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Predictive impact of previous coronary artery bypass grafting on mortality after MitraClip implantation for ischemic functional mitral regurgitation

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ABSTRACT

Background: Many candidates with ischaemic functional mitral regurgitation (FMR) have previously undergone coronary artery bypass grafting (CABG), in which transcatheter mitral valve repair can be reasonable for ameliorating the deteriorated hemodynamic and heart failure symptoms. We sought to elucidate the outcomes of MitraClip (MC) implantation in patients with symptomatic ischaemic FMR after CABG.
Methods: We investigated clinical characteristics, outcomes and predictive impact of previous CABG on mortality in ischaemic FMR patients who underwent MC implantation from two high-volume centres in Germany.
Results: We enrolled 159 patients who previously underwent CABG. Compared with a reference group that did not previously undergo CABG ($n = 182$), the cohort consisted of more elderly patients (75.0, standard deviation [SD] 7.7 versus 72.9, SD 9.6 years, $p = 0.028$), more men (84% vs. 69%, $p < 0.001$), and reduced tricuspid annular plane systolic excursion (14.0, SD 4.0, vs. 16.6, SD 4.6 mm, $p < 0.0001$). The CABG group showed similar outcomes regarding procedural success (91% vs. 94%, $p = 0.24$) and 30-day mortality (5.0% vs. 6.0%, $p = 0.68$), but worse survival after MC implantation (log-rank $p = 0.019$, hazard ratio 1.56 [95% confidence interval (CI) 1.08–2.26]). After propensity score matching ($n = 224$), the hazard ratio was 1.18 [95%CI 0.76–1.84] without statistical significance ($p = 0.46$).
Conclusions: Transcatheter mitral valve repair using the MC is a viable treatment option for patients with symptomatic ischaemic FMR after CABG. Although the baseline characteristics seemed to point to sick patients, CABG itself had only a modest impact on survival.

1. Introduction

Symptomatic patients with ischaemic functional mitral regurgitation (FMR) have been reported as the largest cohort for transcatheter mitral valve repair in European countries [1–4]. The recent multicentre, randomised COAPT trial demonstrated the clinical efficacy of MitraClip® (MC)(Abbott, Menlo Park, CA, USA) implantation for functional mitral regurgitation, while the multicentre, randomised MITRA-FR trial did not show the benefit of MC treatment for patients with FMR [5,6]. From the discrepancies, patient selection might have been considered critical to obtain certain benefits from this treatment. Especially in the case of ischaemic FMR, many candidates have previously undergone coronary artery bypass grafting (CABG). In such a clinical setting, transcatheter mitral valve repair can be a reasonable alternative for eliminating FMR and ameliorating deteriorated hemodynamic and heart failure symptoms. However, no report has addressed transcatheter mitral valve repair for ischaemic FMR patients who previously underwent CABG. Therefore, we investigated the clinical characteristics of ischaemic FMR patients who previously underwent CABG, the outcomes of MC implantation, and predictive impact of previous CABG, in a large cohort study of two high-volume centres in Germany.

2. Methods

2.1. Definitions of ischaemic FMR

Definition of ischaemic FMR and inclusion criteria were described in the previous report [7]. In brief, coronary artery disease patients with left ventricular (LV) dysfunction and FMR without significant degenerative mitral leaflets were defined as having ischaemic FMR. Coronary

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artery disease was considered present in patients with documented significant stenosis (>75%) and/or coronary revascularization in at least one coronary artery.

