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Prevalence of coronary artery fistulae after cardiac surgery: Comparison between coronary artery bypass grafting, valve surgery, and orthotopic heart transplantation

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Abstract

Introduction—Coronary artery fistulae (CAF) are anomalous connections from a coronary artery to a recipient pulmonary vessel or cardiac chamber, and are reported in 0.2% of the general population. The prevalence of CAF in the modern orthotopic heart transplant (OHT) population has been demonstrated to be significantly higher. The mechanism is unknown but one proposal is endothelial and vascular growth factor activation from injury. We hypothesize an incremental increase in CAF prevalence with the complexity of surgery, such that patients who have undergone OHT surgery would have an increased prevalence of CAF, as compared with patients who have undergone coronary artery bypass (CABG) surgery with valve surgery and as compared with patients who have undergone CABG surgery only.

Patients and methods—Consecutive angiograms of 481 patients after CABG surgery and 432 patients after OHT were reviewed. Patients who had previous valve surgery in addition to CABG were identified. Presence of CAF was determined. The chi-squared test was used for statistical analysis.

Results—In all, 436 patients had CABG only (group A), 45 patients had CABG with valve surgery (group B), and 432 patients had OHT (group C). The mean age of patients at the time of surgery for group A, B, and C was 59.0, 66.1, and 55.3 years, respectively. The percentage of male patients was 78.4, 77.8, and 77.1%, respectively. We found 10 patients (2.3%) with CAF in group A compared with 4 patients (8.9%) in group B, and 88 patients (20.4%) in group C, which was statistically significant ($p < 0.001$). All CAF were small, were not associated with hemodynamic compromise or significant adverse events, and were managed conservatively.

Conclusion—There is an increased prevalence of CAF formation both after CABG and OHT compared with the general population. The higher prevalence of CAF in patients who additionally underwent valve surgery or who underwent OHT may be attributed to differences in surgical

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complexity. The increased prevalence of CAF formation after OHT compared with CABG should be further investigated.

Abstract

Koronarfisteln ("coronary artery fistulae", CAF) sind anomale Verbindungen von Koronararterien mit einem Lungengefäß oder einer Herzkammer als Empfänger und werden bei 0,2% der Allgemeinbevölkerung beschrieben. Die Prävalenz der CAF in der Bevölkerung mit moderner orthotoper Herztransplantation (OHT) ist nach-gewiesenermaßen signifikant höher. Der Mechanismus dafür ist nicht bekannt, eine Möglichkeit könnte jedoch die läsionsbedingte endotheliale und vaskuläre Wachstumsfaktoraktivierung sein. Die Hypothese der Autoren ist, dass es mit der Komplexität des Eingriffs stufenweise zu einem Anstieg der CAF-Prävalenz komme, sodass bei Patienten nach erfolgter OHT-Operation gegenüber Patienten nach durchgeführter Koronarbypassoperation ("coronary artery bypass grafting", CABG) plus Klappenoperation sowie gegenüber Patienten mit alleiniger CABG eine erhöhte Prävalenz der CAF bestehe.

Ausgewertet wurden die konsekutiv erstellten Angiographien von 481 Patienten nach CABG und 432 Patienten nach OHT. Es wurden die Patienten ermittelt, bei denen zuvor zusätzlich zur CABG eine Klappenoperation erfolgt war. Darüber hinaus wurde untersucht, ob eine CAF vorlag. Zur statistischen Analyse wurde der Chi-Quadrat-Test verwendet.

Bei 436 Patienten war nur eine CABG erfolgt (Gruppe A), bei 45 Patienten eine CABG mit Klappenoperation (Gruppe B) und bei 432 eine OHT (Gruppe C). Das Durchschnittsalter zum Operationszeitpunkt betrug in Gruppe A 59,0 Jahre, in Gruppe B 66,1 Jahre und in Gruppe C 55,3 Jahre. Der Anteil von Männern lag bei 78,4% in Gruppe A, bei 77,8% in Gruppe B und bei 77,1%, in Gruppe C. Bei 10 Patienten (2,3%) in Gruppe A wurde eine CAF festgestellt, bei 4 Patienten (8,9%) in Gruppe B und bei 88 Patienten (20,4%) in Gruppe C, was statistisch signifikant war ($p < 0,001$). Alle CAF waren klein, gingen nicht mit Beeinträchtigung der Hämodynamik oder wesentlichen unerwünschten Ereignissen einher und wurden konservativ behandelt.

