Case Report

Iatrogenic Aortocoronary Arteriovenous Fistula following Coronary Artery Bypass Surgery: A Case Report and Complete Review of the Literature

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The case of a patient who presented with angina following a coronary artery bypass (CABG) operation during which the left internal mammary artery was inadvertently anastomosed to a cardiac vein is presented. The literature concerning previously reported cases of aortocoronary arteriovenous fistulas (ACAVF) due to inadvertent grafting of a coronary vein is reviewed and the significance of this complication is discussed. ACAVF due to inadvertent grafting of a coronary vein is a rare complication of CABG and may be a more common cause of graft failure than has previously been recognized. Distortion of cardiac anatomy, the presence of epicardial fat, and an intramyocardial course of the artery intended for grafting are predisposing factors. Some patients present with angina pectoris and heart failure whereas others have no symptoms. The diagnostic test of choice is coronary angiography. Cardiac MRI and CT have a limited role due to the smaller size and the more clearly defined course of these fistulas. Asymptomatic patients are simply observed since spontaneous closure of these fistulas is reported. Symptomatic patients can be treated with combined medical management and percutaneous methods.

1. Introduction

Iatrogenic aortocoronary arteriovenous fistula (ACAVF) resulting from placement of an arterial graft to a cardiac vein is a rare complication of CABG. We present a case involving grafting of the left internal mammary artery (LIMA) to a left coronary vein and a review of the literature.

2. Patient Presentation

The patient is a 69-year-old male with hypertension, hyperlipidemia, and type 2 diabetes mellitus who presented with exertional chest pain, dyspnea, decreased functional capacity and occasional palpitations. A myocardial perfusion study one month earlier had demonstrated inferolateral ischemia and preserved left ventricular systolic function (EF 69%).

Subsequent left heart catheterization (LHC) showed 70% ostial left main stenosis (Figure 1), 60% left anterior descending artery (LAD) stenosis, and complete occlusion of the mid circumflex artery with filling via right to left collaterals. The right coronary artery (RCA) had 70% stenosis in its midportion and left ventricular systolic function was normal. He underwent CABG with the following grafts: LIMA to the LAD, SVG to OM, and SVG to the PDA. Postoperative course was uncomplicated.

Three months later, the patient presented with exertional chest pain similar to his pain prior to surgery. Repeated LHC showed no change in the native coronary arteries and patent SVG to OM and SVG to PDA with good flow. Angiography of the LIMA demonstrated that it was anastomosed to a cardiac vein with resultant flow into the coronary sinus (Figure 2).

Percutaneous coronary intervention (PCI) was performed with placement of three drug eluting stents in the LM and ostial/proximal LAD. There was no residual stenosis (Figure 3). Subsequently, eight 3 mm stainless steel coils were deployed in the distal portion of the LIMA just proximal to...
Iatrogenic ACAVF resulting from inadvertent grafting to a coronary vein is a rare complication of CABG. Only 36 cases have been reported (Table 1). Deligonul et al. [24] reported two cases of ACAVF, which closed spontaneously, suggesting that this complication may be more frequent than previously thought. Symptomatic patients experiencing spontaneous closure of the ACAVF would be found to have an occluded graft and an unby-passed artery with coronary angiography. It may be unrecognized in other patients with this complication since they may remain asymptomatic or significantly less symptomatic following bypass surgery and would have no indication for coronary angiography.

This complication can result in significant morbidity by several mechanisms. Postoperative angina can occur either as a result of either residual ischemia due to an unby-passed artery or a coronary steal phenomenon. A state of high output failure can result if there is a significant degree of left-to-right shunting over an extended period of time. If left untreated, shunting can cause other complications, such as bacterial endocarditis or fistula rupture [15, 17, 19, 28, 29]. Although significant morbidity may arise, some patients remain asymptomatic and spontaneous closure of the fistula can occur [24].

