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CABG vs. PCI: Greater Outcomes for Severe Coronary Artery Disease

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Abstract

Coronary artery disease is the leading cause of mortality in the United States. The lifetime probability of developing coronary artery disease after 40 is 40% in men and 32% in women. Cardiac revascularization for patients with complex coronary artery disease is performed commonly. Two common procedures for cardiac revascularization are coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI). The purpose of this systemic review is to compare long-term outcomes of CABG and PCI in patients with severe artery disease. This review concluded that PCI was associated with higher rate of repeat revascularization compared to CABG, but the incidence of stroke was lower in patients who underwent PCI. This review also found that patients with higher SYNTAX scores seem to benefit more from CABG as oppose to PCI. This suggests that PCI is an acceptable strategy for patients with lower SYNTAX scores, but patients with higher SYNTAX scores will present better outcomes with CABG.

Background and Significance

Coronary artery disease (CAD) is the leading cause of mortality in the United States and globally. In 2021, about 610,000 people died from CAD in the United States and 18.2 million Americans aged over 20 have been diagnosed with CAD (Brown et al., 2021). The lifetime probability of developing CAD after 40 is 40% in men and 32% in women. This indicates that men have higher risk of getting CAD than women. Certain ethnic groups, especially minority groups such as Blacks, Hispanics, American Indians, and South Asians, face higher risk of CAD (Volgman et al., 2018). Other major risk factors include hypertension, diabetes, hyperlipidemia, obesity, sedentary lifestyle, poor diet, smoking, and alcohol use (Pencina et al., 2018).

CAD, also called ischemic heart disease, is a result of arteriosclerosis in coronary arteries where plaque buildup in the arteries and interferes with the blood flow. Over time, it partially or totally blocks the oxygen-rich blood and nutrients to the heart, resulting in permanent heart muscle damage and heart failure. As the blockage becomes excessive and gradual decrease in blood flow to coronary arteries, people develop symptoms such as angina, fatigue, and shortness of breath that eventually lead to heart attack or sudden death (Centers for Disease Control and Prevention, 2021).

To relieve myocardial ischemia and avoid further complications, cardiac revascularization is one of the important therapeutic interventions. Especially in patients with multivessel or left main coronary artery disease, if their conditions do not improve with medication therapy or lifestyle changes, either coronary artery bypass grafting or percutaneous coronary intervention is the most common option for revascularization (Habib et al., 2015).

Coronary artery bypass grafting (CABG) is an open-heart surgery in which healthy blood vessels from the person’s leg, arm, or chest are used to connect above and below the narrowed or

blocked section of coronary arteries. These new blood vessels, or grafts, make a new pathway and restore the blood flow to the heart. CABG was first performed by Dr. Vasilii Kolesov in 1964 (Mack et al., 2021). Dr. Rene Favaloro, who is considered the father of CABG, provided reproducible results in 1967 and contributed tremendous achievement in revascularization. Since the 1960s, many researchers and surgeons have undergone numerous developments in improving CABG, and today CABG has become the most common cardiac surgery performed worldwide (Head et al., 2013). Unlike CABG which requires open-heart surgery, percutaneous coronary intervention (PCI) is a non-surgical method that was first introduced and performed by Dr. Andreas Gruntzig in 1977 (Jadhav & Jariwala, 2020). PCI requires cardiac catheterization where the catheter tube is inserted through the person's groin or wrist to identify the problem and open narrowed or blocked coronary arteries (Deb et al., 2013). Since the 1990s, PCI rates have increased exponentially due to less invasive revascularization procedure, faster recovery time, and lower stroke incidence compared to CABG (Habib et al., 2015).

For the last 50 years, both CABG and PCI went through major advances and achieved outstanding outcomes through multiple failures and successes. However, whether CABG or PCI is a more effective treatment than the other for coronary revascularization is still a topic of vigorous debate (Habib et al., 2015). Initially, PCI was mostly performed on patients who have a stable single-vessel disease and CABG was the "gold standard" for unstable patients with multivessel or left main coronary artery disease. However, as the technique of PCI evolved dramatically over time, PCI also became a compatible treatment for patients with unstable multivessel disease (Farina et al., 2019). Recently, patients with multivessel, left main coronary artery disease, or both are receiving more recommendations for PCI and less for CABG (Farina et al., 2019). Studies have shown that compared to PCI, CABG is associated with a higher long-term

survival rate but increased risk of ischemic stroke. On the other hand, the incidence of repeat revascularization and mortality rate at five years is higher in PCI. Up till now, there has been no conclusive agreement on which one is the optimal procedure for a patient with severe coronary disease (Spadaccio & Benedetto, 2018).

This paper compares long-term outcomes of CABG and PCI in patients with coronary artery disease, including risk and benefits, mortality, reintervention, myocardial infarction (MI), and stroke rates. This literature review will help organize the current available knowledge of the optimal treatment option for patients with multivessel, left main coronary artery disease, or both.

