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Effects of Percutaneous Coronary Intervention and Coronary Artery Bypass Grafting on Clinical Outcomes in Patients with Reduced Ejection Fraction Heart Failure and Coronary Heart Disease: A Meta-Analysis

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ABSTRACT

Objective: To clarify the effects of percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) on the clinical outcomes of patients with coronary heart disease (CHD) complicated with reduced ejection fraction heart failure (HFrEF) through meta-analysis.

Methods: Three major literature databases – PubMed, Web of Science, and Cochrane – were searched by search terms and the literature retrieval time was publications dating from January 2007 to December 2021. To search for observational studies and randomized controlled trials (RCT) comparing the efficacy of PCI and CABG in patients with CHD and HFrEF, the abstract or full text of the literature was read and the final included literature was determined, according to inclusion and exclusion criteria. The quality of the included literature was evaluated using the Ottawa scale and data extraction was further completed. Data analysis was made using RevMan5.4 and R4.1 software; relevant forest plots and funnel plots were made, according to the extracted data. Egger's test was used to evaluate whether the data had publication bias. Outcomes were the major adverse cardiovascular events (MACE).

Results: A total of 10 studies were included and 11,032 subjects were included, made up of 5,521 cases of PCI and 5,511 cases of CABG. The results showed no significant difference between the two groups in cardiac mortality (CM) (RR=1.13, 95% CI 0.98-1.30, P = 0.10) and in overall all-cause mortality (ACM) (RR=1.12, 95% CI 0.92-1.37, P = 0.25). In the subgroup analysis of ACM, in the subgroups with left ventricular ejection fraction (LVEF) less than 35% and exceeding 35% and less than 50% (RR=1.12, 95% CI 0.92-1.37, P = 0.25) between the two groups, there was no statistical difference. However, among other MACE, compared with the PCI group, the CABG group had a lower risk of MACE (RR=1.58, 95%CI 1.49-1.70, P < 0.00001), myocardial infarction (MI) (RR=1.99, 95% CI 1.02-3.88, P = 0.04), heart failure (HF) (RR=1.29, 95% CI 1.17-1.43, P < 0.00001) and revascularization (RR=2.74, 95% CI 1.93-3.90, P < 0.00001). Finally in the CABG group, the risk of stroke or transient ischemic attack (TIA) was higher (RR=0.71, 95% CI 0.58-0.86, P = 0.0006) than the PCI group.

Conclusions: The mortality rates of PCI and CABG were similar in patients with CHD complicated with HFrEF. Compared with PCI, CABG had a lower incidence of MACE, MI, HF, and revascularization, and a higher incidence of stroke or TIA.

INTRODUCTION

According to the 2017 Global Burden of Disease research report, cardiovascular disease is one of the diseases with the highest disability rate. In 2017, cardiovascular disease caused 17.79 million deaths worldwide, an increase of 44.9% compared with 1990 [GBD 2018]. According to the China Health and Health Statistical Yearbook 2019 research report, cardiovascular death is the leading cause of total death among urban and rural residents in China, higher than tumors and other diseases. In the Chinese cardiovascular health and disease report 2020 [China Cardiovascular Health and Disease Report 2021], there were 11.39 million coronary heart disease patients. With the development of cardiovascular disease diagnosis and treatment technology, the mortality rate of coronary heart disease patients has not decreased and coronary heart disease is an important cause of left ventricular dysfunction. According to the research of China-HF, about 49.6% of patients with HF suffer from CHD and PCI and CABG are the two main treatment methods for patients with HFrEF combined with CHD, especially in patients with severe HFrEF. With interventional technology improving, more and more studies show that percutaneous coronary intervention can be used for patients with multivessel disease, even for patients with reduced ejection fraction [Shen 2016; Bangalore 2016]. Controversy exists, so this study made a systematic review on the effects of PCI and CABG on clinical outcomes in patients with HFrEF complicated with CHD.

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Table 1. Search strategy

#	Search
1	Left ventricular dysfunction
2	Reduced ejection fraction heart failure
3	#1 OR #2
4	Percutaneous coronary intervention
5	Coronary artery bypass grafting
6	#4 OR #5
7	#3 AND #6

METHODS

Search strategy: To identify relevant published studies of different clinical outcomes in CHD patients with HFrEF where the LVEF was less than 50% in those who had undergone PCI by drug eluting or bare metal stents and CABG. A search of full manuscripts and abstracts with medical subject headings (MeSH) terms was conducted on the electronic databases PubMed, Web of Science, and Cochrane with no language or other methodological restrictions based on authors, study design, location, and sample size. The search period was between January 1, 2007 and December 31, 2021. The following terms were searched: left ventricular dysfunction, reduced ejection fraction heart failure, percutaneous coronary intervention (PCI), and coronary artery bypass grafting (CABG). The determination of LVEF relies primarily on cardiac color Doppler ultrasonography for clarification. In the present study, the HFrEF included heart failure with significantly reduced ejection fraction (LVEF <40%) and heart failure with intermediate range of ejection fraction (40% <LVEF <50%) [Ponikowski 2016]. The search strategy is shown in Table 1. (Table 1)

Study selection criteria: Literature included randomized controlled trials (RCT), multicenter studies, and comparative studies. The included studies were required to report patients' left ventricular ejection fraction, number of patients undergoing PCI and CABG, duration of follow up, and major adverse cardiovascular events (MACE). The full-text article of any identified study that initially met the above-mentioned criteria was retrieved for closer examination by two reviewers, and the final selection was based on consensus. In the event of a disagreement, a third reviewer was summoned to independently determine the article's inclusion in this study.

Data and study quality: The clinical endpoints of this study in patients with CHD with LVEF less than 50% were MACE, ACM, CM, revascularization, HF, MI and stroke, or TIA. The baseline data, including age, sex and comorbid conditions, such as hypertension, diabetes, hypercholesterolemia, stable and unstable angina, prior PCI, prior CABG, multi-vessel disease, smoking status, LVEF, and follow-up duration were tabulated by the reviewers. Each identified study was rated with a quality score based the Newcastle-Ottawa Scale [Wells].

