# Evaluation of Saphenous Vein with or Without Valve and Radial Artery Patency Via Tomography in Patients Who Underwent Coronary Artery Bypass Grafting

**Mehmet Özülkü[1], Fatih Aygün[1], Bilal Egemen Çiftçi[2]**

[1] Baskent University Konya Practise and Research Center, Clinic of Cardiovascular Surgery, Konya, Turkey
[2] Baskent University Konya Practise and Research Center, Clinic of Radiology, Konya, Turkey

## ABSTRACT

**Introduction:** This prospective study investigated the effect of the valves of saphenous veins, which were used as conduits, on patency and the 2-year of remaining patency of saphenous vein with valve, saphenous vein without valve, and radial artery (RA) via multislice computerized tomography (MSCT) angiography.

**Patients and Methods:** Between 2014 and 2015, the patients that underwent coronary artery bypass grafting (CABG) using cardiopulmonary bypass (CPB) and cross-clamp (on-pump with cross-clamp) in our clinic were grouped into three groups depending on the graft type. The first group (Group 1) was RA group, the second group (Group 2) was great saphenous vein with valve group, and the third group (Group 3) was great saphenous vein without valve group.

**Results:** The 2-year rates of the remaining patency of these grafts in the decreasing order was as following: RA (87.5%), great saphenous vein without valve (82.4%), and great saphenous vein with valve (78.8%).

**Conclusion:** The rate of remaining patency was not statistically significant among the RA, saphenous vein without valve, and saphenous vein with valve conduits (p> 0.05; RA vs. vein without valve, p= 0.737; RA vs. saphenous vein with valve, p= 0.321; and saphenous vein without valve vs. saphenous vein with valve, p= 0.465).

**Key Words:** CABG; saphenous vein; radial artery; computerized tomography

## Koroner Arter Baypas Operasyonu Olan Olgularda Kapaklı Kapaksız Safen Ven ve Radiyal Arter Açıklığının Tomografi ile Araştırılması

### ÖZET

**Giriş:** Çalışmamız prospektif bir çalışma olup yalnızca konduit olarak kullanılmış safen venlerin kapakçıklarının açık kalma üzerine etkisi değil, aynı zamanda kapaklı safen venin, kapaksız safen venin, radyal arterin iki yıllık açık kalma oranı çok kesitli bilgisayarlı tomografi (ÇKBT) anjiyografi kullanılarak araştırılmıştır.

**Hastalar ve Yöntem:** Kliniğimizde 2014-2015 yılları arasında koroner arter baypas greft operasyonu (KABGO) yapılmış hastalar üç farklı grefte göre gruplandı. Gruplar kalp akciğer makinası ve X-klemp (On-Pump X-klempli) kullanılarak KABGO yapılan hastalarda kullanılan greftlere göre oluşturuldu. Birinci grup (Grup 1); radiyal arter grubu, ikinci grup (Grup 2); valvli safen ven grubu, üçüncü grup (Grup 3); valv içermeyen safen ven grubu olarak belirlendi.

**Bulgular:** Greftlerde iki yıllık açık kalma oranı, radiyal arter için %87.5, kapaksız safen ven için %82.4 ve kapaklı safen ven için %78.8 bulunmuştur.

**Sonuç:** Radiyal arter, kapaksız safen ven, kapaklı safen ven arasında iki yıllık açık kalma oranları, istatistiksel olarak anlamlı değildir (p> 0.05; radiyal arter vs. valvsiz ven için p= 0.737; radiyal arter vs. valvli ven için p= 0.321; valvsiz ven vs. vavli ven için p= 0.465).

**Anahtar Kelimeler:** KABGO; safen ven; radiyal arter; bilgisayarlı tomografi

## INTRODUCTION

Coronary artery diseases are the leading causes of death observed among the people of the developed countries. Therefore, coronary artery bypass (CABG) surgery is one of the operations most frequently performed worldwide; approximately, > 800.000 patients annually undergo this surgery[1] Conventional CABG is performed using cardiopulmonary bypass device (CPB; heart–lung machine) and is called as on-pump CABG.