2.2. Patients

This study had a two-centre design, representing a collaboration between the Asklepios Klinik St. Georg (Hamburg, Germany) and the Heart Centre Brandenburg (Bernau, Germany). Of 944 consecutive patients who underwent MC implantation between September 2009 and June 2016 at either centre (557 patients from Hamburg and 387 from Bernau), ischaemic FMR patients who previously underwent CABG were enrolled in this study (CABG-group). As a referent group, we assigned ischaemic FMR patients without previous CABG to non-CABG group. Total 341 patients with ischaemic FMR were investigated in the statistical analysis of this study. We excluded patients with degenerative mitral regurgitation (MR) ($n = 308$) and non-ischaemic FMR ($n = 239$); patients who underwent previous mitral valve (MV) procedures ($n = 21$); patients who had undetermined aetiology of FMR because of lacking clinical data ($n = 20$); and patients who had incomplete information regarding procedural results ($n = 5$) (Supplement 1). The follow-up data were acquired from medical records, including clinical manifestation, past history, transthoracic echocardiography, and blood examination. We investigated baseline patient characteristics and echocardiographic findings as well as survival rates to elucidate the differences between ischaemic FMR patients with and without previous CABG. All cases were discussed with the institutional heart team, and, if needed, received coronary revascularization for residual myocardial ischaemia before the index MitraClip implantation. Because of the anonymous retrospective study design, the ethical approval was not required in accordance with the decision by the medical association in Hamburg, Germany. (The reference number: WF-78/18) All patients provided written informed consent and the study protocol conformed to the ethical guidelines of the 1975 declaration of Helsinki.

2.3. The MC procedure and the diagnosis of MR severity

The details of the MC device and procedure have been published in previous reports [8,9]. The diagnosis of FMR was based on echocardiographic parameters of MR severity, according to the recent European Society of Cardiology/European Association for Cardio-Thoracic Surgery guidelines for the management of valvular heart disease [10]. The severity of MR was classified as 1+ (mild), 2+ (mild to moderate), 3+ (moderate to severe), and 4+ (severe). In this study, the indication for the MC procedure was MR severity 3+ or 4+ and high surgical risk according to the consensus of the institutional heart team, in which increase in calculated perioperative mortality, and also other clinical conditions which leaded to adverse perioperative events were taken into consideration. Procedural success was defined as a residual MR grade of ≤2+, which was assessed by transthoracic echocardiography at discharge.

Table 1
Baseline patient characteristics.

