Is it appropriate when the Heart Team changes the decision regarding the modality of myocardial revascularization?

Da li je u redu kada kardiohirurški konzilijum promeni odluku o načinu revaskularizacije miokarda?

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Abstract

Background/Aim. Decision-making by the Heart Team is an established way of making appropriate decisions regarding the management of patients with coronary artery disease. In clinical practice, it is not infrequent to see changes in decisions made by different Heart Teams. However, clinical implications regarding changes in the Heart Team decisions are not clear. The aim of this study was to determine clinical implications of change in the Heart Team decision in patients in whom surgical myocardial revascularization was advised first but consequently changed to percutaneous coronary intervention (PCI). **Methods.** We retrospectively analyzed data for 1,501 patients admitted to a single tertiary care high-volume center for coronary artery bypass grafting (CABG). In all patients, decisions were made by the Heart Team prior to admission. Upon admission, decisions were reevaluated by another Heart Team. The decision regarding the mode of revascularization was changed in 73 (4.86%) of patients. Propensity matching was made with patients from the same population who underwent CABG. Patients in both groups were followed for major adverse cardiac events (MACE) and total mortality for 12 months. **Results.** PCI and CABG groups were balanced with respect to demographic and clinical characteristics. All patients had two- and three vessel disease, with similar incidence of left main stenosis (26% in the PCI group and 30.10% in the CABG group). EuroSCORE II was similar between the groups (2.48 ± 2.38 vs. 2.36 ± 2.92). During the follow-up period, a total of 5 (6.80%) MACE in the PCI group and 12 (5.80%) MACE in the CABG group were observed (log rank 0.096, $p = 0.757$). A total of 6 (8.20%) patients died in the PCI group, and 15 (7.30%) patients died in the CABG group (log rank 0.067, $p = 0.796$). **Conclusion.** Our data indicate that patients in whom CABG was advised first but consequently changed to PCI have a prognosis similar to CABG patients over 12 months after the index procedure.

Key words:
cardiologists; coronary disease; decision making; mortality; myocardial revascularization; percutaneous coronary intervention; treatment outcome.

Apstrakt

Uvod/Cilj. Odlučivanje od strane kardiohirurškog konzilijuma je uspostavljen način donošenja odgovarajućih odluka koje se tiču zbrinjavanja bolesnika sa oboljenjem koronarnih arterija. U kliničkoj praksi nisu retkost promene u odlukama različitih kardiohirurških konzilijuma. Međutim, kliničke implikacije u vezi sa promenama odluka kardiohirurških konzilijuma nisu jasne. Cilj rada je bio da se utvrde kliničke implikacije promene u odluci kardiohirurškog konzilijuma kod bolesnika kojima je prvo preporučena hirurška revaskularizacija miokarda, ali je ta odluka posledično promenjena u perkutanu koronarnu intervenciju (PKI). **Metode.** Retrospektivno su analizirani podaci za 1 501 bolesnika koji su bili primljeni u jedan centar visokog obima tercijarne nege za koronarni arterijski bajpas grafting (KABG). Kod svih bolesnika odluke su bile donete od strane kardiohirurškog konzilijuma pre prijema. Posle prijema, odluke su ponovo procenjivane od strane drugog kardiohiruškog konzilijuma. Odluka o načinu revaskularizacije promenjena je kod 73 (4,86%) bolesnika. Urađeno je usklađivanje skora podudarnja sa bolesnicima iz iste populacije koji su podvrgnuti KABG. Bolesnici u obe grupe praćeni su zbog velikih neželjenih kardiovaskularnih događaja (VNKVD) i ukupnog mortaliteta tokom 12 meseci. **Rezultati.** Grupe PKI i KABG bile su uravnotežene u odnosu na demografske i kliničke karakteristike. Svi bolesnici su imali dvosudovnu ili trosudovnu koronarnu bolest, sa sličnom učestalošću stenoze glavnog stabla (26% u PKI i 30,10% u KABG grupi). EuroSCORE II je bio sličan između grupa (2,48 ± 2,38 vs. 2,36 ± 2,92). Tokom perioda praćenja primećeno