Literature Review

Characteristics of Included Studies

In this paper, eight RCTs have been identified and analyzed to compare at least 5 years of long-term outcome in patients with left main coronary artery (LMCA), multivessel disease, or both who received PCI or CABG. These 8 trials assigned patients randomly to undergo either PCI or CABG to evaluate the outcome and determine the superior approach, by assessing primary and secondary outcomes and comparing them across specific subgroups. Article one Ahn et al. (2015) used Premier of Randomized Comparison of Bypass Surgery versus Angioplasty Using Sirolimus-Eluting Stent in Patients with Left Main Coronary Artery Disease (PRECOMBAT), and reported a five-year follow up in 600 patients with LMCA disease. Article two Park et al. (2020) performed a ten year follow up of the aforementioned PRECOMBAT trial by Ahn et al. (2015). Therefore, both Park et al. (2020) and Ahn et al. (2015) have the same patients and researchers but different follow up periods: ten years and five years respectively. The Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) trial described in article three was conducted by Morice et al. (2014) and evaluated

five-year outcomes of 1,800 patients with LMCA or three-vessel disease (3VD) in 17 countries. Both article four Head et al. (2014) and article five Cavalcante et al. (2016) are five-year follow ups of the SYNTAX trial where Head et al. (2014) analyzed 1,095 patients with 3VD and Cavalcante et al. (2016) analyzed 1,305 patients with LMCA disease. Article six Stone et al. (2019) is the five-year outcome of the Evaluation of XIENCE versus Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization (EXCEL) trial that assigned 1905 patients with both LMCA disease and low to intermediate SYNTAX score. Article seven Holm et al. (2020) reported the five-year outcome of a total of 1,201 patients with LMCA disease in the Nordic-Baltic-British Left Main Revascularization (NOBLE) trial. Lastly, the Future Revascularization Evaluation in Patients with Diabetes Mellitus: Optimal Management of Multivessel Disease (FREEDOM) trial conducted by article eight Farkouh et al. (2012) studied 1,900 patients at 140 international centers with diabetes mellitus (DM) and multivessel coronary artery disease (MVD) for the five-year follow up.

Table 1: Primary Endpoint rate at the five-year or ten-year follow up

Article	PCI Group	CABG Group
MACCE (Composite of all-cause death, MI, stroke, and repeat revascularization)		
Ahn et al. (2015)	17.5%	14.3%
Park et al. (2020)	29.8%	24.7%
Morice et al. (2014)	36.9%	31.0%
Head et al. (2014)	37.5%	24.2%
Cavalcante et al. (2016)	28.3%	23.0%
Holm et al. (2020)	29.0%	19.0%
Composite of all-cause death, MI, and stroke		
Stone et al. (2019)	22.0%	19.2%
Farkouh et al. (2012)	26.6%	18.7%

Primary Endpoint

The primary endpoint is the main outcome of the study that compares long-term outcomes in PCI and CABG. The primary endpoint of Ahn et al. (2015), Park et al. (2020), Morice et al. (2014), Head et al. (2014), Cavalcante et al. (2016), and Holm et al. (2020) is the major adverse cardiac and cerebrovascular events (MACCE), defined as "the composite of all-cause death, myocardial infarction (MI), stroke, and repeat revascularization". The primary endpoint of Stone et al. (2019) and Farkouh et al. (2012) is "the composite of all-cause death, MI, and stroke".

The rate of primary endpoint for the treatment groups per article is outlined in table 1. There were no significant differences in the primary outcomes of Ahn et al. (2015), Park et al. (2020), Morice et al. (2014), Cavalcante et al. (2016), and Stone et al. (2019) studies. On the other hand, the rate of primary outcomes in Head et al. (2014), Holm et al. (2020), and Farkouh et al. (2012) found to be significantly higher in PCI compared to CABG. MACCE was 37.5% for PCI and 24.2% for CABG in Head et al. (2014), and 28% for CABG and 19% for PCI in Holm et al. (2020). Also, the primary outcome, composite of all-cause death, MI, and stroke, in Farkouh et al. (2012) was 26.6% of the PCI group and 18.7% of the CABG group (Table 1).

Secondary Endpoints

The major secondary endpoints of these 8 long-term outcome trials included repeat revascularization and stroke in patients who received PCI or CABG.

Repeat Revascularization. The rate of repeat revascularization observed in each article is outlined in table 2. Except for article eight Farkouh et al. (2012), seven trials including Ahn et al. (2015), Park et al. (2020), Morice et al. (2014), Head et al. (2014), Cavalcante et al. (2016), Stone et al. (2019), and Holm et al. (2020) measured the rate of repeat revascularization. All of

seven trials, from article one to seven, had higher repeat revascularization rate in PCI group vs. CABG group (11.4% vs. 5.5%, 16.1% vs. 8.0%, 26.7% vs. 15.5%, 25.4% vs. 12.6%, 19.5% vs. 10.8%, 16.9% vs. 10%, 17% vs. 10%, respectively) (Table 2).

