Recanalization of an atretic left internal mammary graft after bypass surgery for an anomalous left main coronary artery origin: a case report

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Background
The inter-arterial anomalous course of the left main coronary artery (LMCA) originating from the right coronary sinus of Valsalva is a rare, though potentially lethal pathology. Coronary artery bypass grafting is a potential surgical therapy with previously reported success, however, there is concern for the possibility of graft occlusion in the setting of competitive native vessel flow.

Case summary
A 48-year-old gentleman presented to our facility with a non-ST elevation acute coronary syndrome. A malignant anomalous course of the LMCA was confirmed using invasive coronary angiography and computed tomography (CT). The patient underwent surgical revascularization of the left anterior descending artery with a left internal mammary artery (LIMA) graft, which was found to be atretic on follow-up CT. Seven years later the patient underwent repeat CT imaging, which confirmed recanalization of the previously atretic LIMA.

Discussion
We present the first documented case of a patient with spontaneous recanalization of an occluded LIMA following bypass surgery for an inter-arterial anomalous course of the LMCA. We postulate that the dynamic obstruction of the anomalous LMCA led to variable flow dependence on the bypass graft and subsequent atresia of the LIMA, due to the favourable native flow conditions in the absence of significant obstructive coronary disease. The exact mechanism of LIMA recanalization remains unclear, but in our case may have been partly mediated by a small increase in left main plaque.

Keywords
Interventional cardiology • Anomalous coronary anatomy • Cardiothoracic surgery • Ischaemic heart disease • Revascularization • Case report

Learning points
• The inter-arterial anomalous course of the left main coronary artery originating from the right coronary sinus of Valsalva is a rare, though potentially lethal pathology.
• Care should be taken in selecting the best revascularization strategy in patients with anomalous anatomy to best protect against the potentially lethal outcomes of the disease.
• Patients without flow limiting atherosclerotic disease may carry an additional risk of bypass graft atresia due to preserved native coronary flow.
Introduction
The inter-arterial anomalous course of the left main coronary artery (LMCA) originating from the right coronary sinus of Valsalva is a rare, though potentially lethal pathology. Due to the significant risk of abrupt LMCA occlusion, surgical correction is warranted even in the absence of symptoms. Coronary artery bypass grafting exists as a potential surgical therapy with previously reported success, however, there is concern for graft occlusion in the setting of competitive native vessel flow. We present the first documented case of a patient with spontaneous recanalization of an occluded left internal mammary artery (LIMA) graft following bypass corrective surgery for an inter-arterial anomalous course of the LMCA.

Timeline

| Date       | Events                                                                                                                                 |
|------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 29 April 11| Patient presents to our institution with exertional dyspnoea. Provisional diagnosis of non-ST elevation myocardial infarction made on the basis of serial troponin elevation |
| 29 April 11| Formal angiography demonstrating abnormal appearance of the left main coronary artery (LMCA), but no culprit coronary lesion            |
| 29 April 11| Initial computed tomography of the coronary arteries (CTCA) confirming malignant anomalous course of the LMCA between the aorta and pulmonary trunk |
| 11 May 11  | Patient underwent successful coronary artery bypass graft surgery with a left internal mammary artery (LIMA) grafted to the left anterior descending artery and a saphenous vein graft to the first obtuse marginal branch |
| 11 August 11| Progress CTCA demonstrating atresia of the LIMA graft                                                                                   |
| 8 March 18 | Follow-up CTCA demonstrating recanalization of LIMA graft                                                                               |

Case presentation
A 48-year-old non-smoking gentleman presented to our facility with severe dyspnoea during a 10 km run. He had no significant personal or family history of coronary disease, and denied a history of diabetes, hypertension, or hyperlipidaemia. Vital signs were within normal limits and cardiovascular examination was normal. Initial Troponin T was 217 ng/L (0–14) and serial electrocardiograms demonstrated sinus rhythm without ST segment or T wave abnormalities. Transthoracic echocardiography demonstrated normal biventricular size and systolic function with normal valvular function and no regional wall motion abnormalities. A provisional diagnosis of non-ST elevation myocardial infarction was made. The patient underwent coronary angiography, which demonstrated patent coronary arteries, with difficult engagement of the LMCA due to an abnormal origin. The left main ostium had an abnormal appearance, which did not significantly change following the administration of intracoronary glyceryltrinitrate (Figure 1).