	A. Unmatched patients					B. Propensity-score matched patients				
	CABG group		Non-CABG group		*p*-value	CABG group		Non-CABG group		*p*-value	Standardized difference
No. of patients		159		182			112		112		
Age, years	159	75.0 ± 7.7	182	72.9 ± 9.6	0.028	112	74.3 ± 7.7	112	73.6 ± 9.7	0.99	0.03
Female gender	159	25 (16)	182	57 (31)	<0.001	112	22 (20)	112	22 (20)	1.0	0.00
Body mass index, kg/m^2	155	26.3 ± 4.3	175	26.5 ± 4.2	0.73	109	26.7 ± 4.3	108	26.7 ± 4.2	0.85	0.00
logistic EuroSCORE, %	143	34.5 ± 19.3	162	17.3 ± 12.2	<0.0001	101	33.3 ± 19.4	102	16.5 ± 12.0	<0.0001	1.04
EuroSCORE II, %	138	18.3 ± 10.0	149	7.6 ± 7.2	<0.0001	100	17.7 ± 9.9	94	8.0 ± 7.3	<0.0001	1.11
Heart surgery	159	159 (100)	182	10 (5)	<0.0001	112	123 (100)	112	8 (7)	<0.0001	5.08
Percutaneous coronary intervention	156	86 (55)	180	158 (88)	<0.0001	110	(55)	110	(87)	<0.0001	−0.77
Myocardial infarction	156	70 (45)	180	111 (62)	0.002	112	61 (54)	112	63 (56)	0.79	−0.04
Hypertension	159	126 (79)	181	129 (50)	0.090	112	91 (81)	112	83 (74)	0.20	0.17
Diabetes	159	67 (42)	181	80 (44)	0.70	112	47 (42)	112	51 (46)	0.59	−0.07
Estimated glomerular filtration rate, ml/min/1.73m^2	159	50.5 ± 23.2	179	53.4 ± 21.6	0.11	112	51.1 ± 22.1	112	52.5 ± 20.1	0.41	−0.07
Atrial fibrillation	158	97 (61)	181	111 (61)	0.99	112	71 (63)	112	71 (63)	1.0	0.00
Peripheral artery disease	159	46 (29)	179	28 (16)	0.003	112	23 (21)	112	23 (21)	1.0	0.00
Chronic obstructive pulmonary disease	159	36 (23)	181	43 (24)	0.81	112	27 (24)	112	27 (24)	1.0	0.00
Implantable cardioverter defibrillator	159	70 (44)	182	82 (45)	0.85	112	54 (48)	112	50 (45)	0.59	0.07
Cardiac resynchronization therapy	159	32 (20)	182	45 (25)	0.31	112	28 (25)	112	27 (24)	0.88	0.02
New-York Heart Association functional class											
<III	146	14 (10)	160	8 (5)	0.24	102	9 (9)	98	5 (5)	0.58	0.16
III		96 (41)		105 (66)			70 (69)		71 (72)		−0.07
IV		36 (49)		47 (29)			23 (23)		22 (22)		0.02
N-terminal pro-brain natriuretic peptide, 10^{3}pg/ml	125	4.2 [2.8–9.1]	145	4.9 [2.2–9.2]	0.96	93	4.4 [2.9–9.6]	85	4.9 [2.2–8.0]	0.52	0.11
Left ventricular ejection fraction, %	155	30.5 ± 11.1	174	32.0 ± 12.4	0.26	108	30.5 ± 11.1	106	32.0 ± 11.1	0.21	−0.13
Left ventricular end-diastolic diameter, mm	151	63.6 ± 8.1	168	64.1 ± 10.2	0.56	107	64.1 ± 8.7	103	64.1 ± 10.0	0.80	0.00
Left atrial diameter, mm	136	50.2 ± 7.3	151	48.7 ± 7.6	0.057	96	50.0 ± 7.5	93	50.9 ± 7.9	0.58	−0.11
Tricuspid regurgitation grade	113		133		0.89	90		87		0.69	
0 or 1+		46 (41)		53 (40)			42 (47)		38 (44)		0.06
≥2+		67 (59)		80 (60)			48 (53)		49 (56)		−0.06
Peak systolic tricuspid regurgitation pressure gradient, mmHg	129	41.6 ± 14.8	144	42.3 ± 14.6	0.55	89	43.3 ± 15.2	92	43.2 ± 14.1	0.91	0.01
Tricuspid annular plane systolic excursion, mm	141	14.0 ± 4.0	158	16.6 ± 4.6	<0.0001	98	15.0 ± 3.8	95	15.3 ± 4.2	0.83	−0.07
Number of coronary artery disease											
1-vessel disease	96	10 (10)	97	51 (53)	<0.0001	68	4 (6)	78	41 (53)	<0.0001	−1.2
2-vessel disease		39 (41)		33 (34)			28 (41)		27 (35)		0.12
3-vessel disease		47 (49)		13 (13)			36 (53)		10 (13)		0.94
Duration of coronary artery disease, years	95	15.5 [8.2–22.5]	80	3.8 [0.7–14.6]	<0.0001	64	15.4 [8.6–22.9]	65	3.8 [0.95–16.8]	<0.0001	0.81
<1 year		1 (1)		21 (26)	<0.0001		1 (2)		16 (25)	<0.0001	−0.76
Propensity score	159	0.56 ± 0.19	182	0.38 ± 0.18	<0.0001	112	0.48 ± 0.15	112	0.47 ± 0.15	0.81	0.03
Procedural success	159	144 (91)	182	171 (94)	0.24	112	100 (89)	112	105 (94)	0.23	−0.18

2.4. Statistics

Continuous variables are expressed as mean ± standard deviation (SD) or as median and interquartile range (first to third quartile), where appropriate. These were compared using unpaired Student's *t*-test if normally distributed or Mann-Whitney *U* test if not normally distributed. Categorical variables are expressed as counts (percentages), which were compared using chi-square test or Fisher's exact test (if the number of at least one cell <5).

Survival analysis was conducted using the Kaplan-Meier method for comparisons between the CABG and non-CABG groups. We used a Cox proportional-hazards model to identify clinical predictors of all-cause mortality. In the multivariable regression models, the hazard ratio was adjusted by age, gender, diabetes mellitus, prior myocardial infarction, estimated glomerular filtration rate, tricuspid annular plane systolic excursion, and N-terminal pro-brain natriuretic peptide (NT-proBNP).