Table 2: Repeat revascularization rate at the five-year or ten-year follow up

Article	PCI Group	CABG Group
Ahn et al. (2015)	11.4%	5.5%
Park et al. (2020)	16.1%	8.0%
Morice et al. (2014)	26.7%	15.5%
Head et al. (2014)	25.4%	12.6%
Cavalcante et al. (2016)	19.5%	10.8%
Stone et al. (2019)	16.9%	10%
Holm et al. (2020)	17%	10%
Farkouh et al. (2012)	Not Available	Not Available

Stroke. The rate of stroke in each article were shown in Table 3. In two studies of Morice et al. (2014) and Farkouh et al. (2012), rates of stoke were more frequent in the CABG group than in the PCI group. Morice et al. (2014) showed stroke rate of 1.5% for PCI and 4.3% for CABG, and Farkouh et al. (2012) showed 2.4% for PCI and 5.2% for CABG. Similarly, Cavalcante et al. (2016) reported that PCI rate was numerically lower than CABG (1.1% vs. 2.5%), however these two rates did not reach the statistical significance (P = 0.006). On the other hand, the article of Ahn et al. (2015), Park et al. (2020), Head et al. (2014), Stone et al. (2019), and Holm et al. (2020) revealed no significant difference in the rate of stroke between two groups (Table 3).

Table 3: Stroke rate at the five-year or ten-year follow up		
Article	**PCI Group**	**CABG Group**
Ahn et al. (2015)	2.0%	1.7%
Park et al. (2020)	1.9%	2.2%
Morice et al. (2014)	1.5%	4.3%
Head et al. (2014)	3.0%	3.4%
Cavalcante et al. (2016)	1.1%	2.5%
Stone et al. (2019)	2.9%	3.7%
Holm et al. (2020)	4.0%	2.0%
Farkouh et al. (2012)	2.4%	5.2%

Subgroup analysis by SYNTAX score

SYNTAX score is an angiography grading system that evaluate the complexity and prognosis of patients with CAD undergoing PCI or CABG. The score is divided into three parts as low (≤22), intermediate (23-32), and high (≥ 33) SYNTAX score tertiles. The higher SYNTAX scores are associated with more complex CAD and higher postprocedural risk (Neumann et al., 2019). This paper will compare rates of primary endpoints and repeat revascularization between PCI and CABG in the three SYNTAX score subgroups.

Primary Endpoint by SYNTAX Scores. Ahn et al. (2015), Park et al. (2020), Stone et al. (2019), and Farkouh et al. (2012) reported that primary outcome rates were consistent between patients receiving PCI or CABG in all low, intermediate, and high SYNTAX score subgroups. Meanwhile, Holm et al. (2020) found the primary outcome to be significantly higher after PCI than after CABG in all three SYNTAX subgroups. In the study of Head et al. (2014), no significant differences were observed between PCI and CABG groups in patients with low SYNTAX score, however, patients who underwent PCI had significantly higher rates of primary outcome in intermediate and high SYNTAX score subgroups. Meanwhile, Morice et al. (2014)

and Cavalcante et al. (2016) revealed that the rates of primary outcome were similar between PCI and CABG in low and intermediate SYNTAX score groups. However, in patients with high SYNTAX, the PCI group appeared to have higher primary outcome rate than the CABG group.

Repeat Revascularization by SYNTAX Scores. As shown in Table 2, the seven trials excluding Farkouh et al. (2012) demonstrated higher repeat revascularization rate in PCI group compared to CABG group. The rates of repeat revascularization in patients receiving PCI were high overall compared to CABG, with the rate correlating with the increase in SYNTAX scores.

Conclusion

The eight trials in this review compare the risk of all-cause deaths, MI, stroke, and repeat revascularization in patients with complex CAD for patients that underwent PCI or CABG, to determine which of the two procedures are optimal. Overall, PCI was associated with higher rate of repeat revascularization compared to CABG, but the incidence of stroke was lower in patients who underwent PCI. Primary endpoint was comparable between PCI and CABG for five trials, and the other three trials indicated more favorable results in CABG. For patients with low SYNTAX scores, the primary outcome was similar for both PCI and CABG, but PCI had higher rates of repeat revascularization. Additionally, compared to lower SYNTAX scores, patients with high SYNTAX scores seem to benefit more from CABG as opposed to PCI. This suggests that PCI is an acceptable strategy for patients with lower SYNTAX scores, but patients with higher SYNTAX scores will present better outcomes with CABG (Ahn et al., 2015; Park et al., 2020; Morice et al., 2014; Head et al., 2014; Cavalcante et al., 2016; Stone et al., 2019; Holm et al., 2020; Farkouh et al., 2012).

Research Question

Cardiac revascularization for patients with complex CAD is performed commonly worldwide. Two common procedures for cardiac revascularization are CABG and PCI, and both have achieved great progress in research in the recent years (Habib et al., 2015). The purpose of this systemic review is to compare long-term outcomes of CABG and PCI in patients with severe coronary artery disease. The research question was formulated: In patients with multivessel, left main coronary artery disease, or both, does CABG have greater long-term outcomes in mortality, reintervention, myocardial infarction, and stroke rates compared to PCI?