In CABG, various autogenous grafts are used to bypass the coronary arteries. Besides ITA (Internal thoracic artery/Internal mammary artery), the other choices of graft has always been a matter of debate. The patency of ITA graft used in coronary bypass surgeries is better than that of other grafts as per almost all studies and periods. Here, many factors, including the structure of the coronary artery that is undergoing grafting, the degree of stenosis, the graft structure, resection technique, and the quality of anastomosis, play important roles. The great saphenous vein and radial artery (RA) are the second and third, respectively, most frequently used grafts. The fact that the RA is most commonly used as an arterial graft depends on the suitability of the diameter and length and the ease of harvesting.

This prospective study investigated the effect of the valves of saphenous veins, which were used as conduits, on patency and the 2-year rates of the remaining patency of the saphenous vein with valve, saphenous vein without valve, and RA via multislice computerized tomography (MSCT) angiography.

## PATIENTS and METHODS

An approval of the Başkent University Clinical Research Ethics Committee was obtained as ID KA14/121.

### Clinical Characteristics of Patients

In the present study, all study participants were Caucasians and did not represent any other ethnic group. The study comprised the patients that underwent CABG surgery and postoperative MSCT angiography in our clinic between 2014 and 2015. The data were prospectively collected from the patients. This study included the conduits of 50 participants.

All patients were questioned about their medical history, and they underwent detailed physical examination. In the preoperative period, standard preoperative laboratory analyses, transthoracic echocardiography (TTE; Acuson, Mountain View, California, USA), pulmonary function test (Spirobank Spirometry, MIR medical IRR), and bilateral carotid artery Doppler ultrasonography (Toshiba Xario Prime Ultrasound) were performed in our clinic. The thorax, ascending aorta, and aortic arch calcifications were evaluated by standard telegram prior to the surgery. During the surgery, the entrances of the ascending aorta and aortic arch were carefully evaluated by manipulation. The procedure was amended for the patients in whom plaque was detected by manipulation, and they were excluded.

In the preoperative period, the use of clopidogrel (if applicable) was discontinued five days prior to the surgery and the use of acetylsalicylic acid was discontinued one day prior to the surgery in the cases undergoing on-pump (cross-clamping) CABG. In the preoperative period, blood glucose regulation in the patients with type 2 diabetes mellitus was performed with regular insulin before and after the surgery. The blood glucose concentration of the patients was maintained below 200 mg/dL. In the preoperative period, the blood samples of the study participants were collected into standard tubes containing ethylene diamine tetra-acetic acid as the anticoagulant agent. These samples were analyzed using Cell-Dyne 3700 (Abbott, Abbott Park, IL, USA) device. Prothrombin time, activated partial thromboplastin time (aPTT), and international normalized ratio were measured.

Dyslipidemia in the study participants was described as fasting serum low-density lipoprotein cholesterol ≥ 160 mg/dL, triglyceride ≥ 200 mg/dL, total cholesterol ≥ 240 mg/dL, and/or high-density lipoprotein cholesterol < 40 mg/dL and as receiving/not receiving active drug therapy for it[2]. The serum cholesterol concentration was measured by enzymatic method. Staged approach was adopted and saved for the post-CABG period for the patients in whom carotid artery disease was detected to be > 70% or < 100% before the surgery.