As this is a rare complication, predisposing factors are difficult to identify. It is reasonable to assume that anatomical distortion of the myocardium may increase the risk of iatrogenic anastomosis of a graft to a cardiac vein. The presence of scarring and fibrosis following pericardial disease,
| Author               | Patient | Symptoms/onset after CABG | Murmur     | Graft/Intended Artery/Actual Anastomosis | Shunt                  | Hemodynamics                                      | CABG | Previous MI | Treatment                                                                 |
|---------------------|---------|---------------------------|------------|------------------------------------------|------------------------|---------------------------------------------------|------|-------------|---------------------------------------------------------------------------|
| Vieweg [1]          | 53 M    | CHF/6 weeks               | Continuous 2nd LICS | SVG/LAD/anterior cardiac vein           | Shunt by hydrogen inhalation; normal pulse ox | Mild elevation of right heart pressures | First | No          | Graft removal; regrafting of SVG to LAD                                   |
| Lawrie et al. [2]   | 44 M    | Angina pectoris; <3 months | Systolic; base to neck | SVG/LAD/LAD vein                        | Not mentioned          | Not mentioned                                     | Third | No          | Graft ligation; SVG to LAD                                               |
| Treistman et al. [3]| 55 M    | SVT, palpitations, syncope; 3.5 years | Continuous 3rd LICS | SVG/LAD/anterior interventricular vein   | Normal oximetry        | Mild elevation of right heart pressures             | First | No          | None                                                                      |
| Klinke et al. [4]   | 40 M    | Angina pectoris; 5 months | Not mentioned | SVG/LAD/anterior interventricular vein   | Coronary sinus 02 saturation 90% | Normal                                            | First | No          | CABG                                                                      |
| Starling et al. [5] | 47 M    | None reported, Anterior ischemia; 3 weeks | Continuous 2nd LICS to apex | SVG/LAD/anterior cardiac vein           | None                   | Normal                                            | First | No          | Fistula ligation; SVG to diagonal                                       |
| Starling et al. [5] | 66 M    | Asymptomatic              | Continuous 2nd and 3rd LICS to the apex | SVG/proximal LAD to distal LAD/anterior cardiac vein distal LAD | None                   | Normal                                            | First | No          | None                                                                      |
| Grollman Jr. et al. [6] | 52 M | Fatigue, dyspnea; 1 year | None      | SVG/anterolateral branch of Cx/anterior interventricular vein | 1.1 : 1                | RVEDP 8 mmHg LVEDP 25 mmHg                       | First | No          | Anteroapical MI                                                          |
| Hubert et al. [7]   | 55 M    | CHF, VT; 1 month          | Continuous ULSB | SVG/LV branch of RCA PL of Cx/LV branch posterior interventricular vein | Normal oximetry        | RA 20 mmHg                                        | First | Inferior MI | Ligation of fistula                                                      |
| Przybojewski [8]    | 43 M    | Angina pectoris; 10 days  | Continuous 2nd and 3rd LICS | SVG/LAD/LAD vein                        | Not mentioned          | Not mentioned                                     | First | No          | Ligation; repeat CABG                                                     |
| Goldbaum et al. [9] | 53 M    | Angina pectoris, exertional dyspnea; 4 years | None      | SVG/LAD/anterior interventricular vein   | Small; not quantified  | PA 42/19 LVEDP 19                                 | First | Anterior MI | PTCA of LAD; percutaneous occlusion of SVG with coils                    |
| Ross and Jang [10]  | 44 M    | Anginal pectoris; onset not mentioned | Systolic; ULSB | SVG/intermediate or Cx/Left marginal vein | 1.4 : 1                | Normal                                            | Second | Inferior MI | None reported                                                             |
| Jost et al. [11]    | 57 M    | Angina pectoris; 2 years  | Not mentioned | SVG/LAD/anterior cardiac vein            | 18% of pulmonary flow  | Not mentioned                                     | First | No          | Embolization with silicone balloon                                        |