Subsequent clarification was sought with computed tomography of the coronary arteries (CTCA), which demonstrated the anomalous origin of the LMCA from the right coronary sinus of Valsalva, with a retro-pulmonary inter-arterial course of the vessel. The proximal LMCA was tortuous with a severe ‘fish mouth’ narrowing followed by a distal eccentric, non-obstructive mixed plaque confined to the wall and not causing any luminal stenosis (Figure 2).

Subsequently, the patient underwent coronary artery bypass graft (CABG) surgery. The LIMA was anastomosed to the distal left anterior descending artery, and a saphenous vein graft was anastomosed to the first obtuse marginal branch. The procedure was uncomplicated and the patient recovered uneventfully, however, a follow-up surveillance CTCA unfortunately demonstrated atresia of the LIMA graft (Figure 3). The vein graft remained patent. After 7 years, the patient underwent a repeat surveillance CTCA following a normal stress echocardiogram, which demonstrated recanalization and patency of the LIMA graft with good distal runoff (Figure 4). The distal left main at this time demonstrated a large, though non-obstructive, mixed plaque just proximal to the bifurcation (Figure 5).

Discussion
The anomalous origin of one or more coronary arteries is a well-established entity. Despite the rarity of this phenomenon, with an incidence of approximately 1.3%, the majority of cases have a benign natural history. There exists a subpopulation of patients with...
anomalous anatomy that portends a potentially lethal prognosis; included in this population are those with a left coronary origin from the pulmonary artery or the right coronary sinus, a right coronary artery from the left coronary sinus, and those with a single coronary artery or coronary artery fistulae. The origin of the LMCA from the right coronary sinus accounts for 0.15–1.3% of variants,\(^1,2\) and this anomaly itself has multiple subtypes, of which the rarest and most lethal is the inter-arterial, or ‘malignant’, course of the left main between the aorta and pulmonary artery.

It has been postulated that the cross-sectional expansion of the great vessels during exertion leads to functional compression of the inter-arterial coronary artery,\(^1,2\) however, there is a paucity of robust pathophysiological evidence. Due to the potential for sudden death amongst this phenotype, surgical correction is recommended irrespective of the presence of symptoms.\(^3\) Gulati et al.\(^3\) demonstrated viability of pulmonary artery translocation in two patients as a means of mitigating functional compression of the entrapped coronary artery, which can also be achieved with coronary button reimplantation. Coronary artery bypass graft surgery serves to bypass the malignant course of the LMCA, and is the favoured treatment in patients with underlying coronary disease,\(^4\) however, there is concern that this option may lead to graft atresia due to competitive flow in the native vessel in patients without obstructive coronary disease.

Since the first description by Barner in 1974 of internal mammary artery (IMA) ‘disuse atrophy’ secondary to preserved native coronary flow,\(^5\) more recent case reports and observational studies have highlighted that the progression of native coronary disease and reduced competitive flow may indeed be associated with IMA recanalization.\(^6\)–\(^8\) An exact underlying mechanism remains a topic of debate, as canine competitive flow models in which IMA conduits have been grafted to patent native vessels have failed to reliably demonstrate loss of graft patency.\(^3\)

**Figure 2** Three dimensional computed tomography reconstructions of the main coronary arteries, demonstrating the anomalous origin of the left main coronary artery from the right sinus of Valsalva (arrows).

**Figure 3** Three dimensional computed tomography reconstructions demonstrating the post-operative atretic left internal mammary artery (arrows) with surgical clips in situ.
Cases reporting the recanalization of IMA grafts following CABG are exceptionally scarce, and, to the best of our knowledge, we present here the first case documenting the restoration of LIMA patency after bypass surgery for an anomalous left main origin. We postulate that the dynamic obstruction of the anomalous inter-arterial LMCA led to variable flow dependence on the bypass graft and subsequent atresia of the LIMA, due to the favourable native flow conditions in the absence of significant obstructive coronary disease. The preservation of the saphenous vein graft patency may be explained by the known differences between arterial and vein graft flow dynamics. The flow reserve of vein grafts remains stable with time. However, in the new LIMA graft, there is higher flow velocities and restricted flow capacity, mediated by a smaller diameter. Though this improves with time, in the early post-operative period this phenomenon may jeopardise LIMA patency in the absence of obstructive native disease.