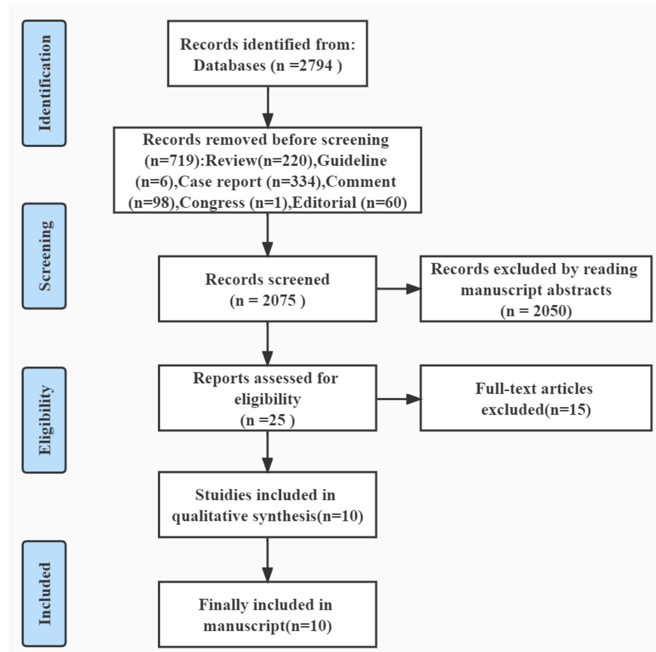

Figure 1. Literature search process

Statistical analysis: The meta-analysis was performed with the Review Manager (RevMan) software (version 5.4.1, Cochrane collaboration, http://ims.cochrane.org/revman/download) and R software (version 4.1, https://mran.microsoft.com/open). Pooled values of the event rates MACE, ACM, CM, MI and risk ratio (RR), and 95% confidence intervals were calculated using the random or fixed-effects model in anticipation of study heterogeneity. Heterogeneity among the outcomes of enrolled studies was evaluated with Q, based on the chi-squared test. In addition, I2 statistics ranging from 0% to 100% were generated to quantify the total variation, consistent with inter-study heterogeneity. A study was deemed to deviate from acceptable homogeneity if the I2 statistic exceeded 50% and when the *P*-value of the Q-test was below 0.05. Lastly, publication bias was evaluated by Egger's test, and a funnel plot was generated.

RESULTS

Literature search results: According to the search terms, Cochrane retrieved a total of 2,974 papers from PubMed and Web of Science, between January 1, 2007 to December 31, 2021. A total of 719 articles were excluded, according to the preliminary literature types (review and meta-analysis) 220 papers, 6 guideline papers, 334 case reports, 60 editorial papers, and one conference paper). Of these, 2,075 papers were obtained and 2,050 papers were excluded after reading the abstracts. Twenty-five papers were read in full. Due to LVEF > 50% or not described, 15 papers were excluded. Finally, 10 articles were included in the study. (Figure 1)

Table 2. Baseline data of the included literature

References (publication year)	Total (*N* =)	PCI (*N* =)	CABG (*N* =)	Study period	Study types	Preprocedural LVEF (%)	Follow up
Sun 2020	4794	2397	2397	2008.10-2016-12	Multicenter study	<35	5.2 (5-5.3) years
Park 2020	184	79	105	2003.1-2016.12	Randomized controlled trial	<35	5 years
Bianco 2020	648	324	324	2011-2018	Comparative study	<50	30 days
Shah 2018	134	67	67	2002.4-2015.4	Comparative study	<30	8 years
Kang 2017	911	469	442	-	Comparative study	≤35	5 years
Shen 2016	270	135	135	2003.1-2013.12	Comparative study	≤50	3 months
Bangalore 2016	2126	1063	1063	2008.1-2011.12	Comparative study	≤35	4 years
Nagendran 2013	1436	718	718	1995.1-2008.12	Randomized controlled trial	<35	15 years
Yang 2013	282	141	141	2003.1-2010.12	Comparative study	<50	32 months
Gioia 2007	220	128	92	2002.5-2005.5	Comparative study	≤35	15±9 months

Table 3. Major adverse cardiovascular events in included studies

References publication year	PCI, CABG	MACE	ACM	CM	Revascularization	HF	MI	Stroke or TIA
Kang 2017	PCI	N	118	84	43	N	41	18
	CABG	N	102	82	5	N	65	12
Shah 2018	PCI	N	37	N	N	N	N	N
	CABG	N	21	N	N	N	N	N
Shen 2016	PCI	N	N	0	N	N	N	0
	CABG	N	N	1	N	N	N	1
Bianco 2020	PCI	134	20	N	20	26	25	10
	CABG	77	16	N	8	17	6	8
Bangalore 2016	PCI	N	185	N	180	N	87	28
	CABG	N	196	N	91	N	46	51
Nagendran 2013	PCI	N	688	N	N	N	N	N
	CABG	N	680	N	N	N	N	N
Yang 2013	PCI	50	30	N	16	N	8	7
	CABG	34	27	N	6	N	2	7
Gioia 2007	PCI	N	10	8	N	N	N	N
	CABG	N	10	9	N	N	N	N
Sun 2020	PCI	1221	720	260	657	618	426	96
	CABG	770	558	213	207	481	154	146
Park 2020	PCI	N	27	N	7	N	3	4
	CABG	N	34	N	6	N	2	6

A total of 11,032 subjects were studied, including 5,521 cases of PCI and 5,511 cases of CABG. The types of studies included comparative studies, multicenter studies, and RCT. The shortest follow-up time was 30 days, and the longest was 15 years. The end point of follow up was due to MACE, including ACM and CM, MI, HF, revascularization and stroke, or TIA. The data extraction results are shown in Tables 2 and 3. (Table 2)(Table 3) The results of literature quality evaluation using the Newcastle-Ottawa Scale are shown in Table 4. (Table 4) The quality of the literature exceeded six points, and the quality of literature inclusion was deemed good.

Major adverse cardiovascular events (MACE): There were three studies [Sun 2020; Park 2020; Yang 2013] involving major adverse cardiovascular events, with a total of 2,286

Table 4. Newcastle-Ottawa score for included studies

Literature	Study cohort selection (1-4)				Comparability (5)	Result (6-8)			Total points (0-9)
	1	2	3	4	5	6	7	8	
Bangalore 2016	1	1	1	1	2	0	0	1	8
Gioia 2007	1	1	1	1	1	0	0	1	6
Kang 2017	1	1	1	1	1	0	1	1	7
Nagendran 2013	1	1	1	1	2	1	1	1	9
Park 2020	1	1	1	1	1	1	1	1	8
Shah 2018	1	1	1	1	2	0	1	1	8
Sun 2020	1	1	1	1	2	0	1	1	8
Bianco 2020	1	1	1	1	2	0	1	1	8
Yang 2013	1	1	1	1	2	0	0	1	7
Shen 2016	1	1	1	1	1	0	0	1	6

Study cohort selection (1-4): 1, representativeness of exposed cohorts; 2, selection of non-exposed cohorts; 3, determination of exposure; 4, no outcome events occurred at the beginning of the study; 5, comparability of exposure and non-exposure; 6, evaluation data quality of outcome events; 7, sufficient follow up; 8, complete follow up

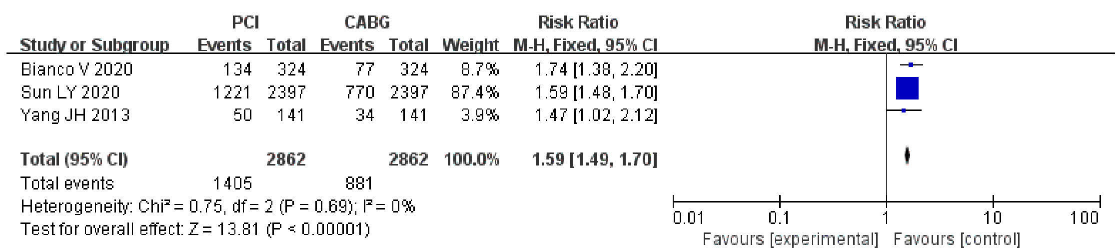

Figure 2A Forest plot of occurrence of MACE in PCI group and CABG group. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting. MACE: Major Adverse Cardiovascular Events.