Es besteht eine erhöhte CAF-Prävalenz sowohl nach CABG als auch nach OHT im Vergleich zur Allgemeinbevölkerung. Die höhere Prävalenz der CAF bei Patienten, bei denen zusätzlich eine Klappenoperation erfolgte oder eine OHT durchgeführt wurde, ist möglicherweise auf Unterschiede in der Komplexität des Eingriffs zurückzuführen. Die erhöhte Prävalenz der CAF-Bildung nach OHT im Vergleich zur CABG sollte näher untersucht werden.

Keywords

Coronary artery fistulae; Orthotopic heart transplant; Coronary artery bypass; Valve surgery; Surgical complexity

Coronary artery fistulae (CAF) are abnormal communications between a coronary artery and a vessel adjacent to the heart or a cardiac chamber. They are rare coronary anomalies with a reported incidence of 0.2% in the general population [1, 2]. Historically, CAF were believed to be congenital, but with the advent of invasive cardiac procedures, CAF have been reported with increasing frequency [3]. CAF have been described as a known, rare complication of cardiac surgery [4, 5]. Although CAF are reported to occur more frequently in patients who have undergone cardiac surgery [3], their exact prevalence in this group of patients has not

been defined, and there has not been a systematic review of the prevalence of CAF in patients after cardiac surgery. Moreover, CAF have been reported to be increased in the modern orthotopic heart transplant (OHT) population [6, 7], which has been theorized to be in part due to inflammation from cardiac surgery. The purpose of this study is to determine the prevalence of coronary artery fistulae after cardiac surgery, specifically after coronary artery bypass (CABG) surgery, CABG with valve surgery, and OHT. We hypothesize an incremental increase in CAF prevalence with the complexity of surgery, such that patients who have undergone OHT surgery would have an increased prevalence of CAF, as compared with patients who have undergone coronary artery bypass (CABG) surgery with valve surgery and as compared with patients who have undergone CABG surgery only.

Patients and methods

Consecutive angiograms of 481 patients after CABG surgery and 432 patients after OHT were reviewed. Patients who had previous valve surgery in addition to CABG were identified. The presence of CAF was determined. The chi-squared test was used for statistical analysis.

A coronary artery fistula (or coronary arteriovenous malformation) was defined as an abnormal communication between one or more of the coronary arteries, bypassing the myocardial capillary bed and entering either a chamber of the heart (coronary–cameral connection) [8] or any segment of the systemic or pulmonary circulation (coronary–vascular connection) [9].

Results

In all, 436 patients had CABG only (group A), 45 patients had CABG with valve surgery (group B), and 432 patients had OHT (group C). The mean age of patients at the time of surgery for group A, B, and C was 59.0 ± 11.6 , 66.1 ± 12.5 , and 55.3 ± 13 years, respectively. The percentage of male patients was 78.4, 77.8, and 77.1%, respectively. The prevalence of coronary risk factors for the CABG cohorts (group A and group B) was as follows: diabetes (45%), hypertension (80%), hyperlipidemia (80%), peripheral vascular disease (23.8%), and history of smoking (47.4%). The mean time of angiography after cardiac transplantation was 5.2 years with a standard deviation of 4.3 years. The mean time of angiography after CABG and/or valve surgery was 13.8 years with a standard deviation of 8.7 years. Ischemic time during cardiac transplantation surgery was 186.7 min with a standard deviation of 70.0 min. The cross-clamping time in CABG was not routinely reported.

CAF were identified in 10 patients (2.3%) in group A compared with 4 patients (8.9%) in group B and 88 patients (20.4%) in group C, which was statistically significant ($p < 0.001$) and summarized in Tab. 1. A total of 11 CAF were found in group A, compared with 5 CAF in group B, and 112 CAF in group C, as summarized in Tab. 2. All CAF were small, were not associated with hemodynamic compromise or significant adverse events, and were managed conservatively.

In CABG patients (groups A and B), approximately 25% (4 of 16) of CAF were coronary–cameral, whereas 75% (12 of 16) were coronary–vascular-type fistulae. CAF originated

from the left main trunk in one case, the left anterior descending (LAD) or diagonal artery on five occasions (31.3%), the left circumflex (LCX) or an obtuse marginal artery on one occasion (6.3%, Fig. 1), and the right coronary artery (RCA) on seven occasions (44.8%, Fig. 2). On one occasion a CAF originated from a left internal mammary artery (LIMA) graft (6.3%). There were no CAF observed arising from saphenous vein grafts, radial artery grafts, or right internal mammary grafts. Drainage of the CAF involved thoracic vessels on eight occasions (50%), the pulmonary artery on four occasions (25%), the right atrium on two occasions (12.5%), the left ventricle on one occasion (6.3%), and the right ventricle (6.3%) on one occasion.