In addition, to adjust for differences in baseline variables between both groups, we conducted a propensity-score matching. Propensity scores were calculated using logistic regression models from 11 baseline covariates (age, gender, previous myocardial infarction, diabetes mellitus, chronic obstructive pulmonary disease, peripheral artery disease, estimated glomerular filtration rate, left ventricular ejection fraction, left ventricular end-diastolic diameter, tricuspid annular plane systolic excursion, NT-proBNP). Logistic EuroSCORE, EuroSCORE II, and covariates related to history of coronary artery disease were excluded from the regression model for propensity score, because the preceding CABG treatment resulted in selection of multi-vessel disease and an increase in surgical risk scores. In the calculation of propensity score, missing values in the data set were complemented with the multiple imputation. Kaplan-Meier curves were described for the overall population and the propensity-score matched patients by the average score from the five imputed data sets.

As parts of the sensitivity analyses for the robustness of the conclusion, statistical analyses using multivariable Cox proportional-hazard regression models were performed in the subset of complete cases, imputed data sets, and propensity-score matched data set. In the multivariable regression model, missing in data set were complemented using with the multiple imputation methods. The results across five imputed data sets were combined through averaging, and standard errors were adjusted to reflect both within-imputation variability and between-imputation variability.

A two-sided *p*-value of <0.05 was considered statistically significant. Statistical analyses were performed using SPSS® software, version 24 (IBM Corporation, New York, NY, United States).

3. Results

Of 341 ischaemic FMR patients, 159 patients (47%) were assigned to the study group with a history of previous CABG surgery (CABG-group) and 182 (53%) patients to the reference group (non-CABG group) (Supplement 1). The median follow-up period was 407 (interquartile range 106–829) days. Follow up was completed in 89% of patients at 1 year and 78% at 2 year2. The median follow-up of patients who died during the observation was 234 (interquartile 67–551) days, while that of surviving patients at the last follow up was 573 (interquartile 354–898) days.

3.1. Baseline characteristics

The baseline patient characteristics are shown in Table 1A. In the CABG group, there were older (75.0 ± 7.7 vs. 72.9 ± 9.6 years, $p = 0.028$), fewer female patients (16% vs. 31%, $p < 0.001$); lower prevalence in previous percutaneous coronary intervention (55% vs. 88%, $p < 0.0001$) and myocardial infarction (45% vs. 62%, $p = 0.002$); higher prevalence in hyperlipidaemia (82% vs. 67%, $p = 0.012$) and prevalence of peripheral artery disease (29% vs. 16%, $p = 0.003$) than in the non-CABG group. All patients had a history of coronary artery disease, and 88% of patients in non-CABG group had received coronary revascularization. In CABG group, there were more multivessel diseases (3-vessel disease 49% vs 13%, $p < 0.0001$) and years from coronary artery disease diagnosis was higher (median [interquartile range] 15.5 [8.1–22.5] vs. 3.8 [0.7–14.6], <0.0001). The surgical risk scores were significantly higher in the CABG groups; logistic EuroSCORE was 34.4% (SD 18.9%) in the CABG group and 17.9% (SD 12.4%) in the non-CABG group ($p < 0.0001$); and EuroSCORE II was 18.2% (SD 10.4%) and 7.9% (SD 7.0%) ($p < 0.0001$), respectively. There were no significant differences in body mass index, estimated glomerular filtration rate, and NT-proBNP, nor in the prevalence of an implantable cardioverter defibrillator,