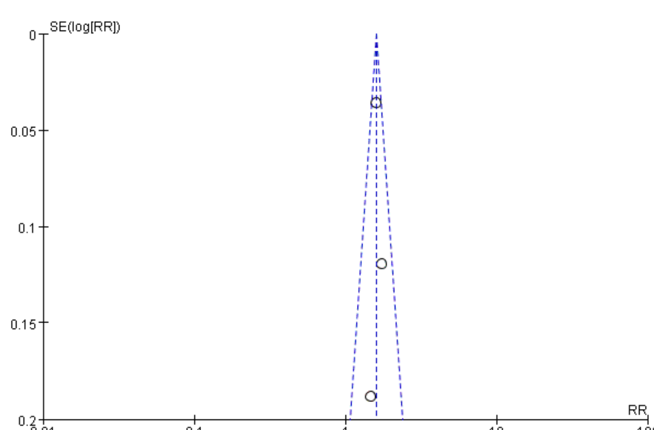

Figure 2B Funnel plot of MACE in PCI group and CABG group. MACE: Major Adverse Cardiovascular Events.

cases, including 1405 cases of PCI and 881 cases of CABG. The types of included studies included two comparative and one multicenter study. The results of the heterogeneity test showed that there was no heterogeneity between each study (P = 0.69, I2=0%) and a fixed-effects model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=1.58, 95% CI 1.49-1.70, P < 0.00001), and the CABG group had a lower risk of MACE compared with the PCI group. (Figure 2A) Publication bias analysis was performed using Egger's test, and the results showed there was no publication bias (Egger's test Z=0.1671, P = 0.8673). (Figure 2B)

Mortality – all-cause mortality (ACM): There were nine studies [China Cardiovascular Health and Disease Report 2021; Sun 2020; Park 2020; Bianco 2021; Shah 2019; Kang 2017; Nagendran 2013; Yang 2013; Gioia 2007] involving ACM, with a total of 3,479 cases, including 1,835 in the PCI group and 1,644 in the CABG group. The types of included studies included six comparative and one multicenter study and two RCTs. The results of the heterogeneity test showed there was heterogeneity between studies (P

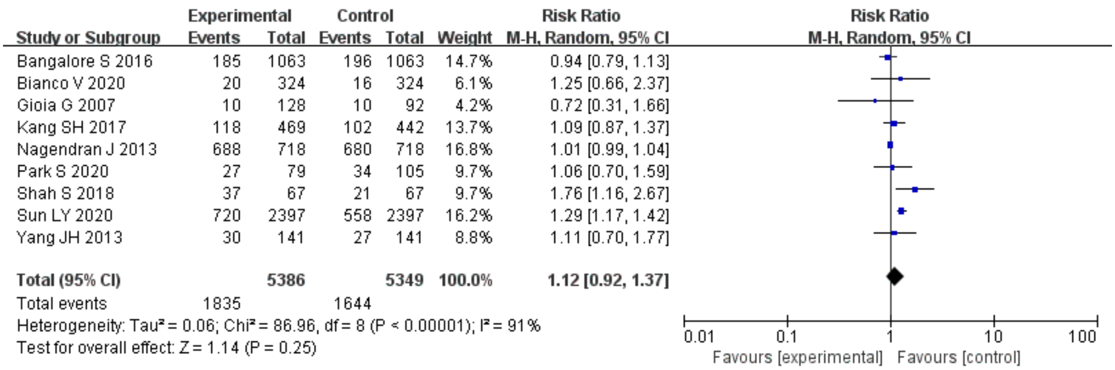

Figure 3A Forest plot of total ACM occurring in PCI group and CABG group. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; ACM: All-cause mortality.

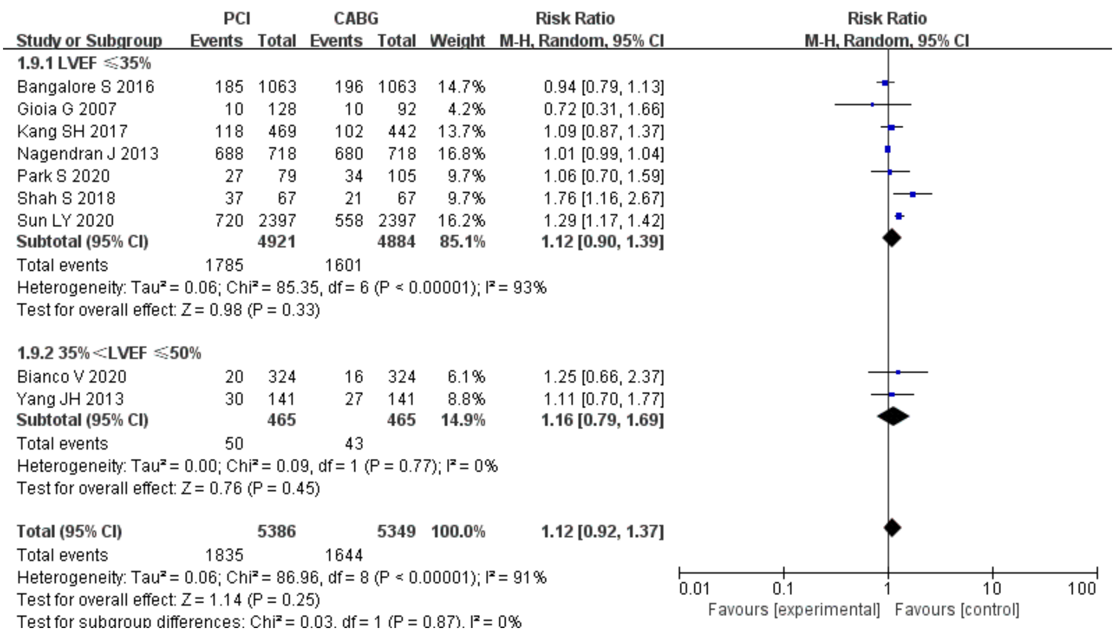

Figure 3B Forest plot of ACM occurrence in left ventricular ejection fraction subgroups in PCI group and CABG group. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; ACM: All-cause mortality; LVEF: Left Ventricular Ejection Fraction. LVEF subgroups were LVEF≤35% and 35% LVEF ≤50%.