In OHT patients (group C), approximately 48% (54 of 112) of CAF were coronary–cameral. CAF originated from the LAD or diagonal artery on 44 occasions (39.3%, Fig. 3), the LCX or an obtuse marginal artery on seven occasions (6.3%), and the RCA on 44 occasions (39.3%, Fig. 4, 5). Drainage of the CAF involved the thoracic vessels on 16 occasions (14.3%), the pulmonary artery on 39 occasions (34.8%), right atrium on 34 occasions (30.3%), the right ventricle on 11 occasions (9.8%), the left atrium on four occasions (3.6%), and the left ventricle on five occasions (4.5%). CAF were additionally found to drain to the aorta in two cases (1.8%) and the superior vena cava in one case (0.9%). These results are summarized in Tab. 2.

Discussion

Our study demonstrates an overall 2.9% prevalence of CAF in patients who have undergone CABG and/or CABG with valve surgery, which represents a tenfold increase as compared with the general population. Moreover, the prevalence of CAF in patients who have undergone OHT surgery is approximately tenfold higher than that in patients having undergone CABG and/or CABG with valve surgery. We believe that this is the first systematic study to examine the frequency and types of CAF in patients after cardiac surgery and cardiac transplant.

CAF have been described as a known, rare complication of cardiac surgery [8, 9, 10, 11], and may occur as a result of direct injury during surgical procedures [4, 5, 12, 13]. Our study demonstrated a significant difference in the presence of fistulae between the CABG, CABG with valve surgery, and OHT cohorts, with their prevalence rising incrementally with increasing surgical complexity and technique. In review of the literature between 1985 and 1995, of 76 subjects and 96 congenital and acquired CAF cases, Said et al. [3] reported that 64% of the fistulae were congenital in origin, while 36% were acquired. The majority of CAF are detected incidentally during cardiac catheterization [14]. While echocardiography [12], computed tomography [13], and magnetic resonance imaging [15] have been shown to detect CAF, coronary angiography remains a critical diagnostic tool for determining the origin, destination, anatomy, size, and number of CAF [14]. Additionally, hemodynamic assessment for potential therapeutic intervention can be made by cardiac catheterization through shunt calculations.

The majority of CAF drain into venous structures, including the right atrium, right ventricle, pulmonary artery, and superior or inferior vena cava [16], which are low-pressure systems

creating a left-to-right shunt [17]. Infrequently, drainage into the left heart chambers, the left atrium and left ventricle, or the bronchial arteries may occur.

Postulations of septal artery-to-left ventricular (LV) cavity fistula after routine bypass surgery were previously attributed to the Guilmet LV venting technique in which a multiperforated needle is inserted from the right ventricle through the septum to the left ventricle to vent the myocardium during cardiac surgery [12]. Coronary–cameral fistula has been reported to develop as a consequence of atrial artery injury during cannulation of the right atrium for cardiopulmonary bypass [4]. Other postulated surgical mechanisms include direct trauma of the right ventricular free wall, injury related to epicardial pacing wire placement, occlusion of the great cardiac vein during anastomosis of the LAD leading to higher thebesian venous pressures, and direct drainage into the cardiac chambers [18]. Similarly, CAF formation between the LCX draining into the left atrium has also been described as a complication of resection of the left atrial appendage [5]. In a small series of patients with hypertrophic cardiomyopathy who underwent septal myectomy, a 19% incidence of CAF from the septal perforators to the left ventricle was reported. The mechanism was believed to be due to incision of the myocardial septum with severing of one or more septal branches, thereby resulting in direct communication of the transected artery and left ventricle [12].

LIMA grafts have become popular because of the greater likelihood of long-term patency, but they are not immune to such fistula formation. In a review of the literature of 15 published cases of LIMA-to-pulmonary artery fistulae between 1996 and 2004, a mean time of diagnosis from CABG to fistula detection was 4 years [19]. Surgical trauma and disrupted visceral pleura may result in direct contact between the dissected mammary artery pedicle and the pulmonary vasculature [20].

The prevalence of CAF is known to be increased in heart transplant recipients. One mechanism of CAF formation in heart transplant recipients is the performance of endomyocardial biopsies and “unroofing” of septal branches into the right ventricle [21]. However, only 8% of fistulae in heart transplant recipients drained into the right ventricle, suggesting that the predominant mechanism of CAF formation is unrelated to endomyocardial biopsies [7]. Although the surgical complexity of performing OHT is higher than that of standard bypass surgery, the near tenfold increase in the risk of CAF formation in OHT recipients compared with CABG patients raises the possibility that biological factors other than direct tissue injury are contributing to CAF formation in OHT patients. These include interactions between the host and donor heart, immunosuppression, and immune modulation. Further investigation is required to ascertain the highly increased rate of angiogenesis and CAF formation observed in heart transplant recipients.