Methods

Research Design

This systemic review is focused on meta-analysis of eight randomized clinical trials (RCTs) comparing the long-term outcomes in patients undergoing CABG and PCI for complex coronary artery disease (CAD). Articles of RCTs reported from January 2012 to March 2022 were identified from Google Scholar, Science Direct, PubMed, EMBASE, and San Jose State University Library Databases with language restriction in English. The search terms “CABG”, “PCI”, “left main disease”, “multivessel coronary disease”, “long-term outcome”, and “RCTs” were used. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist was utilized to collect the relevant research studies in an unbiased manner (Page et al., 2021). A total of 26,859 articles were identified in the initial search, which was selected down to 35 articles after several screenings. Final eight RCTs were selected and included in this systemic review **(Figure 1)**.

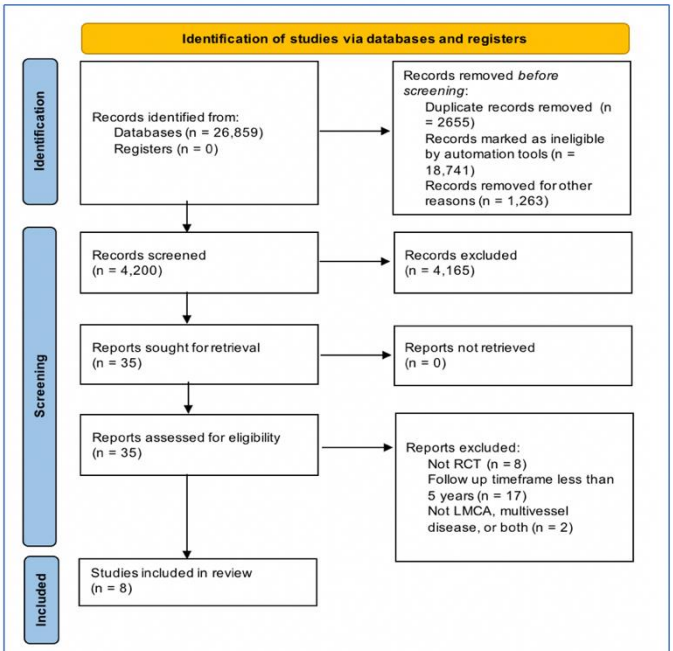

Figure 1. PRISMA flow diagram. Searches of databases and included studies.

Eligibility Criteria and Variables

Eligible trials included following criteria: (1) Comparing CABG and PCI, (2) LMCA, multi-vessel disease, or both, (3) Follow-up periods of five or more years, (4) RCTs including at least 500 recipients of CABG and PCI, and (5) Articles published in the past ten years. Articles were excluded if the study compared CABG alone or PCI alone, follow-up periods less than five years, studies published over ten years, and incomplete information about methods and improper randomization.

The selected eight RTCs were characterized by trial source, number of patients, type of study, follow-up timeframe, types of stent used, and type of patients. The summary of included studies is provided in **Table 4**.

Table 4. Characteristics of included studies

Authors	Source	PCI (n)	CABG (n)	Type of Study	Follow -up (years)	Type of stent used	Type of Patients
Ahn et al. (2015)	PRECOMBAT	300	300	RCT, 13 sites in South Korea	5	Sirolimus DES	LMCA
Park et al. (2020)	PRECOMBAT	300	300	RCT, 13 sties in South Korea	10	Sirolimus DES	LMCA
Morice et al. (2014)	SYNTAX	357	348	RCT, international centers in 17 countries	5	Paclitaxel DES	LMCA
Head et al. (2014)	SYNTAX	546	549	RCT, multinational centers	5	Paclitaxel DES	LMCA or three-vessel disease (3VD)
Cavalcante et al. (2016)	SYNTAX and PRECOMBAT	657	648	RCT, multicenters in 17 countries	5	Sirolimus or Paclitaxel DES	LMCA
Stone et al. (2019)	EXCEL	948	957	RCT, 126 sites in 17 countries	5	Everolimus DES	LMCA
Holm et al. (2020)	NOBLE	592	592	RCT, 36 sites in 9 Northern Europe	5	Umirolimus DES	LMCA
	FREEDOM	953	947	RCT, 25 international centers	5	Sirolimus or Paclitaxel DES	Multivessel coronary disease

Outcomes

Each of the eight meta-analyses of RCTs presented the result of five or more years follow-up after both CABG and PCI, by assessing primary and secondary outcomes. The primary endpoint was the composite of all-cause death, myocardial infarction (MI), stroke, and repeated revascularization or the composite of all-cause death, MI, and stroke. The secondary endpoints were repeat revascularization and stroke.