< 0.00001, I2=91%), and a random-effects model was used for meta-analysis. Overall results showed there was no statistically significant difference between the PCI and CABG groups (RR=1.12, 95% CI 0.92-1.37, *P* = 0.25). (Figure 3A)

Subgroup analysis was performed, according to different ejection fractions, and the results of the heterogeneity test showed there was heterogeneity between studies (*P* < 0.00001, I2=91%). A random effects model was used for meta-analysis. The results showed there was no statistically significant difference between the PCI group and CABG group (RR =1.12, 95% CI 0.92-1.37, *P* = 0.25). (Figure 3B)

Subgroup analysis was performed, according to whether the PCI group and CABG group were matched or not. The results in the matched subgroup showed there was a statistically significant difference between the PCI group and CABG group (RR=1.21, 95% CI 1.12-1.31, *P* < 0.00001), and the CABG group had a lower risk of ACM compared with the PCI group. The results of the overall heterogeneity test showed there was heterogeneity between studies (*P* = 0.06, I2=46%), and a fixed-effects model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=1.19, 95% CI 1.10-1.28, *P* < 0.00001). (Figure 3C)

Subgroup analysis was performed, according to study type, and the results of heterogeneity test showed there was heterogeneity between studies (*P* = 0.06, I2=46%). A fixed-effects model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=1.19, 95% CI 1.10-1.28, *P* < 0.00001), as seen in Figure 3D, and the CABG group had a

Study or Subgroup	PCI Events	PCI Total	CABG Events	CABG Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.11.1 none match						
Gioia G 2007	10	128	10	92	1.2%	0.72 [0.31, 1.66]
Kang SH 2017	118	469	102	442	10.6%	1.09 [0.87, 1.37]
Park S 2020	27	79	34	105	2.9%	1.06 [0.70, 1.59]
Subtotal (95% CI)		**676**		**639**	**14.7%**	**1.05 [0.87, 1.28]**
Total events	155		146			
Heterogeneity: Chi² = 0.89, df = 2 (P = 0.64); I² = 0%						
Test for overall effect: Z = 0.52 (P = 0.60)						
1.11.2 match						
Bangalore S 2016	185	1063	196	1063	19.8%	0.94 [0.79, 1.13]
Bianco V 2020	20	324	16	324	1.6%	1.25 [0.66, 2.37]
Nagendran J 2013	30	141	27	141	2.7%	1.11 [0.70, 1.77]
Shah S 2018	37	67	21	67	2.1%	1.76 [1.16, 2.67]
Sun LY 2020	720	2397	558	2397	56.3%	1.29 [1.17, 1.42]
Yang JH 2013	30	141	27	141	2.7%	1.11 [0.70, 1.77]
Subtotal (95% CI)		**4133**		**4133**	**85.3%**	**1.21 [1.12, 1.31]**
Total events	1022		845			
Heterogeneity: Chi² = 12.34, df = 5 (P = 0.03); I² = 59%						
Test for overall effect: Z = 4.70 (P < 0.00001)						
Total (95% CI)		**4809**		**4772**	**100.0%**	**1.19 [1.10, 1.28]**
Total events	1177		991			
Heterogeneity: Chi² = 14.94, df = 8 (P = 0.06); I² = 46%						
Test for overall effect: Z = 4.56 (P < 0.00001)						
Test for subgroup differences: Chi² = 1.63, df = 1 (P = 0.20), I² = 38.7%						

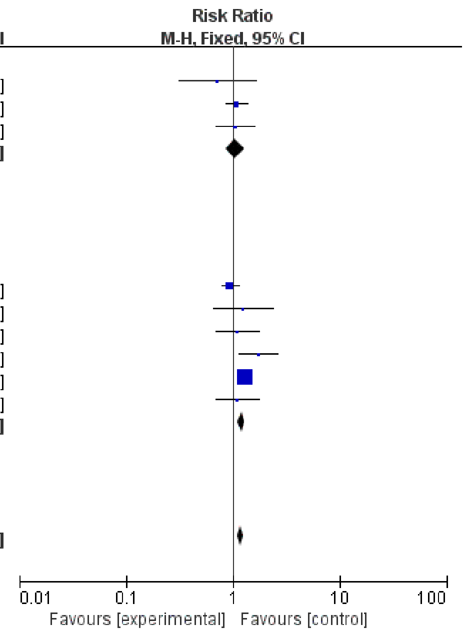

Figure 3C Forest plot of occurrence of ACM in matched subgroups of PCI group and CABG group. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; ACM: All-cause mortality. Match subgroups were match and none match.

Study or Subgroup	PCI Events	PCI Total	CABG Events	CABG Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.10.1 RCT						
Nagendran J 2013	30	141	27	141	2.7%	1.11 [0.70, 1.77]
Park S 2020	27	79	34	105	2.9%	1.06 [0.70, 1.59]
Subtotal (95% CI)		**220**		**246**	**5.7%**	**1.08 [0.79, 1.48]**
Total events	57		61			
Heterogeneity: Chi² = 0.03, df = 1 (P = 0.87); I² = 0%						
Test for overall effect: Z = 0.50 (P = 0.62)						
1.10.2 Comparative Study						
Bangalore S 2016	185	1063	196	1063	19.8%	0.94 [0.79, 1.13]
Bianco V 2020	20	324	16	324	1.6%	1.25 [0.66, 2.37]
Gioia G 2007	10	128	10	92	1.2%	0.72 [0.31, 1.66]
Kang SH 2017	118	469	102	442	10.6%	1.09 [0.87, 1.37]
Shah S 2018	37	67	21	67	2.1%	1.76 [1.16, 2.67]
Yang JH 2013	30	141	27	141	2.7%	1.11 [0.70, 1.77]
Subtotal (95% CI)		**2192**		**2129**	**38.0%**	**1.05 [0.92, 1.19]**
Total events	400		372			
Heterogeneity: Chi² = 8.54, df = 5 (P = 0.13); I² = 41%						
Test for overall effect: Z = 0.74 (P = 0.46)						
1.10.3 Multicenter Study						
Sun LY 2020	720	2397	558	2397	56.3%	1.29 [1.17, 1.42]
Subtotal (95% CI)		**2397**		**2397**	**56.3%**	**1.29 [1.17, 1.42]**
Total events	720		558			
Heterogeneity: Not applicable						
Test for overall effect: Z = 5.26 (P < 0.00001)						
Total (95% CI)		**4809**		**4772**	**100.0%**	**1.19 [1.10, 1.28]**
Total events	1177		991			
Heterogeneity: Chi² = 14.94, df = 8 (P = 0.06); I² = 46%						
Test for overall effect: Z = 4.56 (P < 0.00001)						
Test for subgroup differences: Chi² = 7.06, df = 2 (P = 0.03), I² = 71.7%						