The fact that there had not been a notable increase in the burden of coronary disease over the seven year period confounds the theory that dependence on the bypass graft was mediated by progressive

**Figure 4** Progress computed tomography of the coronary arteries seven years following surgery. Two dimensional view (left panel) demonstrating contrast within the lumen of the left internal mammary artery (arrow), and three dimensional reconstructions (right panels) demonstrating patency of the left internal mammary artery (arrows).

**Figure 5** Initial computed tomography reconstruction of the left main stem (left panel), and progress study after seven years (right panel) demonstrating non-obstructive mixed plaque (arrows).
native coronary obstruction. It is possible that the small increase in size of the distal left main plaque (Figure 5), though non-obstructive, may have had a minor contribution to dynamic native flow impedance, thereby tipping the balance of favourability to the LIMA, though the exact mechanism remains unclear. Serial invasive measurement of LMCA fractional flow reserve could offer additional information regarding the degree to which the left main plaque contributes to flow limitation, but given the lack of symptoms and normal exercise capacity of the patient, invasive assessment has not been pursued.

Conclusion

Here, we present the first documented case of restored LIMA patency post bypass surgery for a malignant anomalous course of the LMCA. Though this is a rare phenomenon, care should be taken in selecting the best revascularization strategy in patients with anomalous anatomy to best protect against the potentially lethal outcomes of the disease. In particular, patients without flow limiting atherosclerotic disease may carry an additional risk of graft occlusion due to preserved native coronary flow. Further studies are required to both elucidate the exact underlying pathophysiological mechanism or graft recanalization and to assist better risk stratification of patients.

Supplementary material

Supplementary material is available at European Heart Journal - Case Reports online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

References

1. Yamanaka O, Hobbs RE. Coronary artery anomalies in 126,595 patients undergoing coronary arteriography. Cathet Cardiovasc Diagn 1990; 21: 28–40.
2. Angelini P, Velasco JA, Flam H. Coronary anomalies. Incidence, pathophysiology, and clinical relevance. Circulation 2002; 105: 2449–2454.
3. Gulati R, Reddy VM, Culbertson C, Helton G, Suleman S, Reinhartz O, Silverman N, Hanley FL. Surgical management of coronary artery arising from the wrong coronary sinus, using standard and novel approaches. J Thorac Cardiovasc Surg 2007; 134: 1171–1178.
4. Cheezum MK, Ghoshhajra B, Bittencourt MS, Hulten EA, Bhatt A, Mousavi N, Shah NR, Valente AM, Rybicki FJ, Steigner M, Hainer J, MacGillivray T, Hoffmann U, Addala S, Di Carli MF, Defana Yeh D, Landberg M, Libertson R, Blankstein R. Anomalous origin of the coronary artery arising from the opposite sinus: prevalence and outcomes in patients undergoing coronary CTA. Eur Heart J Cardiovasc Imaging 2017; 18: 224–235.
5. Barner HB. Double internal mammary-coronary artery bypass. Arch Surg 1974; 109: 627–630.
6. Ans A, Borras X, Ramio J, Ramio J. Patency of internal mammary artery grafts in no-flow situations. J Thorac Cardiovasc Surg 1987; 93: 62–64.
7. Nawaz R, Brener SJ. Flow-dependent changes resulting in restoration of patency of the left internal mammary artery graft after documented atresia. J Invasive Cardiol 2011; 23: 207–209.
8. Villareal RP, Mathur VS. Recruitable patency of the internal mammaryartery graft. Cathet Cardiovasc Interv 2001; 52: 95–99.
9. Spence PA, Lust RM, Zeri RS, Jolly SR, Mehta PM, Otaki M, Sun YS, Chitwood WR. Competitive flow from a fully patent coronary artery does not limit acute mammary graft flow. Ann Thorac Surg 1992; 54: 21–26.
10. Akasaka T, Yoshikawa J, Yoshida K, Maeda K, Hozumi T, Nasu M, Shomura T. Flow capacity of internal mammary artery grafts: early restriction and later improvement assessed by Doppler guide wire: comparison with saphenous vein grafts. J Am Coll Cardiol 1995; 25: 640–647.