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je ukupno 5 (6,80%) VNKVD u PKI grupi i 12 (5,80%) VNKVD u KABG grupi (log rank 0,096, p = 0,757). Ukupno 6 (8,20%) bolesnika umrlo je u grupi PKI, a 15 (7,30%) je umrlo u KABG grupi (log rank 0,067, p = 0,796). **Zaključak.** Naši podaci ukazuju na to da bolesnici kojima je prvi put savetovan KABG, ali je odluka posledično promenjena na PKI imaju sličnu prognozu kao i bolesnici sa KABG, 12 meseci nakon indeksne procedure.

Ključne reči:
kardiolozi; koronarna bolest; odlučivanje; mortalitet; miokard, revaskularizacija; perkutana koronarna intervencija; lečenje, ishod.

Introduction

There are two different modalities of myocardial revascularization: coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) [1]. Clinical practice and trials have shown that neither CABG nor PCI can individually provide the solution for the entire spectrum of patients with coronary artery disease. Therefore, the decision regarding myocardial revascularization must be made for each patient individually, based on the estimated surgical mortality, the anatomical complexity of coronary artery disease and the possibility of complete revascularization [2]. Decision making is particularly difficult in patients with left main stenosis and multivessel coronary disease, as well as in patients with numerous risk factors and comorbidities, including anatomic risk factors (chronic total occlusion and high-risk bifurcation stenosis) [3].

Previous studies indicate that a lower rate of major adverse cardiovascular events (MACE), as well as the possibility of complete revascularization, are the most important advantages of CABG over PCI. Therefore, in previous decades, CABG was considered a standard of care for patients with left main (LM) stenosis, as well as multivessel coronary disease [4]. On the other hand, these data were obtained before the advent of drug-eluting stents (DES), and therefore may not be applicable in the current era. By slowly releasing antiproliferative and antimitotic agents to the arterial wall, DESs have dramatically reduced the incidence of restenosis and improved clinical outcomes in these patients (reducing rates of recurrent angina and repeat revascularizations and improving the quality of life) [5, 6]. Also, when risk factors for postoperative morbidity and mortality are considered, the decision regarding modality of revascularization can shift from CABG towards PCI [7]. Patients with numerous comorbidities are more suitable for PCI, mostly because of the shorter hospitalization period, faster recovery, and less frequent postprocedural stroke [7, 8].

The SYNTAX study was the first randomized clinical trial to compare clinical outcomes after surgical and percutaneous myocardial revascularization in patients with LM stenosis and/or multivessel coronary disease [9]. The SYNTAX study introduced SYNTAX score as a unique tool that predicts the outcome after myocardial revascularization based on the anatomical complexity of coronary artery disease.

Guidelines on myocardial revascularization suggest a balanced, multidisciplinary decision-making process by the Heart Team, consisting of cardiac surgeons, interventional cardiologists, and attending cardiologists [2, 10]. The Heart Team should meet on a regular basis to analyze and interpret the available diagnostic evidence, determine the need for myocardial revascularization, and assess the long-term safety and efficacy of the percutaneous and surgical revascularization. Interdisciplinary institutional protocols should be developed for common case scenarios. On the other hand, patients with complex coronary disease and multiple comorbidities require an individual approach, with additional input from other specialties when needed [2]. In these patients, decision making is not easy, and it is often the case that by reexamining the documentation and the patients' preferences the Heart Team changes the primary decision.

Therefore, the aim of this study was to determine clinical outcomes in patients in whom surgical myocardial revascularization was advised first, but consequently changed to PCI.