Most CAF are clinically silent with no hemodynamic significance. In the absence of symptoms, therapy is usually not recommended. However, percutaneous (coil embolization) or surgical treatment may be offered if symptoms or significant hemodynamic effects develop [22]. Major complications of fistulae include aneurysm formation, infective endocarditis, myocardial infarction, rupture of the fistula, and pericardial effusion [9].

Study limitations

Our study was retrospective involving patients who underwent repeat cardiac catheterization after cardiac surgery and may not be representative of all cardiac surgery patients. Cross-clamping time was not available in all patients; thus, the relationship between cross-clamping time and fistulae formation could not be examined. Additionally, presurgical coronary angiograms or cardiac catheterizations were not available for all patients with fistulae; therefore, a preexisting fistula in these patients cannot be excluded. While all fistulae identified were small visually and not felt to be associated with any hemodynamic perturbation based on retrospective chart review, shunt calculations were not performed.

Conclusion

There is an increased prevalence of CAF formation both after CABG and OHT compared with the general population. The higher prevalence of CAF in patients who additionally underwent valve surgery or who underwent OHT may be attributed to differences in surgical complexity. The increased prevalence of CAF formation after OHT compared with CABG should be further investigated.

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References

1. Baltaxe HA, Wixson D. The incidence of congenital anomalies of the coronary arteries in the adult population. *Radiology*. 1977; 122(1):47–52. [PubMed: 830353]
2. Yamanaka O, Hobbs RE. Coronary artery anomalies in 126,595 patients undergoing coronary arteriography. *Cathet Cardiovasc Diagn*. 1990; 21(1):28–40. [PubMed: 2208265]
3. Said SA, Gamal MI el, Werf T van der. Coronary arteriovenous fistulas: collective review and management of six new cases—changing etiology, presentation, and treatment strategy. *Clin Cardiol*. 1997; 20(9):748–752. [PubMed: 9294664]
4. Lee RT, Mudge GH, Colucci WS. Coronary artery fistula after mitral valve surgery. *Am Heart J*. 1988; 115(5):1128–1130. [PubMed: 3364344]
5. Nguyen-Do P, Bannon P, Leung DY. Coronary artery to the left atrial fistula after resection of atrial appendages. *Ann Thorac Surg*. 2004; 78(2):e26–e27. [PubMed: 15276584]
6. Allen KY, Goldstein BH, Pahl E, et al. Non-cameral coronary artery fistulae after pediatric cardiac transplantation: a multicenter study. *J Heart Lung Transplant*. 2012; 31(7):744–749. [PubMed: 22445194]
7. Wei J, Azarbal B, Singh S, et al. Frequency of coronary artery fistulae is increased after orthotopic heart transplantation. *J Heart Lung Transplant*. 2013; 32(7):744–746. [PubMed: 23664527]
8. Padfield GJ. A case of coronary cameral fistula. *Eur J Echocardiogr*. 2009; 10(5):718–720. [PubMed: 19414488]
9. Said SA. Current characteristics of congenital coronary artery fistulas in adults: a decade of global experience. *World J Cardiol*. 2011; 3(8):267–277. [PubMed: 21876777]
10. Gildein HP, Kleinert S, Layangool T, Wilkinson JL. Acquired coronary artery fistula in children after ventricular septal myectomy of the right or left ventricular outflow tract. *Am Heart J*. 1995; 130(5):1124–1126. [PubMed: 7484747]