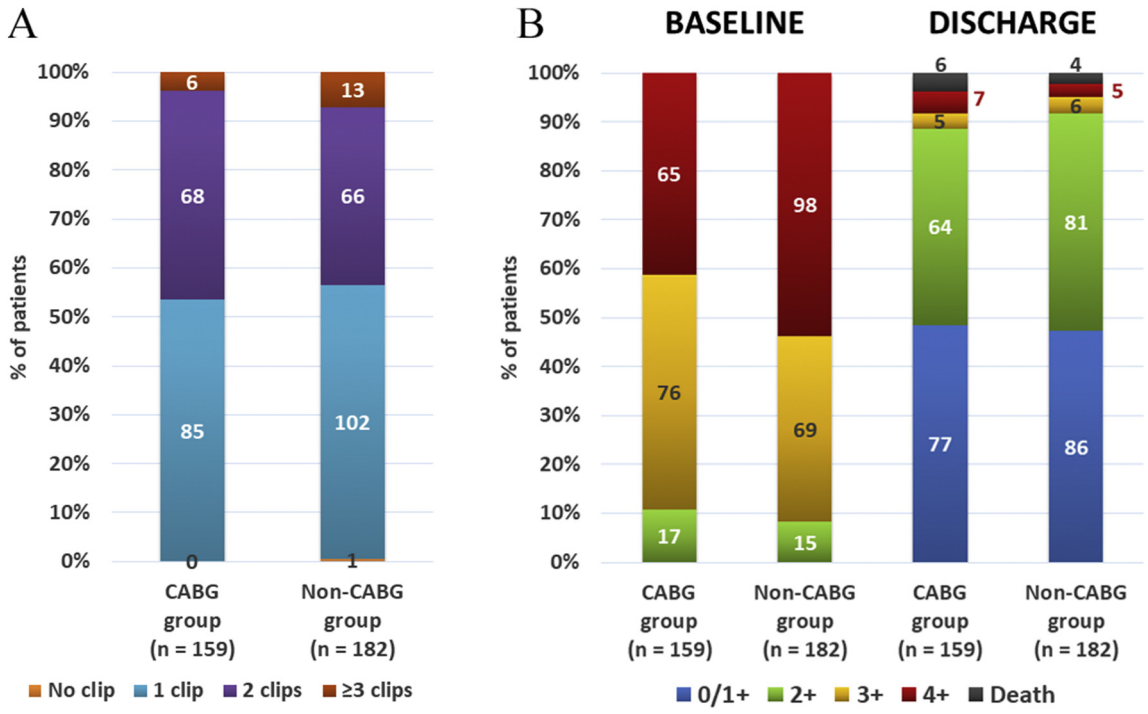

Fig. 1. Short-term outcomes of MitraClip implantation in the 2 study groups. (A) Distributions of clips implanted. (B) Distributions of mitral regurgitation severity at baseline and at discharge. Numbers in column segments denote numbers of patients.

and cardiac resynchronization therapy between the two groups. M-mode parameters of the left ventricle were similar, but tricuspid annular plane systolic excursion was significantly lower in the CABG group (14.0 ± 4.0 vs. 16.6 ± 4.6 mm, $p < 0.0001$).

3.2. Procedural results of MC implantation

The distributions of the number of clips implanted in the 2 patient groups are shown in Fig. 1A. The distributions of FMR severity at baseline and discharge are shown in Fig. 1B. With FMR grade > 2+ at discharge in 15 patients (9%) of the CABG group and 11 patients (6%) of the non-CABG group ($p = 0.50$), procedural success was achieved in 144 patients (91%, 95% confidential interval (CI) 86–95%) and 171 patients (94%, 95%CI 90–97%), respectively. The median length of hospital stay after MC was 6 (interquartile range, 4 to 9) days in both groups. There were 6 in-hospital deaths (3.8%, 95%CI 0.8–6.8%) and 8 deaths at 30 days (5.0%, 95%CI 1.6–8.5%) in the CABG group; corresponding numbers and rates were 4 (2.2%, 95%CI 0.1–4.4%) and 11 (6.0%, 95%CI 2.6–9.5%) in the non-CABG group ($p = 0.26$ and $p = 0.96$, respectively). The reasons of in-hospital deaths in the CABG-group were ventricular arrythmia ($n = 2$), left-sided heart failure (n = 2), sepsis ($n = 1$), and end-stage renal failure (n = 1); in the non-CABG group, septic shock due to pneumonia (n = 1), and unknown ($n = 3$).