Methods

Patients

We retrospectively analyzed data for 1,501 patients admitted to Dedinje Cardiovascular Institute, Belgrade (Serbia) for CABG. In all patients, the decision regarding myocardial revascularization was made by the Heart Team prior to admission. Upon admission, the initial decision made by the Heart Team was reevaluated by another Heart Team. The decision regarding revascularization modality was changed from CABG to PCI in 73 (4.86%) of patients. The reasons for the change of the Heart Team's decision were: reevaluation of coronary anatomy in favor of PCI in 48 patients, high surgical risk in 24 patients, and the patient's preference in 1 patient.

The patients were followed during a 12-month period after the index procedure for major adverse cardiovascular and cerebrovascular events (MACCE) and total mortality. MACCE included nonfatal cerebrovascular insult, nonfatal myocardial infarction, and cardiovascular causes of death. Total mortality was a composite of cardiovascular and noncardiovascular causes of death. The data regarding MACCE and total mortality were collected on control exams one, six, and twelve months after the index procedure, as well as by phone calls to patients and/or their relatives.

The aim of the study was to compare the difference in the occurrence of MACCE and total mortality between the group of patients who underwent CABG and the group of patients in whom revascularization modality was changed to PCI, as well as to compare total mortality between these two groups.

For each patient the following data were collected: age, gender, hypertension (HTA), smoking, diabetes mellitus (DM), prior myocardial infarction (MI), presence of chronic obstructive pulmonary disease (COPD), and presence of peripheral vascular disease (PVD). For each patient left ventricle ejection fraction (LVEF) and creatinine clearance (CrCl) were calculated. CrCl was calculated by the Cockcroft-Gault equation, using an online calculator (https://www.mdcalc.com/creatinine-clearance-cockcroft-gault-equation). LVEF was evaluated by transthoracic echocardiographic examination (TTE) using the Vivid® 9 ultrasound machine (GE Healthcare; Wausheka, Wisconsin, USA), based on the Simpson method.

We used SYNTAX score and SYNTAX score II, which were taken out from guidelines in 2018, in order to analyze the anatomical complexity of coronary artery disease, in addition to clinical parameters. SYNTAX score predicts the outcome after myocardial revascularization based on the anatomical complexity of coronary artery disease [11]. SYNTAX score II is a tool that improves decision-making between CABG and PCI by combining anatomical and clinical variables. By providing accurate assessment of mortality after myocardial revascularization, SXNTAX score II identifies patients for whom either CABG or PCI had a more favorable long-term outcome, and patients for whom long-term outcomes between CABG and PCI were similar [12]. SYNTAX score and SYNTAX score II were calculated using online calculators (http://www.syntaxscore.com/). SYNTAX score and SYNTAX score II were calculated only in the PCI group because we did not have access to coronary angiograms of the patients in the CABG group. Based on the SYNTAX score value, the patients who underwent PCI were divided into three groups: group I: 0–22; group II: 23–32; group III: ≥ 33. Based on the SYNTAX score II recommendation for revascularization modality, those patients were also divided into three groups: CABG only, CABG or PCI, PCI only.

EuroSCORE II was used to calculate perioperative risk for all patients. EuroSCORE II is a prediction model which estimates perioperative mortality for patients undergoing cardiac surgery [13]. The data used to calculate EuroSCORE II were obtained from the Dedinje Cardiovascular Institute patient database. EuroSCORE II was calculated using an online calculator (http://www.euroscore.org/calc.html).

Heart Team

The Heart Team discusses optimal treatment modalities for all patients admitted to Dedinje Cardiovascular Institute. Heart Teams consist of cardiac surgeons, clinical cardiologists, and interventional cardiologists. Our Heart Team consists of 10 cardiac surgeons, 10 interventional cardiologists, and 4 clinical cardiologists. By analyzing coronary angiograms, echocardiographic findings, functional test findings, as well as the clinical parameters, the Heart Team makes a decision regarding the optimal treatment modality for each patient. If myocardial revascularization is preferable, the Heart Team makes a decision regarding the revascularization modality. The Heart Team makes approximately 8,600 decisions annually.