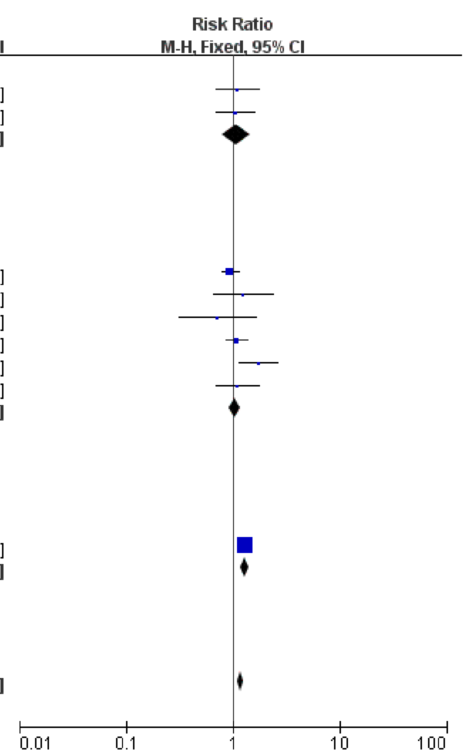

Figure 3D Forest plot of occurrence of ACM in study type subgroups in PCI group and CABG group. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; ACM: All-cause mortality; RCT: Randomized Controlled Trials. Study type subgroups were RCT multicenter studies and comparative studies.

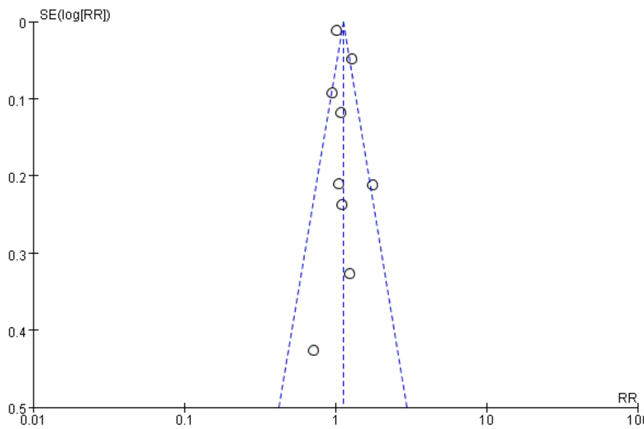

Figure 3E Funnel plot of total ACM in PCI group and CABG group. ACM: All-cause mortality.

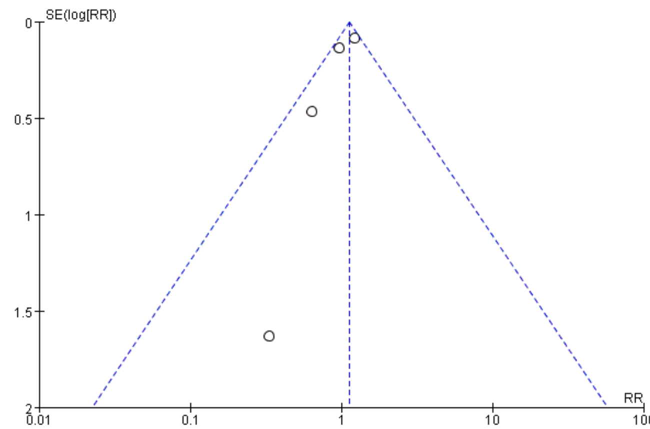

Figure 4B Funnel plot of CM in PCI and CABG groups. CM: Cardiac Mortality.

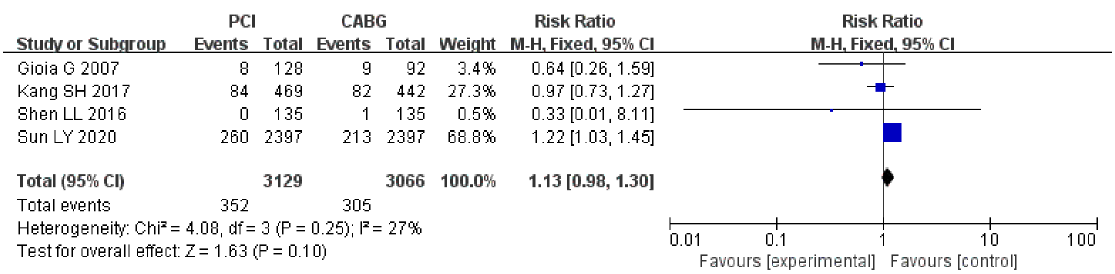

Figure 4A Forest plot of CM in PCI and CABG groups. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; CM: Cardiac Mortality.

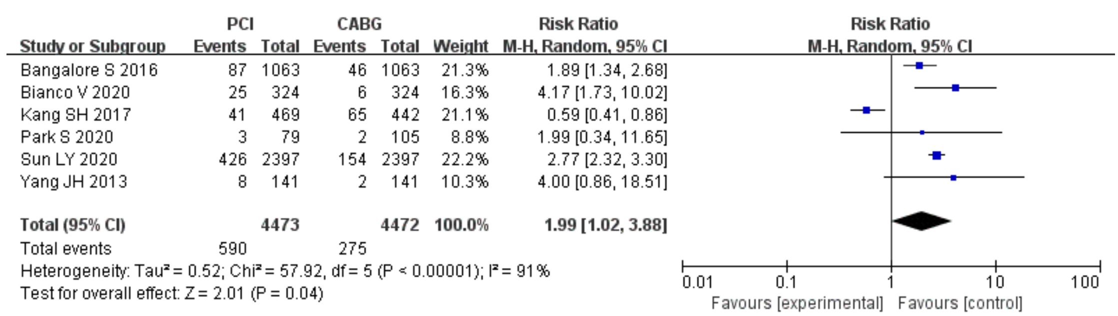

Figure 5A Forest plot of MI in PCI and CABG groups. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; MI: Myocardial Infarction.

higher risk of ACM compared with the PCI group, mainly reflected in the multi-center study subgroup. (Figure 3D) However, because there is only one multi-center study, this reference value needed to be further improved. Egger's test was used to analyze publication bias, and the results showed there was no publication bias (Egger's test Z=0.2222, P = 0.8241). (Figure 3E)