In addition to the primary and secondary endpoints, subgroup analysis was conducted by patients' Synergy between PCI with Taxus and Cardiac Surgery (SYNTAX) score. The score is divided into three parts as low (≤22), intermediate (23-32), and high (≥ 33) SYNTAX score tertiles. The higher SYNTAX scores are associated with more complex CAD and higher postprocedural risk (Neumann et al., 2019). This meta-analysis will compare rates of primary endpoints and repeat revascularization between PCI and CABG in the three SYNTAX score subgroups.

Statistical Analysis

Continuous variables were stratified by PCI and CABG, presented as mean ± standard deviation (mean ± SD), numbers, and percentages. Clinical data were analyzed according to intention-to-treat principle. The statistical analysis of primary endpoint rate during the follow-up period was visually represented by the Kaplan-Meier methods in time-to-event curves. Multivariate regression analysis with a Cox proportional-hazards model was performed to compare the primary endpoint, repeat revascularization, and stroke between PCI and CABG. In this model, Hazard Ratio (HR) and 95% Cl will be assessed.

Risk of Bias Assessment

To ensure the reliable evidence in the randomized trials, the risk of bias in eight RCTs were assessed. The Cochrane Collaboration's risk of bias tool was utilized and the risk was classified into high, low, or unclear **(Figure 2)**. Risk of bias was evaluated in the seven following aspects: random sequence generation, allocation concealment, blinding of participants and personnel, binding of outcome assessment, incomplete outcome data, selective reporting, and other source of bias (Savović et al., 2014).

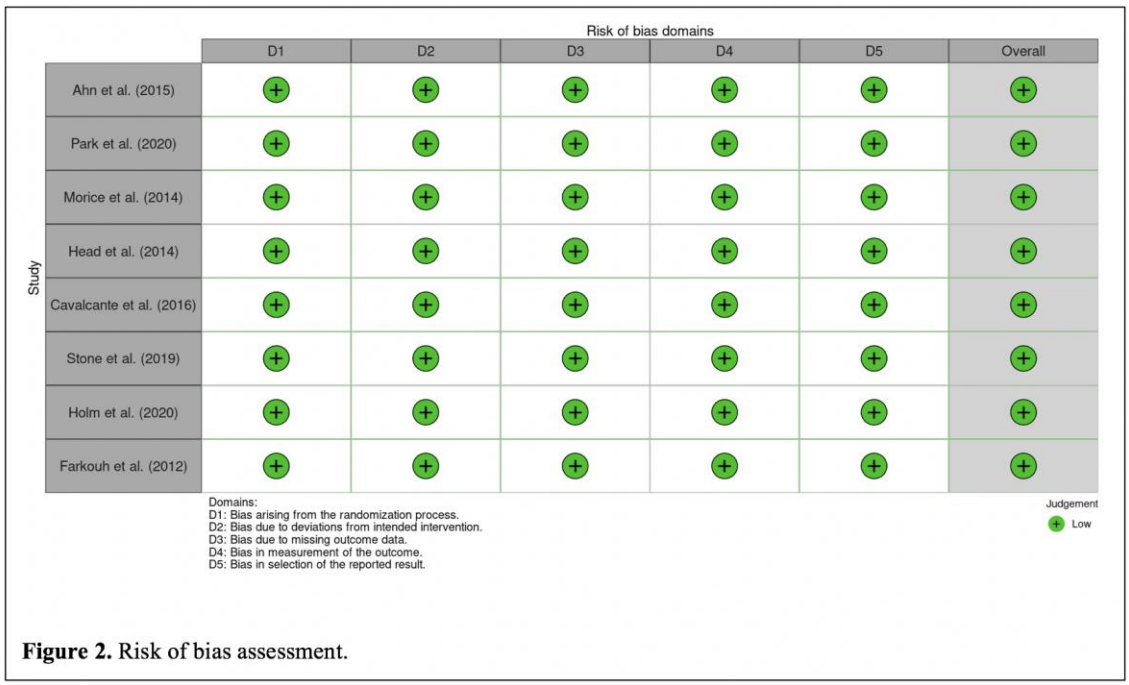

Figure 2. Risk of bias assessment.

Study Limitations

Following these eight studies had several limitations. First, since the follow-up period for these trials were five to ten years, most of the trials used first-generation drug-eluting stents (DES) in PCI, though there are new-generation DES for PCI that have been introduced recently. Investigating the impact of new-generation DES compared to CABG for the long-term follow-up is currently ongoing and more time is needed to evaluate the outcomes. Second, these trials did not reflect upon the detailed cardiovascular medication during the follow up. Whether patients were compliant or non-compliant to the treatment plans after PCI or CABG are unknown. Third, since trials were performed around the world in numerous different facilities, patients have been treated differently during or after the revascularization that may resulted in further complications. It is important to understand that as RCTs reflect the real-world practice and wide variety of patients enrolled, they may carry potential weakness that are not avoidable.

