Research Article

Coronary Angiography Characteristics of Symptomatic Patients with Prior Coronary Artery Bypass Graft: A Descriptive Study

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Objectives. The target of this study was to explore the coronary angiography characteristics for symptomatic patients with prior coronary artery bypass graft (CABG).

Methods. Between 2009 and 2017, 993 patients who had undergone CABG but subsequently suffered recurrent symptoms in Beijing Anzhen Hospital were selected for this study and divided into either medical therapy (MT) group (n = 351) or percutaneous coronary intervention (PCI) group (n = 642) based on the treatment. Clinical data were analyzed between two groups.

Results. Patients in the MT group were older and more likely to have chronic lung disease (6.6% vs 3.4%, P = 0.026) while patients in the PCI group were more likely to have prior MI (8.8% vs 17.0%, P < 0.001). In the MT group, 54.4% of patients had newly developed lesions both in the graft and native coronary artery while 58.1% in the PCI group (P = 0.003), and in the MT group, 80.6% had type C coronary artery disease while 60.1% in the PCI group (P < 0.001). Patients in the MT group presented higher proportion of diffuse lesions (49.3% vs 15.0%, P < 0.001) in native coronary arteries.

Conclusion. Patients receiving MT (35.3%) likely had occluded grafts and type C coronary artery disease featuring as diffuse lesions.

1. Introduction

For patients with prior coronary artery bypass graft (CABG), the likelihood of experiencing recurrent symptoms has increased over years due to longer life expectancy [1] and the possibility of disease progression of native coronary artery (NCA) or surgical graft failure [2].

Frequent recurrent symptoms in patients with prior CABG usually indicate the occurrence of myocardial ischemia. Treatments for symptomatic patients with prior CABG include revascularization by percutaneous coronary intervention (PCI) or redo CABG and medical therapy (MT). However, repeat revascularization procedures are markedly different from de novo interventions performed on patients without prior CABG [3]. As a consequence of the specificity of vessel lesions and clinical characteristics in patients with prior CABG [4], previous surgery may increase procedural risk, technical complexity [5], and mortality [6, 7], especially for redo CABG. MT consists of antiplatelet agent, statins agent, β-blocker, and angiotensin-converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB), considered as optimal medical therapy (OMT) [8]. In fact, clinically, these patients often receive repeat revascularization by PCI for clinical and anatomic factors [2, 9], and patients who could not undergo PCI revascularization would receive MT. However, the coronary angiography (CAG) basis of therapy selection (MT vs PCI) for these patients has been studied in limited data.

In this study, we retrospectively analyzed the clinical data and features of native coronary artery (NCA) lesions and graft lesions by CAG in symptomatic patients with prior CABG who received MT or PCI, aiming to find out CAG characteristics of these patients.
2. Methods

2.1. Study Design. This study was a retrospective observational study conducted in Beijing Anzhen Hospital, Capital Medical University, Beijing Institute of Heart Lung and Blood Vessel Diseases, Beijing, China. We consecutively included symptomatic patients with prior CABG, from 2008 to 2018 in the Department of Cardiology, Anzhen Hospital. Patients with complete data were segreagated into the MT or PCI group, depending on the treatment they received. All data were reviewed by one cardiac surgeon and one cardiologist. This study received approval from the Ethics Committee of Beijing Anzhen Hospital.

2.2. Definitions Used in This Study. A graft with the ratio of stenosis diameter to reference vessel diameter ≥70% was defined as stenosis. A graft with stenosis or occlusion was classified as a diseased graft. The classification of ischemic territory was based on CAG results after rehospitalization and also referred to the CAG results prior to CABG. The newly developed lesions were divided into isolated graft disease, NCA and graft disease, and NCA disease.

2.3. Statistical Analysis. All results were analyzed by using the statistical package SPSS 20.0. Categorical variables are presented by raw numbers (%), and numerical values are presented as means ± standard deviation. Comparison of the medication and PCI groups was achieved by using Fisher’s exact test for each variable and the Mann–Whitney–Wilcoxon nonparametric test for continuous variables. For all analyses reported, P values were 2-sided. Statistical differences were considered significant at P < 0.05.

3. Results

3.1. Patient Population. During the study period, 1456 patients with prior CABG were rehospitalized. Based on the exclusion criteria, 993 patients were included in this study (Figure 1). In each group, symptomatic patients with prior CABG were mainly distributed within 1 to 5 years (44.4% vs 46.4%) followed by 5 to 10 years (33.3% vs 31.6%) after CABG surgery (Table 1). The proportion of patients accepting MT increased as a function of time elapsed after CABG while the proportion of patients accepting PCI treatment decreased (Figure 2).

3.2. Baseline Characteristics. Baseline characteristics are shown in Table 2. Compared with patients in the PCI group, patients in the MT group were older and more likely to have chronic lung disease while patients in the PCI group were more likely to have prior MI. There were no significant differences in comorbidities like diabetes, hypertension, dyslipidemia, prior PVD, prior CVA, prior HF, or prior PCI between two groups. In each group, most patients had recurrent symptoms featuring as chest pain. In both groups, some patients failed to persist in medical therapy like aspirin, statin, or beta blockers.