Cardiac mortality (CM): There were four studies [GBD 2018; Sun 2020; Kang 2017; Gioia 2007] involving CM, with a total of 657 patients, including 352 in the PCI group and 305 in the CABG group. The types of included studies were three comparative and one multicenter study. Heterogeneity test results showed there was heterogeneity between studies (P = 0.25, I2=27%), and a fixed-effects model was used for meta-analysis. The results showed there was no statistically significant difference between the PCI group and CABG group (RR=1.13, 95% CI 0.98-1.30, P = 0.10). (Figure 4A) Publication bias analysis was performed using Egger's test, and the results showed that there was no publication bias (Egger's test Z=-1.6762, P = 0.0937). (Figure 4B)

Myocardial infarction (MI): There were six studies [China Cardiovascular Health and Disease Report 2021; Sun 2020;

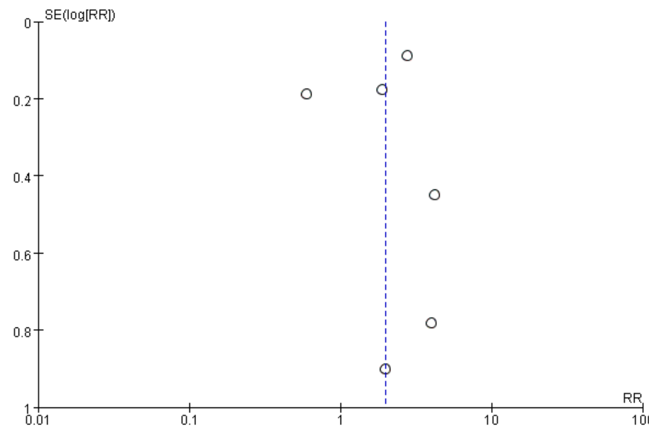

Figure 5B Funnel plot of MI in PCI and CABG groups. MI: Myocardial Infarction.

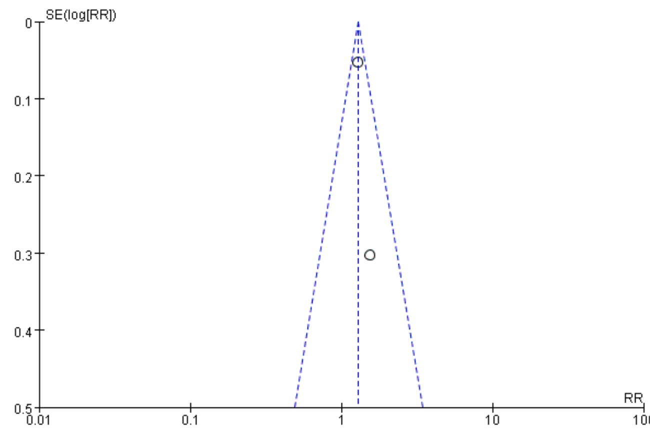

Figure 6B Funnel plot for HF in PCI and CABG groups. HF: Heart Failure.

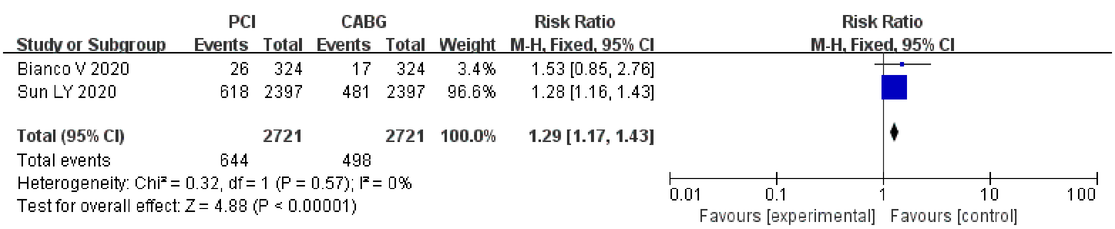

Figure 6A Forest plot of HF in PCI and CABG groups. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting; HF: Heart Failure.

Park 2020; Bianco 2021; Kang 2017; Yang 2013] involved MI with a total of 865 cases, including 590 in the PCI group and 275 in the CABG group. The types of included studies included four comparative studies, one multicenter study, and one RCT. The results of the heterogeneity test showed there was heterogeneity between studies (P < 0.00001, I2=91%), and a random-effects model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=1.99, 95% CI 1.02-3.88, P = 0.04), and the CABG group had a lower risk of MI compared with the PCI group. (Figure 5A) Publication bias analysis was performed using Egger's test, and the results showed there was no publication bias (Egger's test Z=0.7189, P = 0.4722). (Figure 5B)

Heart failure (HF): There were two studies [Sun 2020; Bianco 2021] involving HF, with a total of 1142 patients, including 644 in the PCI group and 498 in the CABG group. The types of included studies were one comparative and one multicenter study. The results of the heterogeneity test showed there was no heterogeneity between each study (P = 0.57, I2=0%), and a fixed-effects model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=1.29, 95% CI 1.17-1.43, P < 0.00001), and the CABG group had a lower risk of developing HF, compared with the PCI group. (Figure 6A) Publication bias analysis was performed using Egger's test, and the results showed there was no publication bias (Egger's test Z=0.5685, P = 0.5697). (Figure 6B)

Revascularization: There were six studies involving revascularization [China Cardiovascular Health and Disease Report 2021; Sun 2020; Park 2020; Bianco 2021; Kang 2017; Yang 2013] with a total of 1,246 patients, including 923 in the PCI group and 323 in the CABG group. The types of included studies were four comparative and one multicenter study and one RCT. The results of the heterogeneity test showed there was heterogeneity between studies (P = 0.003, I2=72%), and a random-effects model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=2.74, 95% CI 1.93-3.90, P < 0.00001), and the CABG group had a lower risk of revascularization compared with the PCI group. (Figure 7A) Publication bias analysis was performed using Egger's test, and the results showed there was no publication bias (Egger's test Z=0.3163, P = 0.7518). (Figure 7B)

Stroke or TIA: There were seven studies involving stroke or transient ischemic attack [GBD 2018 ; China Cardiovascular Health and Disease Report 2021; Sun 2020; Park 2020; Bianco 2021; Kang 2017; Yang 2013], with a total of 394 cases, of which 163 were in the PCI group and 231 cases in the CABG group. The types of included studies included six comparative and one multicenter study. The results of the heterogeneity test showed there was heterogeneity between studies (P = 0.29, I2=18%), and a random fixed model was used for meta-analysis. The results showed there was a statistically significant difference between the PCI group and CABG group (RR=0.71, 95% CI 0.58-0.86, P = 0.0006). Compared with the PCI group, the CABG group had a higher risk of stroke