Literature Review Matrix

Author/ Date	Theoretical/ Conceptual Framework	Research Question(s)/ Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future research	Implications For practice
Ahn et al. (2015)	Determine the 5-year outcomes of PCI compared to CABG in patients with LMCA.	Is PCI safe revascularization strategy for LMCA patients compared to CABG?	PRECOMBAT trial involving 279 PCI patients and 275 CABG patients. Follow-up assessment 1,6,9,12 months and yearly thereafter.	There was no significant difference in any-cause of death, MI, or stroke between PCI and CABG. Repeat revascularization occurred more frequently in PCI.	At 5 years, MACCE rate in patients who underwent PCI and CABG did not show significant differences.	Additional studies of a larger number of patients and longer follow-up are needed.	Insight on long-term outcomes that can help on deciding the optimal revascularization strategy.
Park et al. (2020)	10-year outcomes after PCI and CABG for LMCA patients.	Is PCI safe revascularization strategy for LMCA patients compared to CABG in long-term outcomes?	PRECOMBAT trial involving 279 PCI patients and 275 CABG patients. 11.3 years of median follow-up duration.	No significant differences in MACCE, but higher repeat revascularization rate in PCI group.	At 10-year follow-up, there was no significant difference in MACCE rate of PCI and CABG groups.	Lack of yearly follow-up between five to ten years. Need improvement for future research conducting a long-term follow-up.	This trial is a lager-sized RCT with 10-years follow up that can further help to decide the optimal strategy.
Morice et al. (2014)	Compare 5-year outcomes of LMCA	CABG superior to PCI. Lower incidence of stroke for	SYNTAX trial conducted in 17 countries involving 357	MACCE rate similar between two groups. However, stroke was significantly	No overall differences in MACCE. Patients with	Longer follow-up and additional	PCI can be an alternative procedure in

	patients who received PCI or CABG.	CABG, and increased risk of repeat revascularization with PCI.	PCI and 348 CABG patients.	increased after CABG. Repeat revascularization was higher after PCI.	high SYNTAX score seem to benefit more from CABG.	treatment arm may be needed.	patients with low SYNTAX score.
Head et al. (2014)	Analyze 5-year outcomes of 3VD patients receiving PCI or CABG.	Improvement in PCI lead complex CAD patients being treated with PCI instead of CABG.	SYNTAX trial involving 546 PCI and 549 CABG. Yearly follow-up every year by clinic visit or telephone.	MACCE was significantly higher in PCI compared to CABG. Cardiac death and MI higher in PCI. Repeat revascularization more frequent after PCI. No significant difference in stroke between two groups.	CABG was associated with significant lower rate of death, MI, and revascularization. PCI is acceptable treatment in patients with low SYNTAX score, though PCI have higher repeat revascularization rate.	RCT are needed to assess newer-generation DES for PCI. Also, this trial was only for 3VD patients. Study for more variety coronary artery patients are needed.	PCI can be an alternative procedure in patients with low SYNTAX score.
Cavalcante et al. (2016)	Compare 5-year outcomes of CABG and PCI in LMCA patients.	Improvement in PCI lead complex CAD patients being treated with PCI instead of CABG. Which one is the best revascularization strategy?	SYNTAX and PRECOMBAT trial involving 657 PCI and 648 CABG patients.	MACCE similar between two groups. PCI had higher rate of repeat revascularization. In high SYNTAX score group, repeat revascularization and MACCE after PCI was more frequent than lower SYNTAX score groups.	CABG is associated with reduced need for repeat revascularization. In patient with low to intermediate SYNTAX score, PCI is acceptable treatment.	Investigating the impact of new-generation DES compared to CABG for the long-term follow-up is needed.	PCI can be an alternative procedure in patients with low to intermediate SYNTAX score.
Stone et al. (2019)	5-year outcomes of PCI compared with CABG in LMCA patients.	Long-term outcomes after PCI in LMCA patients are not clear. Can PCI replace CABG?	EXCEL trial assigned at 126 sites in 17 countries involving 948 PCI and 957 CABG patients.	Rates of primary outcome were similar between two groups. Stroke was less frequent after PCI, but repeat revascularization was more frequent after CABG.	No significant difference in primary outcome between two groups.	More studies needed including more patients with LMCA disease and high SYNTAX score.	PCI can be an alternative procedure in patients with low to intermediate SYNTAX score.
Holm et al. (2020)	5-year outcomes of PCI compared with CABG in LMCA patients.	The use of PCI is increasing in patients with LMCA. Can PCI replace the standard treatment of CABG?	NOBLE trial involving 598 PCI and 603 CABG patients enrolled at 36 hospitals.	In MACCE rate, CABG found to be superior to PCI. Repeat revascularization higher in PCI. MACCE of all low, intermediate, and high SYNTAX score patients was higher after PCI.	Does not suggest PCI to be suitable in patients with low SYNTAX score. PCI had higher rates of repeat revascularization.	Additional studies of a longer follow-up are needed.	This trial does not suggest PCI to be suitable in patients with low SYNTAX score.
Farkouh et al. (2012)	5-year outcomes of PCI and CABG in patients with diabetes and multivessel CAD.	Whether CABG or PCI is a superior approach to revascularization?	FREEDOM trial at 140 international centers involving 954 PCI and 947 CABG patients.	Primary outcome, MI, and Stroke were higher in PCI. Stroke was more frequent after CABG.	CABG is superior to PCI in patients with DM and multivessel CAD. CABG significantly reduce rate of death and MI, but higher rate of stroke.	Patients may have been treated differently on the basis of the surgical procedure.	CABG is a better revascularization option for diabetic and advance CAD patients.