3.3. Survival of patients after MC implantation

The Kaplan-Meier curves of cumulative survival shown in Fig. 2. There was significant higher mortality in the CABG-group during the follow up period (log-rank $p = 0.032$). The estimated survival rates at 1 year and 2 years were 73% (95%CI, 64–81%) and 59% (95%CI, 49–69%) in the CABG-group, and 78% (95%CI, 71–85%) and 72% (95%CI, 64–80%) in the non-CABG group, respectively.

In a univariate Cox proportional-hazard model, a history of CABG was a significant predictor of mortality after MC implantation (hazard ratio 1.56 [95%CI: 1.08–2.26], $p = 0.019$) (Fig. 2A). In the multivariable Cox proportional-hazard regression model, the hazard ratio of a previous CABG was 1.23 [95%CI 0.82–1.84] without statistical significance ($p = 0.31$) (Table 2). Sensitivity analyses were performed for this result and ascertained its robustness. (Supplement 2).

3.4. Survival analysis for propensity-score matched population

After propensity-score matching, there were no statistically significant differences of the adjusted covariates between the patient groups, and each standardized difference was below the prespecified cut off value (< 0.185) (Table 1B). In the matched cohort, a history of CABG was not significantly predictive of mortality after MC implantation (unadjusted hazard ratio 1.18 [95%CI: 0.76–1.84], $p = 0.46$) (Fig. 2B). The Kaplan-Meier curve demonstrated no significant difference in the survival after MC implantation. (log-rank $p = 0.46$).

4. Discussion

This registry consisted of consecutive patients who underwent MC implantations in two German high-volume centres, reflecting the real-world clinical setting of this treatment. We investigated the clinical backgrounds, outcomes of MC implantation, and predictive impact of previous CABG on mortality in patients with symptomatic ischaemic FMR. The present study elucidated the following findings.

(1) The majority of patients with previous CABG was characterised by advanced age, impaired right ventricular systolic function, long history of coronary artery disease, and multivessel disease.
(2) In comparison with the non-CABG group, the CABG group showed similar acute results within 30 days of MC implantation, despite worse middle-term survival after MC implantation.
(3) In the overall ischaemic FMR cohort and the subgroup analyses, the history of previous CABG affected mortality after MC implantation (1.56 times higher), while the propensity-score matched patients with previous CABG presented with a modest increase (1.18 times higher) in the mortality, yet without statistical significance.

Patients with symptomatic ischaemic FMR after CABG experienced ischaemic cardiomyopathy based on a long history of coronary artery disease and multivessel disease. In such a clinical setting, medical treatments often fail to improve heart failure symptoms, especially if the patient is not responding to cardiac resynchronization therapy. These patients seemed unlikely to be candidates for repeat cardiac surgery because of advanced age and low LV systolic function. Therefore,