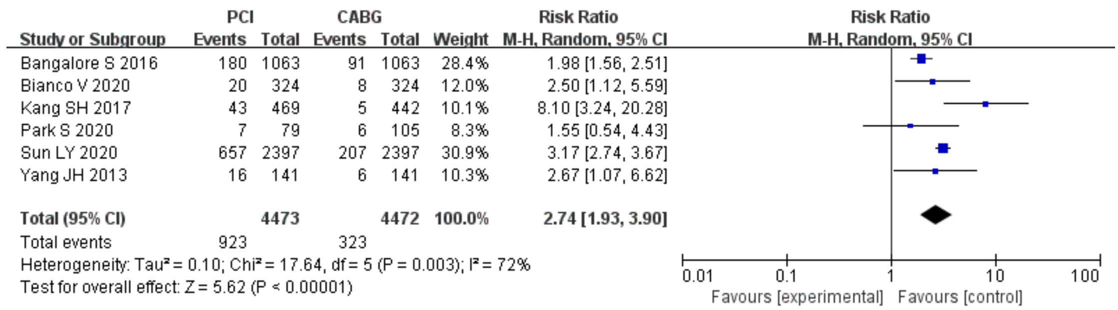

Figure 7A Forest plot for Revascularization in PCI and CABG groups. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting.

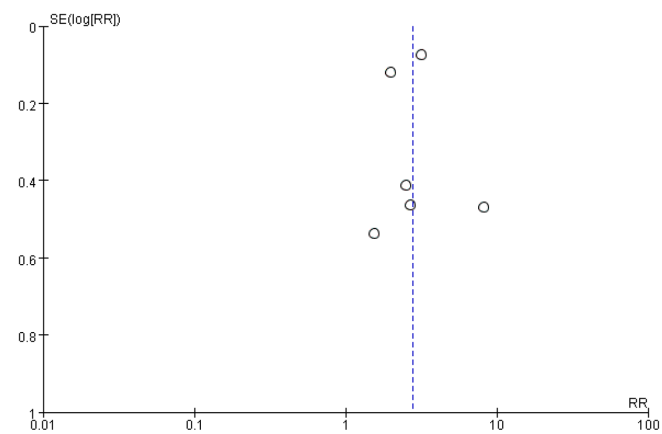

Figure 7B Funnel plot for Revascularization in PCI and CABG groups.

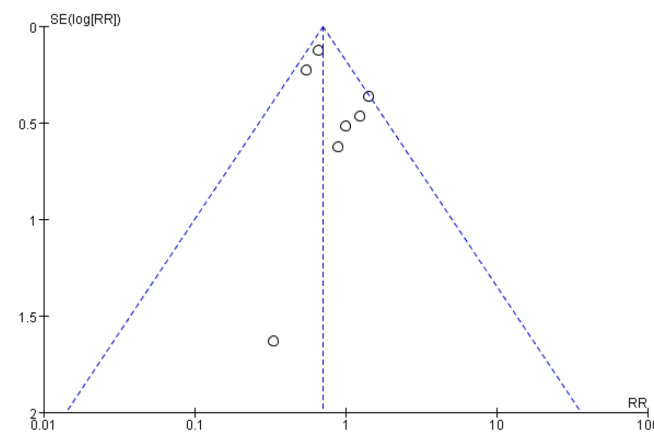

Figure 8B Funnel plot of Stroke or Transient Ischemic Attack occurring in PCI group and CABG group.

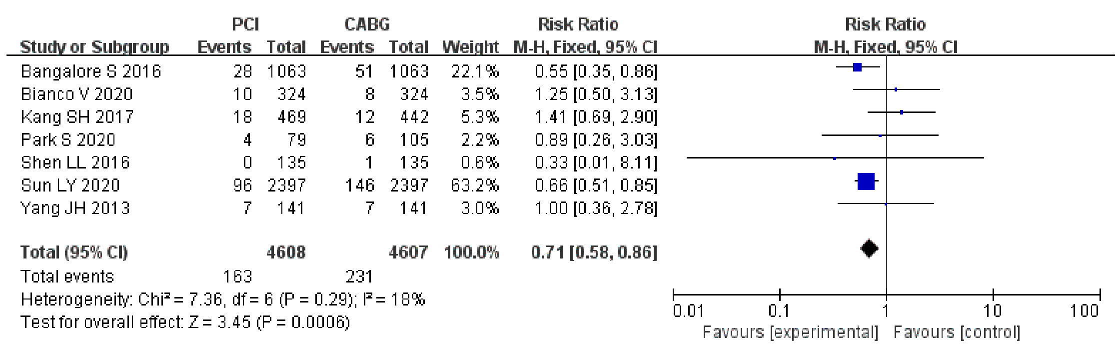

Figure 8A PCI Forest plot of Stroke or Transient Ischemic Attack occurring in group and CABG group. PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting.

or TIA. (Figure 8A) Publication bias analysis was performed using Egger's test, and the results showed there was no publication bias (Egger's test Z=1.2587, $P = 0.2082$). (Figure 8B)

DISCUSSION

According to the China Cardiovascular Health and Disease Report 2020 study [China Cardiovascular Health and Disease Report 2021], cardiovascular disease death is still one of the leading causes of death in China. With the improvement of CHD diagnosis and treatment technology, relevant research data shows the number of deaths, due to CHD, has not declined but may have an upward trend, despite the comprehensive management of CHD patients. In the diagnosis and treatment of CHD, it was found that different treatment strategies of patients with comorbidities will have an impact on clinical outcomes. Similarly, there is still controversy about PCI and CABG in patients with HFrEF, so this study discusses the effect of PCI and CABG on clinical outcomes in patients with CHD and HFrEF, with a systematic review to provide clinicians with a reliable choice of treatment strategies.

CHD complicated with HFrEF is an emergency and its mortality rate is high, but its treatment is still controversial. Several studies have shown [Mestres 2021] that CABG remains the treatment of choice for CHD patients with low left ventricular ejection fraction and three-vessel coronary artery disease. A study of short- and long-term clinical outcomes of CABG in patients with severe left ventricular systolic dysfunction by Tribak et al. found that in-hospital mortality was 9.9%, postoperative morbidity was 36.9%, the 5-year survival rate was 90.5%, and 10-year survival rate was 43.4%. CABG is used in patients with ischemic cardiomyopathy and severe left ventricular systolic dysfunction with acceptable in-hospital morbidity and mortality and long-term survival [Tribak 2022]. A long-term follow-up study Fukui et al. of CABG examined a total of 161 patients with left ventricular dysfunction where LVEF was less than 40%. After a 7-year follow up, the 7-year survival rate was 73.9±5.3% and the early postoperative and follow-up anastomotic patency rate and ejection fraction recovery rate had a good prognosis [Fukui 2014]. The results of the above study found the technique and prognosis of CABG in patients with coronary heart disease and left ventricular failure were significant, but the recovery of ejection fraction after CABG was slower and it also was related to whether the ejection fraction was high or normal before surgery, with a high preoperative LVEF value associated with an increased patient risk. It previously was thought that low left ventricular ejection fraction was associated with CABG, but the findings of this study showed that high ejection fraction was associated with CABG surgery risk [Maile 2021]. Similarly, Zhang et al. [Zhang 2021] performed CABG on patients with left ventricular systolic dysfunction and coronary heart disease and found there was no significant difference in death, during hospitalization, between patients with normal left ventricular systolic function and mild systolic dysfunction. After 3.2 years of follow up, patients with mild LV systolic dysfunction had higher rates of ACM and CM, HF and MACE, with no significant difference in MI and revascularization. Different preoperative ejection fraction status had an influence on the prognosis of patients or CABG surgery and there was no significant difference in short-term mortality of patients after surgery. However, in long-term follow up, it was found that patients with left ventricular dysfunction died or developed cardiovascular disease, so the risk of adverse events remains substantial.