References

Ahn, J.-M., Roh, J.-H., Kim, Y.-H., Park, D.-W., Yun, S.-C., Lee, P. H., Chang, M., Park, H. W., Lee, S.-W., Lee, C. W., Park, S.-W., Choo, S. J., Chung, C. H., Lee, J. W., Lim, D.-S., Rha, S.-W., Lee, S.-G., Gwon, H.-C., & Park, S.-J. (2015, March 15). *Randomized trial of stents versus bypass surgery for left main coronary artery disease: 5-year outcomes of the PRECOMBAT study*. Journal of the American College of Cardiology. Retrieved from https://www.sciencedirect.com/science/article/pii/S0735109715008414?via%3Dihub

Brown, J. C., Gerhardt, T. E., & Kwon, E. (2021, June 5). *Risk factors for coronary artery disease*. Retrieved from https://pubmed.ncbi.nlm.nih.gov/32119297/ f

Cavalcante, R., Sotomi, Y., Lee, C. W., Ahn, J.-M., Farooq, V., Tateishi, H., Tenekecioglu, E., Zeng, Y., Suwannasom, P., Collet, C., Albuquerque, F. N., Onuma, Y., Park, S.-J., & Serruys, P. W. (2016, August 29). *Outcomes after percutaneous coronary intervention or bypass surgery in patients with unprotected left main disease*. Journal of the American College of Cardiology. Retrieved from https://www.sciencedirect.com/science/article/pii/S0735109716336737?via%3Dihub

Centers for Disease Control and Prevention. (2021, July 19). *Coronary artery disease*. Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/heartdisease/coronary_ad.htm

Deb, S., Wijeysundera, H. C., Ko, D. T., Tsubota, H., Hill, S., & Fremes, S. E. (2013, November 20). *Coronary Artery Bypass Graft Surgery vs Percutaneous Interventions in Coronary*

Revascularization: A Systematic Review. JAMA. Retrieved from https://jamanetwork.com/journals/jama/article-abstract/1779540

Farina, P., Gaudino, M. F. L., & Taggart, D. P. (2019, August 20). *The eternal debate with a consistent answer: CABG VS PCI.* Seminars in Thoracic and Cardiovascular Surgery. Retrieved from https://www.sciencedirect.com/science/article/pii/S1043067919301820

Farkouh, M. E., Domanski, M., Sleeper, L. A., Siami, F. S., Dangas, G., Mack, M., Yang, M., Cohen, D. J., Rosenberg, Y., Solomon, S. D., Desai, A. S., Gersh, B. J., Magnuson, E. A., Lansky, A., Boineau, R., Weinberger, J., Ramanathan, K., Rankin, J., Bhargava, B., … Fuster, V. (2012, December 20). *Strategies for multivessel revascularization in patients with diabetes: Nejm*. New England Journal of Medicine. Retrieved from https://www.nejm.org/doi/10.1056/NEJMoa1211585

Habib, R. H., Dimitrova, K. R., Badour, S. A., Yammine, M. B., El-Hage-Sleiman, A.-K. M., Hoffman, D. M., Geller, C. M., Schwann, T. A., & Tranbaugh, R. F. (2015, September 1). *CABG versus PCI: Greater benefit in long-term outcomes with multiple arterial bypass grafting*. Journal of the American College of Cardiology. Retrieved from https://www.jacc.org/doi/full/10.1016/j.jacc.2015.07.060

Head, S. J., Davierwala, P. M., Serruys, P. W., Redwood, S. R., Colombo, A., Mack, M. J., Morice, M.-C., Holmes, D. R., Feldman, T. E., Ståhle, E., Underwood, P., Dawkins, K. D., Kappetein, A. P., & Mohr, F. W. (2014, May 21). *Coronary artery bypass grafting vs. percutaneous coronary intervention for patients with three-vessel disease: Final Five-year*

follow-up of the syntax trial. European Heart Journal, Volume 35, Issue 40. Retrieved from https://academic.oup.com/eurheartj/article/35/40/2821/2293222?login=false

Holm, N. R., Mäkikallio, T., Lindsay, M. M., Spence, M. S., Erglis, A., Menown, I. B. A., Trovik, T., Kellerth, T., Kalinauskas, G., Mogensen, L. J. H., Nielsen, P. H., Niemelä, M., Lassen, J. F., Oldroyd, K., Berg, G., Stradins, P., Walsh, S. J., Graham, A. N. J., & Christiansen, E. H. (2019, December 23). *Percutaneous coronary angioplasty versus coronary artery bypass grafting in the treatment of unprotected left main stenosis: Updated 5-year outcomes from the randomised, non-inferiority Noble trial*. The Lancet Volume 395, Issue 10219. Retrieved March 31, 2022, from https://www.sciencedirect.com/science/article/pii/S0140673619329721