PCI procedure

PCI was performed by one of 10 interventional cardiologists. As an arterial approach for the PCI procedure, the right radial artery or the right femoral artery were used. Standard PCI protocol was used in all patients: initially, optimal dose of unfractionated heparin (UFH) [60–100 international units (IU) per kilogram (kg)] was administered, following implantation of optimal size DES. Hemostasis was performed by a transradial bracelet (in case of transradial approach) or by manual compression (in case of transfemoral access). At hospital discharge, patients who had undergone the PCI procedure dual antiplatelet therapy for at least 6 months, as well as other therapy according to the guidelines [2].

In order to compare 73 patients in whom the indication was changed from CABG to PCI (the PCI group), with 1,501 patients in whom surgical revascularization was performed, we used propensity score matching (PSM). The matching score is the probability that a unit with certain characteristics will be assigned to the treatment group (as opposed to the control group). PSM creates the participants' treatment ratios (the treatment and control groups). A "matched" set consists of at least one participant in the treatment group and one in the control group having a similar matching score.

In a group of 73 patients in whom the indication was changed from CABG to PCI (the PCI group), we selected clinical and demographic characteristics which we considered to be the best descriptors of the patient population. Afterwards, logistic regression was performed in the whole group of patients, based on these characteristics, in order to calculate propensity scores. Once the propensity scores were calculated, we performed the nearest neighbor matching with replacement, in order to compare one patient in the PCI group to more than one patient with similar clinical and demographic characteristics in the CABG group. Using PSM, a total of 206 patients, in whom surgical revascularization was performed, were identified (the CABG group).

The data analyzed in the study are presented as absolute numbers, percentages, or as mean value ± standard deviation (SD). The paired samples *t*-test was applied in order to compare subgroups for continuous variables. Differences in the incidence of MACCE and total mortality between the two groups were analyzed by using the Kaplan-Meier analysis. The value of $p < 0.05$ was considered a statistically significant difference. Statistical data analysis was performed by using the IBM SPSS Statistics (version 25).

Results

Clinical and demographic characteristics

Regarding the clinical and demographic characteristics, there was no statistically significant difference between the patients in the two groups, PCI and CABG ($p > 0.05$). In both

groups patients were dominantly male (69.90% vs. 72.80%). The average age in the PCI group was 66.18 ± 8.56 years, while in the CABG group it was 65.60 ± 5.05 years. The most common risk factor in both groups was hypertension (98.60% in the PCI group and 92.70% in the CABG group). 43.80% of the patients in the PCI group and 43.20% of the patients in the CABG group had DM. Clinical and demographic characteristics of patients are presented in Table 1.

32.90% of patients, while three coronary arteries were treated in 5.50% of patients. The PCI procedure of the LM coronary artery was performed in 17.80% of patients. In the CABG group, surgical myocardial revascularization with triple coronary artery bypass grafting was performed in 59.20% of patients, while quadruple CABG was performed in 28.60% of patients. Surgical myocardial revascularization with double CABG was performed in 10.20% of patients,

Table 1

Clinical and demographic characteristics of patients who underwent percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) in relation to the revascularization modality

Variable	PCI group (n = 73)	CABG group (n = 206)	p
Age (years), x̄ ± SD	66.18 ± 8.564	65.6 ± 5.05	0.49
Male, n (%)	51 (69.9)	150 (72.8)	0.63
DM, n (%)	32 (43.8)	89 (43.2)	0.93
HTA, n (%)	72 (98.6)	191 (92.7)	0.06
Smoking, n (%)	42 (57.5)	97 (47.1)	0.13
COPD, n (%)	6 (8.2)	12 (5.8)	0.47
PVD, n (%)	21 (28.8)	43 (20.9)	0.17
MI, n (%)	43 (58.9)	117 (56.8)	0.76
LM, n (%)	19 (26)	62 (30.1)	0.51
LVEF, x̄ ± SD	43.01 ± 13.14	44.32 ± 12.04	0.44
CrCl, x̄ ± SD	77.66 ± 31.11	79.49 ± 15.39	0.52
ES II, x̄ ± SD	2.48 ± 2.38	2.36 ± 2.92	0.76