With the continuous development and progress of PCI technology and the continuous application of PCI treatment technology in CHD and its comorbidities, PCI is also widely used in patients with CHD complicated with left ventricular dysfunction. A study by Yu et al. on baseline ejection fraction levels and MACE after PCI found that baseline LVEF less than 60% was associated with an increased incidence of MACE after PCI [Yu 2017]. A study by Brophy et al. on PCI in patients with CHD complicated with left ventricular dysfunction, where LVEF was less than 35%, showed that a total of 4628 patients were included in the study, 1322 patients received PCI treatment, and the rest received drug treatment. At three years of follow up, PCI reduced ACM or readmission rates [Brophy 2021]. A network meta-analysis of treatment strategies in patients with CHD and left ventricular dysfunction by Yokoyama et al. showed that ACM was similar between CABG and PCI after adjustment for stenting in the PCI group [Yokoyama 2021]. From the above studies, it can be concluded that PCI can be used to treat CHD complicated with HFrEF, and its efficacy may be like that of CABG.

Although both CABG and PCI can be used to treat patients with CHD and HFrEF, there is still some controversy as to which of the two can better reduce the occurrence of MACE. Yee et al. conducted a comparative study on the recovery of left ventricular function after PCI and CABG in patients with multi-vessel disease and left heart dysfunction. They found that after 1-year follow up, there was no significant difference in the recovery of ejection fraction after PCI combined with CABG. However, the LVEF of patients receiving multivessel PCI was statistically significant over time, but patients receiving CABG showed greater gains over the same time period [Yee 2016]. In a study comparing the survival rate of CABG and PCI in patients with LVEF less than 30% by Shah et al., a total of 717 patients were included and after propensity scoring, 134 matched combinations finally were selected, showing that CABG still was superior to PCI as a revascularization modality in patients with left ventricular dysfunction [Shah 2019]. A Bianco et al. study comparing the efficacy of PCI and CABG in patients with coronary heart disease with reduced ejection fraction showed patients with reduced ejection fraction who received CABG had significantly improved survival and lower MACCE compared with patients who received PCI, with fewer repeat revascularization procedures [Bianco 2021]. A RCT of CABG and PCI with LVEF less than 50% and exceeding 50% by researchers by Marui et al. found that by prospectively following up 3,584 patients for 5 years, the CABG group was significantly better than PCI, with better survival [Marui 2014]. The above studies showed that although CABG could improve the survival rate of patients, CABG was not necessarily better than PCI in other MACE.

However, CABG had a higher or similar mortality rate than PCI in some studies. A meta-analysis study by Khan et al. on the treatment of patients with left ventricular failure and coronary heart disease showed how a CABG group compared with PCI group in the long-term. Mortality and revascularization rates were higher, and PCI was associated with higher short-term stroke rates [Khan 2021]. But with the further improvement and progress of PCI technology, researchers such as Zhang conducted a meta-analysis of the efficacy of CABG and PCI in 6082 patients with coronary heart disease and left ventricular systolic dysfunction in nine studies. It was associated with long-term mortality, myocardial infarction, and repeat revascularization, but not with short-term mortality [Zhang 2017]. A meta-analysis study on the use of PCI in patients with left ventricular systolic dysfunction less than 40% by Kunadian et al. showed that a total of 19 studies with 4766 patients were included. There was no significant difference in long-term mortality [Kunadian 2012]. A meta-analysis of comparative studies comparing PCI and CABG in patients with left ventricular dysfunction by Cui et al. found that PCI was associated with higher all-cause mortality and cardiac death than CABG, including 10,268 patients in eight studies, where death rates, myocardial infarction and strokes were similar in incidence [Cui 2018].

A study comparing PCI and CABG revascularization in patients with multivessel coronary artery disease and severe left ventricular dysfunction found that long-term survival was similar between the PCI and CABG groups. It also found that PCI was associated with a higher risk of myocardial infarction, repeated bleeding and reconstructive surgery, while the CABG group was associated with a higher risk of stroke [China Cardiovascular Health and Disease Report 2021]. It can be seen from the above studies that the efficacy of PCI in the treatment of coronary heart disease complicated with HFrEF was increasingly similar to CABG.

Last but not least, this study showed that in patients with CHD complicated with HFrEF, whether PCI or CABG was performed, there was no statistical significance between the two end points of ACM and CM. At the same time, after subgroup analysis of LVEF, where it was less than 35%, greater than 35% and less than 50%, study type and whether the PCI group and CABG group in the study were matched, it was found that its endpoint ACM was statistically significant between the two groups. Similarly, this meta-analysis of the remaining endpoints in patients with CHD complicated with HFrEF found that the PCI group and CABG group were significantly different between MACE, MI, HF, revascularization, TIA or stroke, or cerebrovascular accident. All statistically were significant, and it was found that the PCI group had a higher incidence of MACE, MI, HF, and revascularization. The CABG group had a higher incidence of TIA or stroke in the follow up.

Finally, after this and related studies have shown that PCI and CABG had similar mortality rates in the treatment of patients with CHD complicated with HFrEF and there were still differences in other related MACE, they could lead to the best treatment occurring. Based on these results, it is probable that PCI will become the main treatment method for patients with CHD complicated with HFrEF.

Study limitations: A total of 10 studies were included, and the study types included seven observational studies, two RCTs, and one multicenter study. Additional randomized controlled studies were lacking as evidence-based support, so follow-up research will improve the RCT of patients with CHD complicated with HFrEF and establish a multi-center and large-sample clinical database, to further improve the choice of treatment for CHD complications and reduce the occurrence of related complications.

CONCLUSION

According to this meta-study, the mortality rate of PCI and CABG in patients with CHD complicated with HFrEF was similar. Compared with PCI, CABG had a lower incidence of MACE, MI, HF, and revascularization, but the CABG group had a higher incidence of TIA or stroke during follow up.

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