| Author                  | Patient Gender | Symptoms/onset after CABG | Murmur          | Graft/Intended Artery/Actual Anastomosis | Shunt                  | Hemodynamics  | CABG     | Previous MI | Treatment                                                                 |
|------------------------|----------------|---------------------------|-----------------|------------------------------------------|------------------------|---------------|----------|-------------|-----------------------------------------------------------------------------|
| Graeb et al. [12]      | 56 F           | Angina pectoris; 1 year   | Not mentioned   | SVG/PDA/PDV                              | Small                  | Normal        | First    | No          | Balloon embolization of PDA (unsuccessful)                                 |
| Marin-Neto et al. [13] | 57 M           | Dyspnea, chest pain; 1 month (no ischemia detected) | Systolic; pulmonic area | SVG/first diagonal/anterior cardiac vein | 23% of pulmonary flow | Normal        | First    | Inferior MI | None                                                                         |
| Marin-Neto et al. [13] | 84 M           | Angina pectoris; 14 months | Not mentioned   | SVG/first diagonal/antrolateral coronary vein | 12% of pulmonary flow | Not mentioned | First    | No          | PTCA of new RCA lesion, no treatment of fistula                              |
| Scholz et al. [14]     | 49 M           | Angina pectoris 15 months | Systolic ULSB   | SVG/OM1, OM2/OM1, coronary vein          | Small                  | Normal        | First    | No          | Observation                                                                  |
| Calkins Jr. et al. [15]| 51 F           | Angina pectoris; 2-3 months | None            | SVG/OM1, OM2/OM1 coronary vein          | None                   | RV 55/15 PA 55/17 | Second   | No          | Coil embolization                                                            |
| De Marchena et al. [16]| 73 M           | Diminished exercise capacity, dyspnea; 2 months | None            | LIMA/LAD/great cardiac vein              | Small                  | RV 68/12 RA 12 mmHg | First    | No          | Observation                                                                  |
| Khunnawat et al. [17]  | 75 F           | Dyspnea; 10 years         | S3, no murmur   | SVG/RCA/cardiac vein                     | Not mentioned          | Not mentioned | First    | Not mentioned | Not mentioned                                                              |
| Khunnawat et al. [17]  | 57 M           | Dyspnea; 6 years          | None            | LIMA/LAD/LAD cardiac vein                | Not mentioned          | Not mentioned | First    | Not mentioned | Not mentioned                                                              |
| Maier et al. [18]      | 50 M           | Dyspnea and Angina pectoris; 2 years | Systolic murmur at ULSB | SVG/D1/coronary vein                     | Large left to right    | Pulmonary C.O. 6.6 L/mm, systemic CO 4.8 L/mm, normal pulmonary pressures | First    | Not mentioned | PCI to revascularize Cx; then coil embolization of RIMA                      |
| Patterson et al. [19]  | 67 M           | angina Pectoris; 7 months | Not mentioned   | LIMA-RIMA/PL/PL vein                     | Present                | Not mentioned | First    | Not mentioned | Not mentioned                                                              |
| Author          | Patient | Symptoms/onset after CABG | Murmur       | Graft/Intended Artery/Actual Anastamosis | Shunt                  | Hemodynamics                          | CABG | Previous MI | Treatment                                                                 |
|-----------------|---------|---------------------------|--------------|------------------------------------------|------------------------|----------------------------------------|------|--------------|---------------------------------------------------------------------------|
| Sheiban et al. [20] | 73 M    | Positive stress test and angina with exertion; 2 months | Not mentioned | LIMA/LAD/GCV                             | Present “arteriovenous steal” Moderate L-R Shunt | Not mentioned | First | No           | PCI with DES of LAD and PCI with covered stent of GCV through coronary sinus |
| Hmem et al. [21]   | 76 M    | Dyspnea, LE edema, CHF/RHF; 2 months | None         | LIMA/LAD/LIMA/cardiac vein               | Not mentioned          | Not mentioned                         | First | AS Q waves  | Coil embolization to proximal LIMA                                        |