x̄ – mean value; SD – standard deviation; DM – diabetes mellitus; HTA – hypertension; COPD – chronic obstructive pulmonary disease; PVD – peripheral vascular disease; MI – myocardial infarction; LM – left main; LVEF – left ventricular ejection fraction; CrCl – creatinine clearance; ES II – EuroSCORE II.

EuroSCORE II

The mean value of EuroSCORE II in the PCI group was 2.48 ± 2.38%. Compared to the CABG group, where the mean value was 2.36 ± 2.92%, there was no statistically significant difference ($p = 0.764$).

SYNTAX score and SYNTAX score II

As for the SYNTAX score in the PCI group, we identified 34 patients in the group I (46.60%), 25 patients in the group II (34.20%) and 14 patients in the group III (19.20%). Regarding the recommendation for the revascularization modality based on the SYNTAX score II, 27 patients (37%) had a recommendation for "CABG only", 45 patients (61.6%) had a recommendation for "CABG or PCI", and 1 patient (1.40%) had a recommendation for "PCI only".

Procedure characteristics

In the PCI group, in most cases (43.80%), one coronary artery was treated. Two coronary arteries were treated in

while 1% of patients underwent surgical revascularization with single CABG, and the same percentage with quintuple CABG.

Follow-up

The follow-up period was 12 months, and included 100% of patients in both groups. In the PCI group, 5 MACCEs (6.80%) were observed, of which all 5 were due to cardiovascular causes of death. Neither nonfatal MI nor nonfatal stroke was observed. In the CABG group, 12 MACCEs (5.80%) were observed, of which all 12 were due to cardiovascular causes of death, while nonfatal MI and nonfatal stroke were not detected. Total mortality in the PCI group was 6 (8.20%), of which 5 deaths were due to cardiovascular causes, while one death was due to an accident (a fall from a window). In the CABG group, total mortality was 15 (7.30%), with cardiovascular deaths in 12 patients, while death due to respiratory failure occurred in 2 patients, and 1 death was caused by lung carcinoma. Kaplan-Meir analysis showed no statistically significant difference in MACCE rates (Log-Rank *p* value = 0.757)

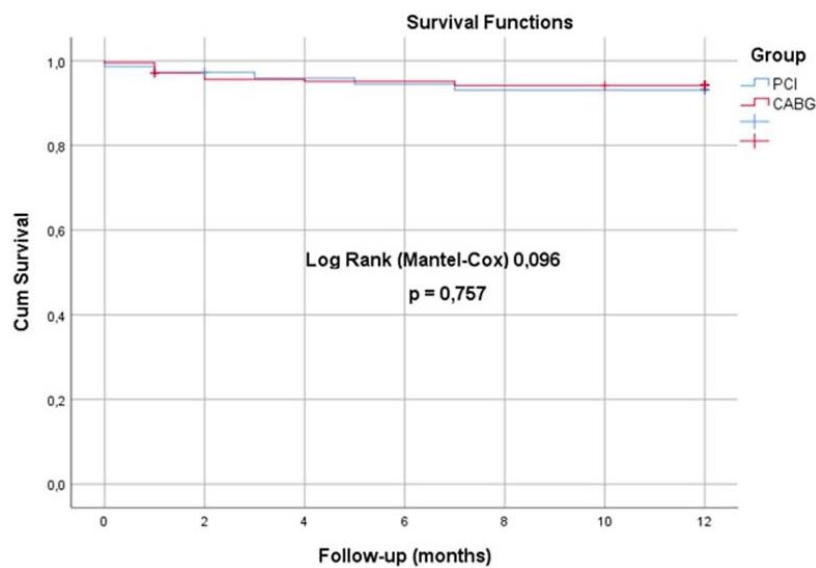(Figure 1) and total mortality (Log-Rank *p* value = 0.796) (Figure 2) between the PCI and CABG groups.