### Surgical Procedure

All study participants were operated by the same surgery team, and they initially underwent isolated CABG surgery. Fentanyl, midazolam, and pancuronium bromide were used for the induction of anesthesia. Standard median sternotomy was further performed. Left internal mammary artery and other vascular conduits (saphenous vein and RA) were prepared. Heparin sodium (Nevparin® flakon 25.000 IU/5 mL) was administered at a dose of 300 IU/kg. CPB, cross-clamp, standard aortic, and two stage venous cannulas were used, and Jostra–Cobe (Model 043213 105, VLC 865, Sweden) heart–lung machine was used. Crystalloid cardioplegia was administered to all patients during the surgery, and hot-shot cardioplegia was administered at the end of the surgery. While the LIMA was used in all cases, the right internal mammary artery was not used. The great saphenous vein and RA were used as grafts. The valve control of the conduit segments of the saphenous vein was performed by administering physiological serum through the distal end using an olive-tip injector. LIMA was preferred as the conduit for the left anterior descending (LAD) coronary artery, RA was preferred for circumflex coronary artery, and the great saphenous vein (with or without valve) was preferred for right coronary artery or diagonal coronary arteries of LAD. The graft type for each coronary artery was recorded. Meticulous aseptic technique was performed during the surgery. The entrances of the ascending aorta and aortic arch were precisely examined by

manipulation during the surgery. The procedure was amended for the patients in whom plaque was detected by manipulation, and these patients were excluded. Unnecessary electrocautery usage and luxury perfusion in CPB were avoided. Hematocrit (Hct) and hemoglobin (Hb) values were checked every 20 min after the induction of anesthesia until the completion of the surgery. Intraoperative blood transfusion was performed when the Hct value decreased to 20%. Full revascularization was performed. Mediastinum and chest drains were subxyphoidally placed. Proximal anastomoses to the aorta were performed using side clamp. At the end of the surgery, the patients that underwent CABG received protamine hydrochloride (Protamin® ampoule 1000 IU/L mL) at appropriate doses for full-dose neutralization, and activated clotting time was maintained between 100 and 120 s. Some data relevant to the surgery are demonstrated in Table 1.

Graft patency was evaluated by cardiac tomography angiography performed two years after the discharge. For the present study, the patients were selected among those aged between 50 and 70 years and who underwent multiple artery coronary bypass surgeries, regardless of the sex. It was stipulated that all patients must have undergone bypass surgery as supported by the heart-lung machine that indicated stopped heart and that the RA and saphenous vein must have been used as grafts in all patients. The patients that were discharged without any complication were enrolled.

**Postoperative Care**

At the end of surgery, the patients were admitted to the cardiovascular surgery (CVS) intensive care unit (ICU). They were monitored in the ICU for Hct and Hb every four hours. We attempted to maintain the Hct level at 28% in all patients in the ICU.

In the postoperative period, acetylsalicylic acid (Coraspin 300®) at a dose of 300 mg/day was commenced along with enteral nutrition for all patients to reduce the risk of stroke after CABG. Cefazolin sodium (1 g; Cefamezin®-IM/IV), which is used as a standard prophylactic antibiotic in our clinic, was administered as a single dose for 30 min before the surgery and after every 8 hours after the surgery and was continued for 72 hours. Blood