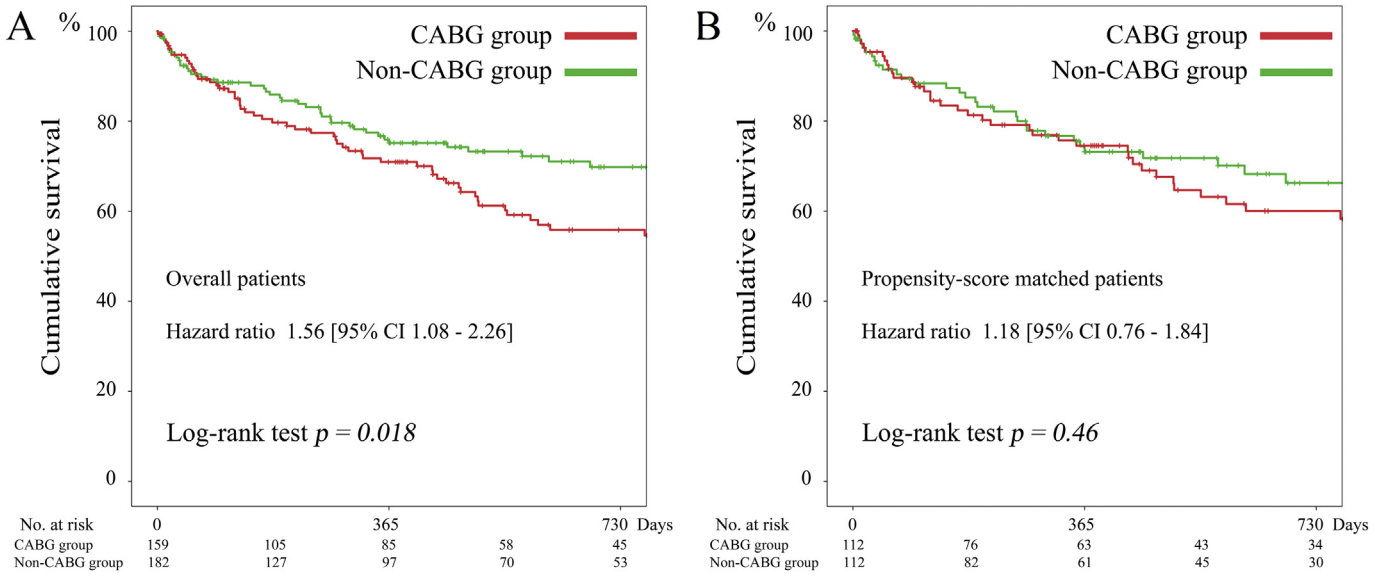

Fig. 2. Kaplan-Meier survival curves of patients with and without a history of previous coronary bypass surgery and patients. (A) Unmatched patients (B) Propensity-score matched patients.

Table 2
Previous history of coronary bypass surgery as a predictor of mortality in Cox proportional-hazard regression models.

	All-cause mortality		
	Hazard ratio	95% confidence interval	*p* value
Previous history of coronary bypass surgery			
Unadjusted	1.56	1.08–2.26	0.019
Adjusted	1.23	0.82–1.84	0.31
Variables in the multivariable model			
Age, year	1.03	1.00–1.05	0.044
Female	0.64	0.39–1.06	0.085
Diabetes mellitus	1.58	1.08–2.30	0.018
Prior myocardial infarction	1.18	0.79–1.76	0.41
estimated glomerular filtration rate, ml/min/1.73m^2	0.99	0.98–1.00	0.020
Tricuspid annular plane systolic excursion, mm	0.95	0.90–0.99	0.018
N-terminal pro-brain natriuretic peptide, per 10^3pg/ml	1.01	1.00–1.02	0.12

transcatheter mitral valve repair using MC implantation is expected to be an effective alternative option for such a cohort with significant ischaemic FMR. Unsurprisingly, according to favourable short-term results of MC implantation, which were similar to those without previous bypass surgery, MC implantation can be considered as a viable treatment option in cases of symptomatic ischaemic FMR developing after CABG. However, the survival after MC implantation differs between both groups. The baseline characteristics of the CABG group seemed to point to sicker patients than in the non-CABG group, in which those variables were considered confounding factors in estimating the predictive impact of previous CABG on survival. In the propensity-score matched population, there was only modest predictive impact of previous CABG on survival, and the residual effect seemed to be explained by the different extent and history of the coronary artery disease. Based on the present findings, although we should be aware of an increased mortality after MC implantation in such patients, CABG itself has no effect on the survival.

On the other hand, findings in patients without a history of CABG should be carefully interpreted, because a considerable number of patients undergo MC implantation within 1 year from the diagnosis of coronary artery disease. These patients might have developed acute MR after myocardial infarction. Otherwise, ischaemic MR might have developed asymptomatically or with anginal symptoms until the presentation of heart failure, in which ongoing myocardial damage due to underlying coronary artery disease might have already persisted for years. Since this cohort is likely to be heterogeneous and different from the CABG-group, further investigation is needed to clarify the results from the non-CABG group.