Jadhav, K. P., & Jariwala, P. V. (2020, October 5). *Evolving Concepts in Post-PCI Antiplatelets Therapy*. Indian Journal of Clinical Cardiology. Retrieved from https://journals.sagepub.com/

Mack, M. J., Squiers, J. J., Lytle, B. W., DiMaio, J. M., & Mohr, F. W. (2021, July 19). *Myocardial revascularization surgery: JACC historical breakthroughs in perspective*. Journal of the American College of Cardiology. Retrieved from https://www.sciencedirect.com/science/article/pii/S0735109721051858

Morice, M.-C., Serruys, P. W., Kappetein, A. P., Feldman, T. E., Ståhle, E., Colombo, A., Mack, M. J., Holmes, D. R., Choi, J. W., Ruzyllo, W., Religa, G., Huang, J., Roy, K., Dawkins, K. D., & Mohr, F. (2014, April 3). *Five-year outcomes in patients with left main disease treated with either percutaneous coronary intervention or coronary artery bypass grafting*

in the synergy between percutaneous coronary intervention with Taxus and cardiac surgery trial. Circulation Vol 129, Issue 23. Retrieved from https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.113.006689?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub++0pubmed

Neumann, F.-J., Sousa-Uva, M., Ahlsson, A., Alfonso, F., Banning, A. P., Benedetto, U., Byrne, R. A., Collet, J.-P., Falk, V., Head, S. J., Jüni, P., Kastrati, A., Koller, A., Kristensen, S. D., Niebauer, J., Sibbing, D., Stefanini,, G. G., Windecker, S., Yadav, R., … Richter, D. J. (2019, July 1). *2018 ESC/EACTS Guidelines on myocardial revascularization*. European Heart Journal, Volume 40, Issue 2. Retrieved from https://doi.org/10.1093/eurheartj/ehy394

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021, March 29). *The Prisma 2020 statement: An updated guideline for reporting systematic reviews*. The BMJ. Retrieved from https://www.bmj.com/content/372/bmj.n71

Park, D.-W., Ahn, J.-M., Park, H., Yun, S.-C., Kang, D.-Y., Lee, P. H., Kim, Y.-H., Lim, D.-S., Rha, S.-W., Park, G.-M., Gwon, H.-C., Kim, H.-S., Chae, I.-H., Jang, Y., Jeong, M.-H., Tahk, S.-J., Seung, K. B., & Park, S.-J. (2020, March 30). *Ten-year outcomes after drug-eluting stents versus coronary artery bypass grafting for left main coronary disease*. Circulation Volume 141, Issue 18. Retrieved from https://www.ahajournals.org/doi/full/10.1161/CIRCULATIONAHA.120.046039

Pencina, M. J., Navar, A. M., Wojdyla, D., Sanchez, R. J., Khan, I., Elassal, J., D'Agostino Sr, R. B., Peterson, E. D., & Sniderman, A. D. (2018, December). *Quantifying importance of major risk factors for coronary Heart Disease*. Circulation. Retrieved from https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.117.031855

Savović, J., Weeks, L., Sterne, J. A. C., Turner, L., Altman, D. G., Moher, D., & Higgins, J. P. T. (2014, April 15). *Evaluation of the cochrane collaboration's tool for assessing the risk of bias in randomized trials: Focus Groups, online survey, proposed recommendations and their implementation - systematic reviews*. BioMed Central. Retrieved from https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/2046-4053-3-37

Spadaccio, C., & Benedetto, U. (2018, July). *Coronary artery bypass grafting (CABG) vs. percutaneous coronary intervention (PCI) in the treatment of Multivessel Coronary Disease: Quo vadis? -A review of the evidences on coronary artery disease*. Annals of cardiothoracic surgery. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6082779/#r15

Stone, G. W., Kappetein, A. P., Sabik, J. F., Pocock, S. J., Morice, M.-C., Puskas, J. P., Kandzari, D. E. K., Karmpaliotis, D. K., Brown, M., Lembo, N. J., Banning, A., & Merkely, B. (2020, July 16). *Five-year outcomes after PCI or CABG for left main coronary disease: Nejm*. New England Journal of Medicine. Retrieved from https://www.nejm.org/doi/full/10.1056/nejmoa1909406

Volgman, A. S., Palaniappan, L. S., Aggarwal, N. T., Gupta, M., Khandelwal, A., Krishnan, A. V., Lichtman, J. H., Mehta, L. S., Shah, K. S., Shah, S. H., & Watson, K. E. (2018, May

24). *Atherosclerotic cardiovascular disease in South Asians in the United States* . Circulation. Retrieved from https://www.ahajournals.org/doi/10.1161/CIR.0000000000000580