3.3. CAG Characteristics of Diseased Grafts. The CAG characteristics of diseased grafts are shown in Table 3. There were 480 diseased grafts (stenosis and occlusion) in the MT group, accounting for 46.8% of 1025 grafts, which were lower than those...
3.4. CAG Characteristics of Ischemic Territory and Relevant Native Coronary Arteries. Table 4 shows CAG characteristics of the ischemic territories. Patients in the MT group (53.0%) were more likely to suffer one ischemic territory while patients in the PCI group were more likely to suffer two ischemic territories (45.2%); patients in each group were less likely to suffer three ischemic territories (8.8% vs 14.3%), with a significant difference between two groups ($P = 0.001$).

In one ischemic territory subgroup, in each group, patients were more likely to suffer RCA ischemic territory (36.5% vs 40.8%); in two ischemic territories subgroups, patients were more likely to suffer LCX ischemic territory and RCA ischemic territory (67.2% in the MT group vs 62.8% in the PCI group).

The CAG characteristics of NCA relevant to ischemic territory are also shown in Table 4. In the MT group, 80.6% of patients had type C CAD (severe lesions, based on ACC/AHA Classification of CAD) and no patient had type A CAD, which were obviously different from that in the PCI group ($P < 0.001$). Compared to the PCI group, patients in the MT group were more likely to suffer diffuse lesions (49.3% vs 15.0%, $P < 0.001$). There were no significant differences in CTO lesions, lesions involving coronary artery branches, or openings between two groups.

3.5. Supplemental Data of CAG Characteristics and Progression of NCAs. CAG characteristics and progression of native coronary arteries before CABG and at the time of rehospitalization are shown in Supplemental Table 1. Before CABG, 7.4% of patients had single vessel lesion, 34.5% had two vessel lesions, and 58.1% had three vessel lesions in the MT group; when symptoms recurred after CABG, CAG showed that 2.6% had single vessel lesion, 29.1% had two vessel lesions, and 68.4% had three vessel lesions, which
Table 4: CAG characteristics of ischemic territory and relevant native coronary arteries in symptomatic patients with prior CABG (n = 993).

| Variables                              | MT n = 351 | PCI n = 642 | P value |
|----------------------------------------|------------|-------------|---------|
| Ischemic territory                     |            |             |         |
| One territory                          | 186 (53.0%)| 260 (40.5%) | 0.658   |
| LAD                                    | 52 (28.0%) | 73 (28.1%)  |         |
| LCX                                    | 66 (35.5%) | 81 (31.2%)  |         |
| RCA                                    | 68 (36.5%) | 106 (40.8%) |         |
| Two territories                        | 134 (38.2%)| 290 (45.2%) | 0.378   |
| LAD + LCX                              | 22 (16.4%) | 64 (22.1%)  |         |
| LAD + RCA                              | 22 (16.4%) | 44 (15.2%)  |         |
| LCX + RCA                              | 90 (67.2%) | 182 (62.8%) |         |
| Three territories                      | 31 (8.8%)  | 92 (14.3%)  | NS      |
| LAD + LCX + RCA                        | 31 (100.0%)| 92 (100.0%) |         |
| Classification of CAD<sup>#</sup>      |            |             | <0.001  |
| Type A                                 | 0 (0.0%)   | 244 (38.0%) |         |
| Type B                                 | 68 (19.4%) | 9 (1.4%)    |         |
| Type C                                 | 283 (80.6%)| 389 (60.6%) |         |
| Lesion characteristics                 |            |             |         |
| CTO                                    | 192 (54.7%)| 321 (50.0%) | 0.163   |
| Diffuse lesions                        | 173 (49.3%)| 96 (15.0%)  | <0.001  |
| Branches involved                      | 97 (27.6%) | 201 (31.3%) | 0.247   |
| Opening involved                       | 97 (27.6%) | 195 (30.4%) | 0.383   |

CABG = coronary artery bypass graft; CAD = coronary artery disease; CAG = coronary angiography; CTO = chronic total occlusion; LAD = left anterior descending artery; LCX = left anterior descending artery; MT = medical therapy; NS = not significant; RCA = right coronary artery; ψ = ACC/AHA Classification of CAD.

indicated the progression of disease in NCAs. This progression was also observed in the PCI group. There were no significant differences in the number of diseased NCAs between the two groups before CABG or at the time of rehospitalization.

Figure 3 shows the distribution of patients with newly developed lesion sites, and there was no significant difference between two groups. In each group, patients were more likely to have newly developed lesions both in NCA and graft, especially in the PCI group (58.1%).

3.6. Supplemental Data of PCI Procedural Characteristics. In the PCI group, 86.0% of patients underwent PCI in only NCA and 8.4% underwent PCI in only graft. In patients with ACS, 59 patients (15.5%) underwent PCI in graft, of which 22.0% had PCI in 17 occluded vein grafts (Supplemental Table 2).

4. Discussion

For all we know, this is the largest observational, single-center Chinese study to compare the CAG characteristics of MT versus PCI therapy for symptomatic patients with prior CABB. We find that symptomatic patients with prior CABB are more likely to have newly developed lesions both in the native coronary artery and graft, and patients receiving MT (35.3%) likely had occluded grafts and type C coronary artery disease featuring as diffuse lesions.