| Lopez et al. [22]   | 74 M    | Rest angina; 3 months     | Not mentioned | SVG-OM2-OM3/SVG-L marginal vein of OM3   | No significant left to right shunt | Not mentioned                         | Second | Not mentioned | PCI, embolization of marginal vein                                        |
| Braun et al. [23]   | 58 M    | Angina; 6 months          | Not mentioned | LIMA/LAD/LIMA/cardiac vein               | Not mentioned          | Not mentioned                         | Second | Not mentioned | RCA-PTCA; coil embolization                                               |
| Deligonul et al. [24] | 66 M    | Asymptomatic              | None         | LIMA/LAD/anterior interventricular vein  | Small                  | None                                  | First | No           | Spontaneous closure                                                       |
| Deligonul et al. [24] | 57 M    | Asymptomatic              | None         | LIMA/LAD/anterior interventricular vein  | Small                  | None                                  | First | No           | Spontaneous closure                                                       |
| Miranda et al. [25] | 66 M    | Angina; 2 weeks           | Not mentioned | LIMA/LAD/anterior interventricular vein  | Small                  | Pulmonary artery pulse ox 66%        | Second | No           | PTCA to diagonal branch graft followed by balloon occlusion of fistula    |
| Author                  | Patient | Symptoms/onset after CABG | Murmur                        | Graft/Intended Artery/Actual Anastamosis | Shunt | Hemodynamics                                      | CABG | Previous MI | Treatment                                                      |
|-------------------------|---------|----------------------------|-------------------------------|------------------------------------------|-------|--------------------------------------------------|------|-------------|---------------------------------------------------------------|
| Peregrin et al. [26]    | 54 M    | Unstable angina; 1 year    | Systolic/diastolic left parasternal | Graft/diagonal branch/graf vena cordis magna | Not mentioned | Not mentioned                                     | First | Inferior MI | PTCA of RCA and balloon occlusion of AV fistula               |
| Cardoso [27]            | 55 F    | Angina                     | Continuous second left intercostals space | SVG/LAD/LAD vein                          | LV 171/19, RV 43/12, mean PCWP 21        | First | No                  | Not mentioned                                                  |
| White et al. [28]       | 56 M    | Angina and troponin elevation; 5 years | Not mentioned | LCX-vein graft-marginal/LCX-coronary sinus | None | None                                           | First | No          | MRI; coil embolization                                        |
| Thomas et al. [29]      | 76 M    | Angina with exertion; 3 months | Not mentioned | LIMA/LAD/AIV                             | Not mentioned | Not mentioned                                     | First | Not mentioned | PCI with stenting and PCI with embolization                    |
| Mukhopadhyay et al. [30]| 60 M    | Exertional angina          | Not mentioned | LIMA/LAD/cardiac vein                    | Left to right shunt                     | First | Not mentioned | PCI with failed coil embolization, deferred to surgical correction |
| Jung et al. [31]        | 50 M    | Asymptomatic               | Not mentioned | LIMA/LAD/GCV                             | Not mentioned | ECHO showed LV hypokinesis and LV systolic dysfunction. | First | Not mentioned | CT angiogram; PCI/DES and Coil embolization                    |
| Current Case            | 69 M    | Angina with exertion left arm radiation; 3 months | None | LIMA/LAD/LIMA/cardiac vein               | None | Aorta 119/54, mean 77, LV systolic: 130, LVEDP: 14, LV-angiography EF = 55% | First | No          | PCI/DES and coil embolization to LIMA                          |
myocardial infarction (MI), or previous CABG as well as the presence of epicardial fat can make identification of the artery more difficult [15, 19, 20, 29]. Thirty-five percent of patients had a previous MI and 18% had undergone CABG. The majority of cases involved the LAD (22 patients, 61%) and its diagonal branch (4 patients, 11%), which can be deeply embedded in epicardial fat or myocardium.