To address the development of ischaemic FMR during the chronic phase after CABG, the underlying mechanisms should be discussed in individuals. The severity of ischaemic FMR may change dramatically depending on physical condition, LV loading status, and LV remodelling. Currently, LV remodelling after a previous ischaemic event is considered as the main mechanism for the development of ischaemic FMR and needs to be attenuated by achieving complete revascularization and optimal medical treatment. Indeed, the CABG group had long-standing ischaemic heart disease, in which LV remodelling might have been augmented based on impaired myocardium or possible recurrent ischaemia due to graft failure and/or new stenotic lesions of an unprotected coronary vessel. A recent study reported that incomplete revascularization affected mortality after MV surgery [11]. Residual myocardial ischaemia might have deteriorated further LV remodeling followed by worsened FMR. In the clinical setting, when MitraClip implantation is planned, residual coronary stenosis is revascularized so much as possible. In some patients, complete revascularization could not be obtained, such as for chronic total occlusion, in which complicated collateral networks developed. This issue could not be addressed in the present study and needs to be investigated in future studies.

In this registry, the proportion of patients who underwent CABG and concomitant MV repair (4.8%) was comparable to that (4.0%) in the registry of the German Society for Thoracic and Cardiovascular Surgery [12]. Here, two scenarios can possibly be presumed: previously existing ischaemic FMR worsened during medical treatment after CABG, or significant MR emerged due to LV remodelling. In both scenarios, further ischaemic LV remodelling seems to be the main mechanism of newly diagnosed moderate-to-severe or severe FMR. For surgical treatment of ischaemic FMR at the time of CABG, the appropriateness of adding MV surgery to CABG has been controversial for years, especially in patients with moderate ischaemic FMR. The addressed issues are whether ischaemic FMR improves after simple coronary revascularization or whether additional MV surgery is beneficial despite requiring open cardiac surgery under cardiopulmonary bypass. Some investigators reported that sufficient myocardial viability and the absence of papillary muscle systolic dyssynchrony were independent predictors of improvement of moderate ischaemic FMR after isolated CABG [13,14]. However, predicting the improvement of ischaemic FMR through remission of myocardial hibernation and reverse remodelling of the LV still remains a challenging. MV repair with CABG is more effective than isolated CABG for reduction of MR, whereas isolated CABG also provides favourable survival in patients with ischaemic FMR [15]. For decision making of additional MV surgery to CABG, dominant HF symptoms rather than angina, absence of incremental risk of additional MV repair, absence of myocardial viability in the posterolateral LV, and annular dilatation (Carpentier classification type I) were considered reasonable for additional MV surgery [16]. At this time, in the 2014 AHA/ACCF guidelines, recommendations for surgery for moderate ischaemic FMR are conservative, and current guidelines of the European Society of Cardiology/European Association for Cardio-Thoracic Surgery do not recommend adding MV annuloplasty to CABG procedures for patients with moderate MR [10], because no survival benefit was proven in prospective, multicentre, randomised trials [17–20]. Transcatheter mitral valve repair using MC is a reasonable option for patients with symptomatic ischaemic FMR after CABG but in whom MV surgery was withheld for moderate ischaemic FMR.

Recently, adding subvalvular intervention to mitral annuloplasty has been introduced in some tertiary centres [21–23], and favourable outcomes of transcatheter mitral valve implantation were reported for patients with recurrent MR after MV surgery using an annuloplasty ring and bioprosthetic valves [24]. For patients with planned bypass surgery and mild to moderate MR, the selection of MV treatments might change in the clinical setting if reliable novel techniques are established.

4.1. Limitations

First, this study was conducted in only two high-volume centres in Germany. Therefore, the results are not generalisable to other institutes

under different conditions. Second, we did not investigate the diagnosis of acute MR, the type of diseased coronary vessel, status of ischaemic heart disease, and achievement of complete revascularization, which seemed to affect survival in patients with coronary artery disease after transcatheter mitral valve repair using MC. Further investigation is required to address this issue.

4.2. Conclusions

Transcatheter mitral valve repair using the MC is a viable treatment option for patients with symptomatic ischaemic FMR after CABG. The patients in the CABG group were older; were predominantly men; and had higher surgical risk scores, lower right ventricular systolic function, more multi-vessel disease, and a longer history of coronary artery disease than those in the non-CABG group. Accordingly, the survival after MC implantation of patients with previous CABG was reduced in comparison with non-CABG group. However, as CABG itself had only a modest impact on survival, coronary artery disease should be treated according to the guideline recommendation.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcard.2019.02.045.

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Conflicts of interest

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