11. Kobashigawa JA, Patel J, Furukawa H, et al. Five-year results of a randomized, single-center study of tacrolimus vs microemulsion cyclosporine in heart transplant patients. *J Heart Lung Transplant*. 2006; 25(4):434–439. [PubMed: 16563974]
12. Jebara VA, Sarkis A, Acar C, et al. Coronary artery-left ventricle fistulas after cardiac surgery. *Am Heart J*. 1991; 122(6):1759–1762. [PubMed: 1957770]
13. Wright DH, Nipper M, Baisden CE. Left ventricular-coronary sinus fistula after mitral valve replacement: case report and ultrafast CT findings. *J Thorac Imaging*. 1994; 9(2):85–87. [PubMed: 8207785]
14. Lin C, Lin T. The current status of coronary artery fistula. *J Intern Med Taiwan*. 2009; 20(6):484–489.
15. Gruberg L, Satler LF, Pfister AJ, et al. A large coronary artery saphenous vein bypass graft aneurysm with a fistula: case report and review of the literature. *Catheter Cardiovasc Interv*. 1999; 48(2):214–216. [PubMed: 10506784]
16. Ata Y, Turk T, Bicer M, et al. Coronary arteriovenous fistulas in the adults: natural history and management strategies. *J Cardiothorac Surg*. 2009; 4:62. [PubMed: 19891792]
17. Said S, Thiadens A, Fieren M, et al. Coronary artery fistulas. *Neth Heart J*. 2002; 10:65–78. [PubMed: 25696067]
18. Tami LF. Coronary artery-right ventricular fistula after coronary artery bypass grafting. *Clin Cardiol*. 1993; 16(2):155–157. [PubMed: 8435931]
19. Garrean S, Tshibaka C, Hanhan Z, et al. Coronary-pulmonary steal caused by internal thoracic artery-pulmonary artery fistula after coronary artery bypass operations. *J Thorac Cardiovasc Surg*. 2005; 130(2):569–571. [PubMed: 16077433]
20. Blanche C, Eigler N, Bairey CN. Internal mammary artery to lung parenchyma fistula after aortocoronary bypass grafting. *Ann Thorac Surg*. 1991; 52(1):141–142. [PubMed: 2069446]
21. Sandhu JS, Uretsky BF, Zerbe TR, et al. Coronary artery fistula in the heart transplant patient. A potential complication of endomyocardial biopsy. *Circulation*. 1989; 79(2):350–356. [PubMed: 2644055]
22. Hajj-Chahine J, Haddad F, El-Rassi I, Jebara V. Surgical management of a circumflex aneurysm with fistula to the coronary sinus. *Eur J Cardiothorac Surg*. 2009; 35(6):1086–1088. [PubMed: 19356944]

Fig. 1.
Coronary artery fistula from the obtuse marginal to the left ventricle; right anterior oblique projection

Fig. 2.
Right coronary artery to thoracic artery; left anterior oblique projection (**a**), right anterior oblique projection (**b**)

Fig. 3.
Left anterior descending artery to pulmonary artery; left anterior oblique caudal projection

Fig. 4.
Right coronary artery to thoracic vessels; left anterior oblique projection

Fig. 5.
Right coronary artery to right atrium; posterior–anterior cranial projection

Tab. 1

Prevalence of coronary artery fistulae after CABG, CABG with valve surgery, and OHT*

	CABG only (n=436)	CABG + valve (n=45)	OHT (n=432)
Number of patients with fistulae	10 (2.3%)	4 (8.9%)	88 (20.4%)

CABG coronary artery bypass graft, *OHT* orthotopic heart transplant.*
p<0.001 (chi-squared test)

Tab. 2

Coronary artery fistulae characteristics

	CABG only CAF (n=11)	CABG + valve CAF (n=5)	OHT CAF (n=112)
RCA to RA	2 (18.2%)	None	33 (29.5%)
RCA to RV	1 (9.1%)	None	6 (5.4%)
RCA to LV	None	None	2 (1.8%)
RCA to PA	None	None	6 (5.4%)
RCA to SVC	None	None	1 (0.9%)
RCA to aorta	None	None	1 (0.9%)
RCA to thoracic vessels	3 (27.3%)	2 (40.0%)	12 (10.7%)
LMT to PA	None	1 (20.0%)	None
LAD to RV	None	None	5 (4.5%)
LAD to LV	None	None	3 (2.7%)
LAD to PA	1 (9.1%)	2 (40.0%)	32 (28.6%)
LAD to aorta	None	None	1 (0.9%)
LAD to thoracic vessels	2 (18.2%)	None	3 (2.7%)
LCX to RA	None	None	1 (0.9%)
LCX to LA	None	None	4 (3.2%)
LCX to LV	1 (9.1%)	None	None
LCX to PA	None	None	1 (0.9%)
LCX to thoracic vessels	None	None	1 (0.9%)
LIMA to thoracic vessels	1 (9.1%)	None	None

CABG coronary artery bypass graft, **LA** left atrium, **LAD** left anterior descending artery, **LCX** left circumflex artery, **LIMA** left internal mammary artery, **LMT** left main trunk, **LV** left ventricle, **OHT** orthotopic heart transplant **PA** pulmonary artery, **RA** right atrium, **RCA** right coronary artery, **RV** right ventricle, **SVC** superior vena cava