverse event is peculiar for its pathophysiology and not yet discussed among the mechanical circulatory support community.

KEYWORDS

heart failure, HeartMate3, left ventricular assist device, outflow graft stenting

1 | INTRODUCTION

The enhanced hemocompatibility of last generation left ventricular assist devices (LVADs) has dramatically reduced the incidence of pump-related complications, especially pump thrombosis.[1] However, pump flow obstructions still represent very dangerous events that warrant timely diagnosis and treatment. In particular, outflow graft obstructions (OGO) is challenging as a consequence of endoluminal thrombosis, kinking, twisting, dissection, ab-extrinseco compression,[2–6] and a potential role of the graft material itself in OGO determination has also been identified.[7] We present a series of five destination therapy (DT) patients supported with HeartMate3 LVAD (Abbott Labs, Chicago, IL) that developed an extrinsic OGO after 607–1250 days of support, during prolonged antithrombotic regimen. We discuss diagnosis, management, and outcomes.

1.1 | Patient 1

A 69 years old man was implanted a HeartMate3 LVAD for ischemic cardiomyopathy as DT in September 2018 and was admitted to the intensive care unit for severe heart failure in May 2020 (Table 1). After invasive monitoring confirmed low cardiac output with high left and right heart preloads (WP 19 mm Hg, PVC 8 mm Hg), he was treated with iv inotropes and negative hydric balances. With RAMP test LVAD rpm were progressively increased,

TABLE 1 Characteristics of five HeartMate3 LVAD patients with outflow graft obstruction

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age	**69**	**74**	**74**	**78**	**67**
Time of presentation, days	607	1112	1250	930	757
Device strategy	DT	DT	DT	DT	DT
Data at admission					
Symptoms	Dyspnea, peripheral oedema, low flow alarms	Pulmonary edema, low cardiac output	Dyspnea	Dispepsia, peripheral oedema, pulmonary congestion	Dyspnea, ascites, right heart failure
NYHA class	III	IV	IV	IV	IV
INR	2.28	2.02	2.15	2.65	1.71
Aspirin therapy	No	No	No	No	No
LDH, U/L (pre-treatment)	330	376	290	422	157
Free hemoglobin mg/L (pre-treatment)	NA	119	94	131	143
LDH, U/L (post-treatment)	302	213	254	No treatment	281
Free hemoglobin, mg/L (post-treatment)	NA	102	31	No treatment	122
LVAD parameters					
Flow (pre-treatment), L/min	4.1	4.8	3.9	5	5.5
Flow (post-treatment), L/min	4.8	5	4.5	–	4.2
RPM (pre-treatment)	5300	5400	5300	5600	6000
RPM (post-treatment)	5400	5600	5300	–	5000
Power (pre-treatment), W	3.6	4	3.6	4.2	4.9
Power (post-treatment), W	3.8	4.3	3.7	–	3.4
Pulsatility index (pre-treatment)	3.9	4.3	3.8	3.1	2.1
Pulsatility index (post-treatment)	2.8	NA	3.2	–	3.3
Treatment	Percutaneous stenting (1 Bentley BeGraft 16×48)	Percutaneous stenting (3 Bentley BeGraft 14×59, 14×49, 12×59)	Percutaneous stenting (2 Bentley BeGraft 14×48)	WW	WW (6 months)—Percutaneous stenting (BeGraft 16×59+16×49) and a endoprosthesis (Gore 16×16×9.5)
Procedural access	Left axillary artery	Left axillary artery + left omeral artery	Left axillary artery	–	Left axillary artery

Abbreviations: DT, destination therapy; INR, international normalized ration; LDH, lactate dehydrogenase; LVAD, left ventricular assist devices; NA, not available; NYHA, New York Heart association; OGO, outflow graft obstruction; RPM, right per minute; WW, watchful waiting.

but the patient had no clinical improvement and at computed tomography angiography (CTA) an eccentric mass (maximum thickness 7 mm, length 60–70 mm) conditioning critical OGO of the proximal tract of the outflow graft was described. Log files analysis did not show reduction of pump flow but few episodes of low flow. Under general anesthesia in a hybrid operating room, OGO diagnosis was confirmed by angiography and intravascular ultrasound (IVUS) and the patient underwent outflow graft stenting (Bentley BeGraft 16×48) via percutaneous left axillary artery, with complete obstruction resolution. The patient was discharged 10 days later; neither recurrence of heart

failure nor pump alarms were observed after 637 days follow-up from treatment.