Fig. 1 – Kaplan-Meir analysis of major adverse cardiovascular and cerebrovascular events (MACCE) in the percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) groups.
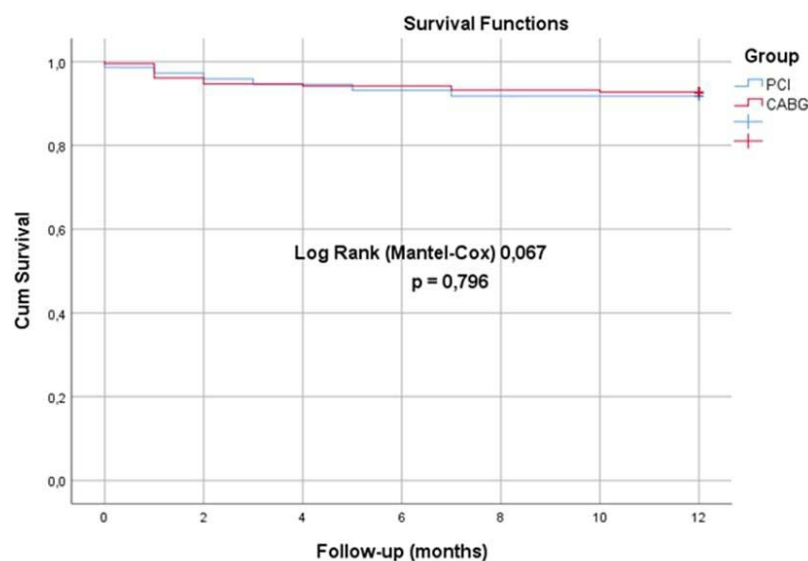

Fig. 2 – Kaplan-Meir analysis of total mortality in the percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) groups.

Discussion

Our results indicate that during a one-year follow-up period there was no statistically significant difference in overall mortality and incidence of MACCE between patients who underwent CABG and those who were reassigned to PCI.

The present study included mostly patients with less complex coronary artery disease. The average perioperative risk, as described by EuroSCORE II, was relatively low

(2.48% in the PCI group and 2.36% in the CABG group). As for anatomical complexity of coronary artery disease, the majority of patients in the PCI group had low SYNTAX score (46.60% of patients). Observing SYNTAX score II, most patients who underwent PCI were suitable for both PCI and CABG. Clinically and anatomically uncomplicated coronary artery disease, as well as similar patient characteristics in both groups, are possible explanations for a relatively good outcome and low incidence of adverse events, which did not significantly differ in the examined groups.

Interestingly, in the group of patients who underwent surgical revascularization but were not included in PSM, a

total of 87 MACCEs (7.12%) were observed, of which 28 (2.29%) were due to cardiovascular causes of death, while 32 (2.62%) patients had nonfatal myocardial infarction, and 27 (2.21%) patients had nonfatal stroke. Total mortality in this group was 50 (4.09%), of which 28 deaths were due to cardiovascular causes and 22 deaths were due to noncardiovascular causes.

Our results are comparable to the results of the ARTS II study, which compared safety and efficacy of drug-eluting stents in patients with *de novo* multivessel coronary artery disease with historical controls that underwent surgical revascularization [14]. Similarly to our study, during a one-year follow-up period, the ARTS II study showed that there was no statistically significant difference in overall mortality and incidence of MACCEs between these two groups. On the other hand, after two and three years, following a comparatively greater number of additional MACCEs in the DES group, the overall MACCE rate was insignificantly higher in the DES group. This was mainly caused by relatively higher rates of reintervention in the DES group compared to the CABG group, as a result of late stent thrombosis. Results showed that 32% of adverse events occurred due to late stent thrombosis, mostly after two- and three-year follow-up periods.