The occurrence of myocardial ischemia in patients with prior CABB might be caused by graft failure or disease progression of NCA [10]. Graft lesion rates of SVG and internal mammary artery (IMA) were about 20%–35% and 10%–20% within 5 years following CABB, respectively, and approximately 50%–75% and 20%–40% within 10 years following CABB [2, 11, 12], respectively. Graft failure can be due to conduit defects, anastomotic technical errors, poor native vessel runoff or competitive flow with the native vessel, or atherosclerosis [13]. In this study, 78% of the patients were within 1 to 10 years following CABB, patients included in this study are those with recurrent symptoms after CABB, and most patients have graft stenosis >70% (81.5% in the MT group, 79.1% in the PCI group); therefore, the proportion of patients with graft lesions is high. 44.1% of patients in the MT group and 38.3% of patients in the PCI group have graft age more than 5 years; with the prolongation of time after CABB, the risk of graft disease would also increase. When patients were discharged from hospital after CABB, doctors usually recommended them to take aspirin, beta blockers, and statins throughout their life and control blood pressure and blood sugar. However, in the follow-up, we found that not all the patients in this study did persist in taking these drugs for some reasons like side effects or economic burden, and patients have always been poor in compliance with doctor’s advice on medical therapy and lifestyle like exercise, smoking cessation, and low-fat diet. We also observe a high proportion of patients with risk factors associated with atherosclerosis [14], including gender (male), hypertension, diabetes, and hyperlipidemia [15, 16]. Besides, we cannot rule out that the high incidence of graft lesions is associated with the anastomotic technique of surgeons; after all, there is still a gap of medical level and
surgical techniques between China and European or American countries.

Redo CABG in patients with prior CABG is more challenging than the first CABG in many aspects [17, 18] including poor basic physical condition, severe pericardial adhesion, and unavailable conduits, which would increase the risk of perioperative complications. Redo CABG is a therapeutic option for some symptomatic patients with prior CABG, especially in those situations where surgical risk is acceptable; adequate grafts are available, and multiple graft lesions and total occlusions of native coronary arteries and larger amount of ischemic myocardium are present. Compared to redo CABG, PCI had irreplaceable advantages in symptomatic patients with prior CABG, including lower risk of procedural mortality [19, 20], the similar long-term outcome [8], and low medical expense. However, PCI in patients with CTO should be considered against the risk of greater contrast volume, longer fluoroscopy time, and higher MACE rates in comparison with non-CTO patients.

When patients have recurrent symptoms after CABG surgery, they expect to get positive treatment than patients with initial angina, which may be related to their sensitivity to fear and pain of disease. In this study, some patients with stable angina also received PCI, and the choice of therapy depended mainly on doctors but also on the opinions of patients or their family members. Patients receiving MT are older and have more comorbidities; 80.6% had type C lesion featuring as diffuse lesions, which are often accompanied with extensive atherosclerotic and calcified vessels and longer lesions [21], leading to fewer amenable options for re-intervention and suboptimal stent expansion [3]; we reviewed the data of patients with occluded vein grafts in the MT group; cardiologists tried CTO PCI in 22 patients, but all failed at last. Clinically, it was difficult to perform PCI in these patients for high procedural risks and technical-demanding complexity. We did not perform follow-up to these patients who accepted different treatments to further assess outcomes.

5. Limitations

Firstly, this study was a retrospective observational study; therefore, it is subject to all the limitations of observational studies. Secondly, the angiography film results were analyzed by one cardiac surgeon and one cardiologist. Thirdly, the classification of graft lesions was in reference to the evaluation criteria of native vessels. Fourthly, the decision to perform PCI for each patient was taken by two operators, based on an evaluation of CAG during CAG. Fifthly, we were just analyzing the clinical characteristics of patients receiving different treatments, especially coronary angiography. We had not yet studied the perioperative complications and follow-up outcomes of these patients treated with different treatments. Sixthly, due to the limitation of medical level and surgical techniques in Beijing Anzhen Hospital in China, we cannot rule out this condition that there might be some unreasonable aspects in surgical techniques and program of the first CABG which are associated with graft failure.

6. Conclusions

Symptomatic patients with prior CABG are more likely to have newly developed lesions both in the native coronary artery and graft. Most patients (64.7%) could receive PCI. Patients receiving MT (35.3%) likely had occluded grafts and type C coronary artery disease featuring as diffuse lesions.

Data Availability

The clinical data used to support the findings of this study are included within the supplementary information file.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

J. Wang obtained funding and designed the study. P. Chen, C. Zeng, M. Xin, Q. Ye, and Y. Zhao collected and analyzed the data. X. Ma drafted the manuscript. All authors have read and approved the final manuscript.

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Supplementary Materials

Supplemental Table 1: CAG characteristics and progression of native coronary arteries before CABG and at the time of rehospitalization. Supplemental Table 2: PCI procedural characteristics of symptomatic patients with prior CABG (n = 642). (Supplementary Materials)

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