1.2 | Patient 2

A 73 years old man implanted with HeartMate3 LVAD as DT in 2017 due to ischemic cardiomyopathy developed symptoms of severe heart failure requiring hospitalization in July 2020 (Table 1). Heart failure was refractory to medical therapy and examinations revealed the presence of severe aortic regurgitation and 60% OGO of 70 mm length. The patient underwent transaortic aortic valve implantation. Despite full hemodynamic support, regular function of aortic prosthesis, mechanical ventilation, and iv diuretics, refractory heart failure, and low cardiac output syndrome with high dose inotropes need persisted. The patient was then scheduled for endovascular outflow graft stenting in hybrid operating room. Despite multiple stenting of the proximal tract of the outflow (stents in overlap: Bentley BeGraft aortic 14 × 59 + 14 × 49 + 12 × 59mm), low flow persisted, and intraoperative angiography and IVUS documented a new-onset distal outflow graft obstruction (likely due to the migration of the material causing OGO during stenting procedure). Further stenting of distal outflow graft via left omeral access (stent Abre 20 × 80 mm) leading to OGO resolution was performed. The patient recovered from heart failure, was weaned from inotropes and ventilation and was discharged after 10 days. The patient had no recurrence of heart failure after 536 days follow-up.

1.3 | Patient 3

A 74-year-old patient with HeartMate3 LVAD due to end stage ischemic cardiomyopathy as DT was admitted due to heart failure (Table 1). LVAD parameters were in the normal range and no signs of hemolysis were present. Medical therapy increase and RPM augmentation did not improve symptoms and the patients remained inotrope-dependent (WP 26 mm Hg, PVC 19 mm Hg CI, 2.26 L/min/m^2). CTA performed at admission documented a 60 mm long filling defect of the proximal tract of the outflow graft (minimal residual diameter 7 mm), with maximum thickness of 9 mm. The patient was scheduled for endovascular OGO treatment, and intraoperative IVUS confirmed critical outflow graft stenosis (>50%). Outflow graft stenting with two Bentley BeGraft 14 × 48 via left axillary was performed under IVUS guide without angiography, leading to outflow graft canalization. Postoperative course was complicated by intracranial hemorrhage (right parieto-temporo-occipital region) on postoperative day 10, requiring neurosurgical intervention for intracranial hypertension. The patient recovered, was discharged 25 days after, and had no recurrence of heart failure at 457 days follow-up.

1.4 | Patient 4

A 78 years old man with HeartMate3 LVAD as DT due to idiopathic dilatative cardiomyopathy, required hospital admission for heart failure approximately 930 days after implant (Table 1). Following echocardiographic diagnosis of severe aortic regurgitation, CTA was performed with the perspective to perform TAVI procedure: a proximal outflow graft obstruction was documented (length 5 cm, maximum thickness 9 mm and residual lumen 6 × 16 mm).

The patient underwent TAVI procedure and could be weaned from inotropes and mechanical ventilation. Since the patient recovered from heart failure, we decided to monitor the clinical course and to follow-up the OGO with a "watchful waiting" approach. After 487 days of follow-up, the patient had no recurrence of heart failure.

1.5 | Patient 5

A patient with idiopathic dilatative cardiomyopathy was implanted HeartMate3 LVAD as DT in May 2018 at the age of 64. He suffered from recurrent gastrointestinal bleeding events and was hospitalized due to a hemorrhagic kidney cyst requiring surgical intervention and afterwards permanent dialysis. At a postoperative CT, a proximal OGO was found, conditioning stenosis >50% (757 days after LVAD implantation). Since the patient was free from heart failure symptoms and no pump alarms were recorded, we opted for a "watchful waiting approach" and he was discharged from hospital. After 6 months, he was admitted with heart failure, dyspnea, severe right heart failure, and ascites despite chronic hemodialysis. Intraoperative angiography and IVUS confirmed severe proximal tract outflow graft obstruction: two partially overlapping stents (BeGraft 16 × 59 + 16 × 49) and an endoprosthesis (Gore 16 × 16 × 9.5) were implanted leading to OGO resolution. Despite temporary mechanical circulatory support with Impella RP, refractory right heart failure persisted and the patient died due to liver and end-organ failure after 24 days.

2 | DISCUSSION

The type of OGO observed in the reported series of five HeartMate3 LVAD patients (out of the 41 implanted with