**Table 1. Data according to the groups**

| | Group 1 (n= 40) (radial artery) | Group 2 (n= 33) (saphenous vein with valve) | Group 3 (n= 51) (saphenous vein without valve) | p |
|---|---|---|---|---|
| Age (± SD) (year) | 60.4 ± 9.7 | 63.9 ± 8.8 | 60.9 ± 11.5 | 0.308[A] |
| Gender (male) | 33 (82.5%) | 24 (72.7%) | 40 (78.4%) | 0.602[P] |
| PAD | 2 (5%) | 3 (9.1%) | 3 (5.9%) | 0.923[S] |
| Right carotid artery | | | | |
| Stenosis < 50% | 11 (27.5%) | 14 (51.5%) | 18 (35.3%) | |
| 50% < stenosis ≤ 70% | 0 | 2 (6.1%) | 2 (3.9%) | *0.169[S] |
| 70% ≤ stenosis < 100% | 0 | 0 | 2 (3.9%) | |
| Stenosis= 100% | 0 | 0 | 0 | |
| Left carotid artery | | | | |
| Stenosis < 50% | 3 (7.5%) | 2 (6.1%) | 4 (7.8%) | |
| 50% < stenosis ≤ 70% | 1 (2.5%) | 2 (6.1%) | 0 | *0.109[S] |
| 70% ≤ stenosis < 100% | 0 | 0 | 0 | |
| Stenosis = 100% | 2 (5%) | 1(3%) | 0 | |
| Body surface area | 1.8 ± 0.1 | 1.8 ± 0.1 | 1.8 ± 0.1 | 0.693[A] |
| BMI | 39.7 ± 7.1 | 38.8 ± 6.6 | 39.8 ± 6.9 | 0.796[A] |
| Preoperative ejection fraction | 49.3 ± 9.5 | 38.8 ± 6.6 | 39.8 ± 6.9 | 0.478[A] |
| The period from CABG to MSCT angiography (m) | 34.9 ± 5.4 | 35 ± 4.9 | 34.4 ± 4.3 | 1[A] |
| Ejection fraction (before MSCT angiography) | 62.6 ± 9.6 | 57.3 ± 9.9 | 60.3 ± 9.8 | 0.074[A] |
| Graft patency | 35 (87.5%) | 26 (78.8%) | 42 (82.4%) | 0.604[P] |

[A]: p-value was presented as a result of one-way ANOVA test,
[P]: p-value was presented as a result of the Pearson chi-square test,
[S]: p-value was presented as a result of the Spearman correlation test,
* p-value was calculated according to no carotid artery stenosis.
BMI: Body mass index, SD: Standard deviation, PAD: Peripheral artery disease, CABG: Coronary artery bypass grafting, MSCT: Multislice computerized tomography.

glucose regulation in diabetic patients was strictly conducted with 100 IU/mL insulin glargine (Lantus® flacon) and 100 IU/mL human soluble (regular) insulin (Humulin-R® flacon) after the surgery. Insulin infusion was permitted in case of necessity. The blood glucose concentration was maintained below 200 mg/dL in all diabetic patients. RA grafts are more spasmodic than other grafts, particularly than saphenous grafts. Therefore, after harvesting, all radial arteries were kept in moderate warm solutions such as diltiazem, papaverine, and heparin.

After staying at the CVS ICU for 48 h in the postoperative period, the patients were then transferred to the CVS clinic within the third 24 hours. The patients were discharged from the hospital between days 6 and 11 after the surgery.

### Statistical Analysis

Statistical analyses were performed using SPSS program (SPSS Inc., Chicago, IL, USA). Statistical significance of nonparametric data between the groups was analyzed by chi-square and Fisher's exact tests (because the observed values were below the expected values). Parametric data are shown as minimum, maximum, and mean ± standard deviation. Statistical significance of the parametric data between the groups was analyzed using the Kaplan-Meier test. The result was considered statistically significant if two-tailed p-value was < 0.05 (Table 1).

### MSCT Image Reconstruction and Occlusion Evaluation

MSCT angiography was performed using Somatom Sensation 64 (Siemens, Forchheim, Germany) tomography device, and scanning parameters were selected as following: gantry rotation time, 330 ms; tube voltage, 120 kW and 250 mA; and detector collimation, 0.6 mm. Images were obtained at a single breath in approximately 8.4-13.1 s and in the cranio-caudal direction from the carina to the subcostal level. During MSCT angiography, 80-110 mL of non-ionized contrast agent (Iomeron 400, Bracco s.p.a., Milan, Italy), depending on the patient's body weight, was rapidly provided through the antecubital vein at a speed of 5.0 mL/second followed by 40 mL normal saline given as bolus infusion. Automatic peak contrasting density obtained from the ascending aorta was specified as +140 Hounsfield units. Reconstruction was obtained according to the retrospective electrocardiography synchronization technique enhancing 0.6 mm artifact free image sections by 0.6 mm images in the multiplanar reformat; three-dimensional volumetric display (volume rendering) format were created from axial thin sections, and coronary artery anatomy was evaluated.