The SYNTAX trial was designed to assess the optimal revascularization strategy between percutaneous coronary intervention and coronary artery bypass grafting, for patients with left main and/or three-vessel coronary disease. A five-year follow-up of these patients has shown that the outcome is significantly affected by the complexity of coronary artery disease [15]. In patients with a low SYNTAX score (0–22), total mortality and MACCE rates did not significantly differ between the treated groups. On the other hand, the difference in total mortality and the MACCE rates was observed only in the patients with intermediate (23–32) and high (≥ 33) SYNTAX scores after the third year [16], mostly due to stent thrombosis and MI. These results suggest that CABG is a standard of care for patients with complex lesions (high or intermediate SYNTAX score), while patients with less complex coronary disease (SYNTAX score ≤ 22) can safely and efficiently be treated with PCI. In our study, almost half of the patients (n = 34) in the PCI group had a low SYNTAX score, which can possibly explain relatively good outcomes and low rates of both endpoints.

The outcome after myocardial revascularization depends not only on anatomical and clinical complexity of coronary artery disease, but also on comorbidities and risk factors, including DM. In our study, 32 (48.3%) patients in the PCI group and 89 (43.2%) patients in the CABG group had DM. The FREEDOM trial compared outcomes after PCI and CABG in high-risk diabetic patients with multivessel coronary disease [17]. All the treated patients had numerous comorbidities, including hypertension, hyperlipidemia, and diabetes, and nearly half of the patients had intermediate SYNTAX score (23–32). The optimal revascularization modality in these patients is a common subject of discussion. This trial

showed that in the patients with a low SYNTAX score, there is no difference in incidence of both endpoints between the PCI group and the CABG group. This difference occurs in the patients with intermediate and high SYNTAX scores, with significantly lower incidence of both endpoints in the CABG group, similarly to our study.

In our study, the average perioperative risk was relatively low (the average EuroSCORE II was 2.48% in the PCI group and 2.36% in the CABG group). The Heart Team's decision was changed in 24 (32.88%) of patients due to a high perioperative risk. The average EuroSCORE II in these patients was 3.72%. In high risk patients, decision-making by the Heart Team is difficult, and the optimal revascularization modality is often the subject of discussion. As a result, most of the trials comparing PCI and CABG exclude this group of patients. The AWESOME study compared long-term survival between PCI and CABG groups in patients with medically refractory ischemia and an increased risk of adverse outcomes after CABG [18]. Results of this study have shown that there is no statistically significant difference in survival between the two treated groups, suggesting that PCI is a safe alternative for CABG in patients with estimated high perioperative mortality.

Our results, as well as the results from previously mentioned randomized clinical trials, indicate that safety and efficacy of PCI is comparable to surgical revascularization during a one-year follow-up. Higher rates of total mortality and MACCEs in the PCI group are observed after 2–3 years, predominantly as a result of late stent thrombosis and MI. However, in patients with less complex coronary disease (a low SYNTAX score), as well as in patients with a high operative risk, PCI with DES implantation is a safe and efficient alternative to CABG.

Limitations of the study

This study has several limitations: (1) The SYNTAX score was not calculated for the patients who underwent coronary artery bypass grafting, because we did not have access to all their coronary angiograms, which made it difficult to compare these two groups of patients based on the anatomical complexity of coronary artery disease; (2) a small number of patients from a single center; and (3) a relatively short follow-up period that might not provide data about long-term outcomes. However, we believe that these limitations did not have major effects on the results of the study.

Conclusion

Our study showed that it appears that during a one-year follow-up period there is no statistically significant difference in overall mortality and MACCEs between selected patients who underwent surgical revascularization and those in whom surgical myocardial revascularization was firstly advised but consequently changed to PCI.

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