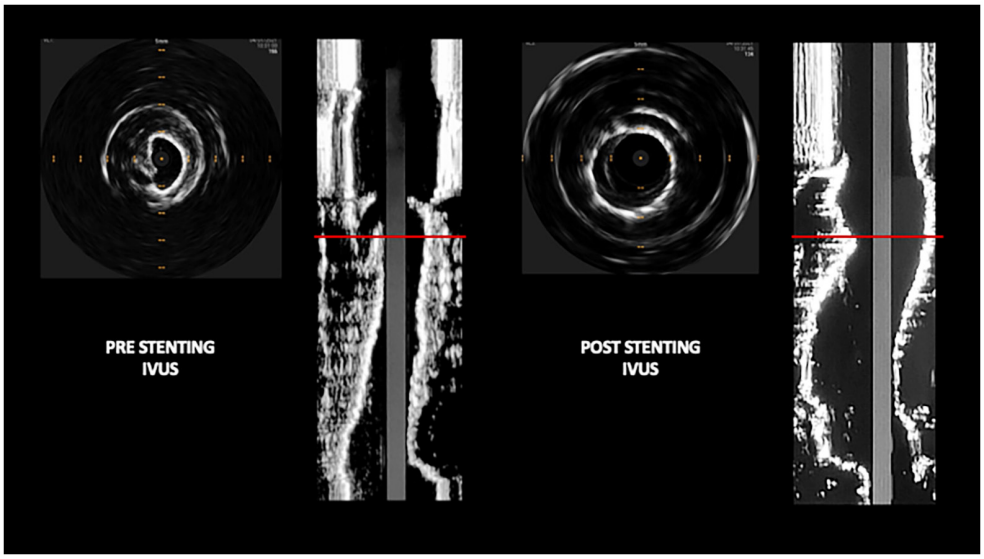

FIGURE 1 Intravascular ultrasound of outflow graft obstruction before and after endovascular treatment.

this type of LVAD since 2016 at our institution, 12%) has peculiar common features[2–5,7,8]: critical narrowing of the proximal outflow graft conditioning flow obstruction with no endoluminal thrombosis was documented (IVUS was in this sense diagnostic, Figure 1); hemolysis was absent, no progressive decline in LVAD blood flow was observed as in other types of OGO.[1] Resolution of flow obstruction with endovascular treatment resulted in recovery from heart failure and home discharge in three of four symptomatic patients. Poor outcome was recorded in only one case where treatment was delayed (a patient with contraindication to full anticoagulation and severe right heart failure). Pump failure due to OGO is the worst adverse event for its subtle expression and critical presentation on top on the difficulties in approaching the obstruction point. Although OGOs have been extensively reported for all types of LVADs, a similar pattern of outflow graft alterations conditioning flow obstruction has been reported only recently from preliminary experiences limited to the HeartMate3 LVAD.[2–5,7,8] Compared with existing reports,[8] our work attempted to present the clinical emerging problem of OGO in a 360° approach: patients were indeed extensively characterized in terms of clinical presentation, hemodynamic data, relevant laboratory parameters, and longer follow-up. Furthermore, diagnostic and treatment steps are presented for each patient in order to provide the most relevant information for the clinical management of this complication. Unfortunately, HeartMate3 log files are insufficient for active surveillance due to their limited storing capacity. Therefore, diagnosis is currently based on CTA; intraoperative angiography and IVUS complement each other in diagnosis and treatment.[2,3,9] In our experience, endovascular approach via axillary artery is the choice option for treatment in this series with contraindications to open heart surgery although it does not allow direct obstruction evaluation and material sampling.[8] All the patients were safely managed during endovascular procedure with intravenous anticoagulation (heparin bolus with target activated clotting time of approximately 250 s) and reduction of LVAD pump speed with a short pump stop at the time of stent delivery. No protamine was administered at the end of procedure; arterial access control was performed with ProGlide closure system (Abbott Vascular Inc., Santa Clara, CA, USA). We would like also to highlight the tricky situation of migration of stenosis that may expose patients to multiple balloon stenting and to hemodynamic collapse. On the contrary, treatment in the case of occasional finding of OGO obstruction at imaging without heart failure symptoms is currently not performed at our center. However, late stenting procedure also proved futile. Although something is known, much is not. There is the clinical perception that outflow graft material may play a role in the establishment of this type of OGO,[7,8] eventually due to leakage of intravascular content into the virtual space between the outflow graft and the bend relief resulting in lumen occlusion. This complication occurred late after implantation and was an occasional finding in two out of the five patients of our casistic: the material causing obstruction may accumulate progressively over time, leading to misleading clinical presentation and late treatment. Furthermore, although we believe that this type of OGO may be ascribed to extrinsic compression of the outflow graft within the strain relief rather than intrinsic thrombosis (clearly shown by IVUS as in Figure 1), we also highlight the fact that all our patients had no ongoing antiaggregant therapy (Table 1). As technology and

clinical management in the field of mechanical circulatory support evolve at the maximum speed, therefore, and as much as patients continue to live on support, late events may occur, and it is crucial to address new issues. This case series highlights the role of OGO in late heart failure, the efficacy of percutaneous treatment in terms of technical success and relief of symptoms, if timely, and paves the way to strategies to prevent and minimize this complication during implant, rather than to strategies to implement surveillance and diagnosis in outpatients' care.

AUTHOR CONTRIBUTIONS

Silvia Ajello: concept/design, data analysis/interpretation, critical revision of article, approval of article. Marina Pieri: data collection, data analysis/interpretation, drafting article, critical revision of article, approval of article. Luca Bertoglio and Anna Mara Scandroglio: concept/design, data analysis/interpretation, drafting article, critical revision of article, approval of article. Savino Altizio and Pasquale Nardelli: data collection, drafting article, critical revision of article, approval of article.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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ORCID

Anna Mara Scandroglio https://orcid.org/0000-0003-0639-8227

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