The majority of patients presented with angina (23 patients, 63.9%) or dyspnea (8 patients, 22.2%) (Table 1). Three presented with heart failure symptoms, two with arrhythmias (VT and SVT), one with syncope, and one with diminished exercise capacity. Four were asymptomatic. No symptoms were reported for another patient who was found to have anterior ischemia on an ECG. The time of onset of symptoms following CABG was variable, ranging from 10 days [8] to 10 years [17]. No obvious trend was present concerning the onset of symptoms following CABG. Symptoms occurred in 14 patients within the first three months postoperatively and between one and 10 years postoperatively in 16 patients.

The most common physical finding was a continuous or systolic murmur, followed by signs of heart failure (Table 1). However, the majority of reports did not mention whether or not a murmur was present.

In all of the reported cases, the standard diagnostic tool was LHC since it allows direct visualization of the ACAVF and guides percutaneous therapy. Right heart catheterization (RHC) was performed in 19 cases and demonstrated elevated filling pressures in nine patients and normal pressures in 10 (Table 1).

Coronary angiography can identify the origin of a coronary fistula and assess hemodynamics, but may fail to demonstrate the relation to other structures and the drainage site [32]. Cardiac MRI and CT angiography have emerged as valuable modalities to demonstrate the size, course, anatomic connection, and other anatomic features of larger and more complex congenital and acquired coronary fistulas [32, 33] and provide valuable information necessary for surgical treatment [34–38]. None of the more recently reported ACAVFs due to inadvertent grafting of a coronary vein were evaluated by MRI or CT, most likely because these fistulas are smaller and better defined and because surgical closure has been replaced by percutaneous treatments.

Medical management and observation remain the treatment of choice for asymptomatic patients. Deligonul et al. [24] presented 2 cases of asymptomatic iatrogenic ACAVF, which closed spontaneously while the patients received medical management, supporting a more conservative approach to these patients. For symptomatic patients and those who are refractory to medical therapy, surgical closure of the ACAVF and grafting of the native artery have historically been preferred. With improvements in percutaneous methods, coil or balloon embolization, sometimes combined with stenting of the ungrafted artery, have become the new standard [18, 29]. In nearly half of the reported patients who were treated percutaneously (7 out of 15), the un bypassed vessel was not treated and the patient was treated with optimal medical therapy for coronary artery disease. These patients remained asymptomatic, suggesting that the shunt, rather than the un bypassed artery, might have been the underlying cause of the patients’ symptoms.

Another advance in the treatment of this complication is the percutaneous approach to the ACAVF via the coronary sinus. Sheiban et al. [20] described a case in which a covered stent was deployed in the cardiac vein using this approach for the closure of an end-to-side anastomosis of the graft to the vein. Additionally, Lopez et al. [22] also used a coronary sinus approach to treat a side-to-side anastomosis of the proximal segment of a sequential graft that was Anastomosed to a cardiac vein, with preservation of the distal end-to-side anastomosis to the coronary artery.

4. Conclusion

Iatrogenic aorto-coronary arteriovenous fistula due to inadvertent anastomosis of a bypass graft to a cardiac vein is a rare complication that is probably more common than previously believed and may be a more frequent cause of graft failure and recurrent angina following CABG. Anatomical distortion of the surface of the myocardium, the presence of epicardial fat, and an intramyocardial course of the intended artery for grafting are predisposing factors.

Left heart catheterization is the diagnostic test of choice for this complication. Cardiac MRI and CTA have a more limited diagnostic role due to the smaller size of the fistula and its more easily defined course when compared to congenital and other types of acquired coronary artery fistulas. Asymptomatic patients should be observed and managed medically as they may have spontaneous closure of their fistulas. Percutaneous embolization with either detachable balloons or coils combined with stenting of the ungrafted artery is an effective and safe method of treatment for symptomatic patients.

Conflict of Interests

There is no conflict of interests among any of the authors of this paper.

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