All coronary artery segments and grafts were visually examined. Stenoses were classified as total occlusion (100% stenosis), severe stenosis (≥ 70% stenosis), and mild stenosis-complete patency (< 0% stenosis). MSCT angiography examinations were performed by independent radiologists, cardiovascular surgeons, and cardiologists (Figures 1-4).

### Study Groups

The patients that underwent CABG were grouped depending on the graft type. The groups were established according to the grafts used in the patients that underwent CABG using CPB and cross-clamp (on-pump with cross-clamp). The first group (Group 1) was RA group, the second group (Group 2) was great saphenous vein with valve group, and the third group (Group 3) was great saphenous vein without valve group. In all patients, CABG was performed in ≥ 3 coronary arteries on CPB. Left internal mammary artery, RA, and saphenous vein were used as the grafts in the subjects participated in the study. The graft choice and coronary anastomosis sites were recorded in these patients. Unlike the standard procedure, the presence of a valve in the saphenous vein used was also reported. Proximal anastomoses were performed using side clamp. The duration of the cross-clamp did not exceed 90 min, and the duration of cardiopulmonary bypass did not exceed 120 min in the patients that underwent CABG by CPB with the cross-clamp technique. To create a homogeneous group, the dialysis patients or the patients with creatinine level > 2 g/dL, with aortic pathology detected during the surgery, and those in whom the surgery was amended, and the patients who underwent surgery in emergency status, redo CABG, or CABG without touching the ascending aorta (no-touch) or LIMA-LAD (single vascular disease patients) CABG were excluded from the study. Moreover, the patients that underwent second CABG surgery, those in whom the valve and coronary artery surgeries were performed in the same session, those who needed postoperative IABP support, those who were re-explored due to any postoperative reason, those who underwent CABG in an emergency status, and dialysis patients were also excluded to create more homogeneous and similar groups.

The patients who were allergic to contrast agent and who had chronic obstructive pulmonary disease, atrial fibrillation, tachycardia, or rhythm disorders, which would hinder MSCT angiography imaging, were also excluded. Among the eligible patients as per the study criteria, those who accepted the risk of coronary CT angiography, who agreed to participate in the study, and had appropriate pulse for coronary CT angiography were selected. Accordingly, 50 patients were enrolled. MSCT angiography was performed approximately 34.9 ± 4.8 m after the surgery to assess graft patency in the patients that were discharged from the hospital following on-pump CABG surgery.
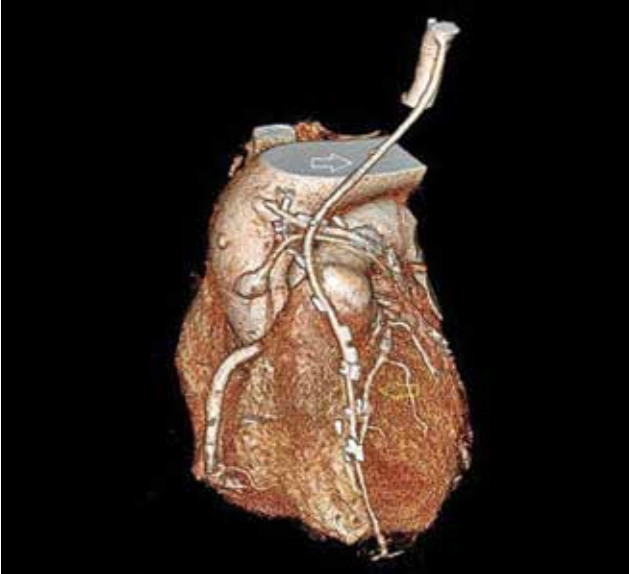
**Figure 1.** LIMA-LAD anastamosis. The white arrow is points out LIMA, and the yellow arrow is points out LAD.
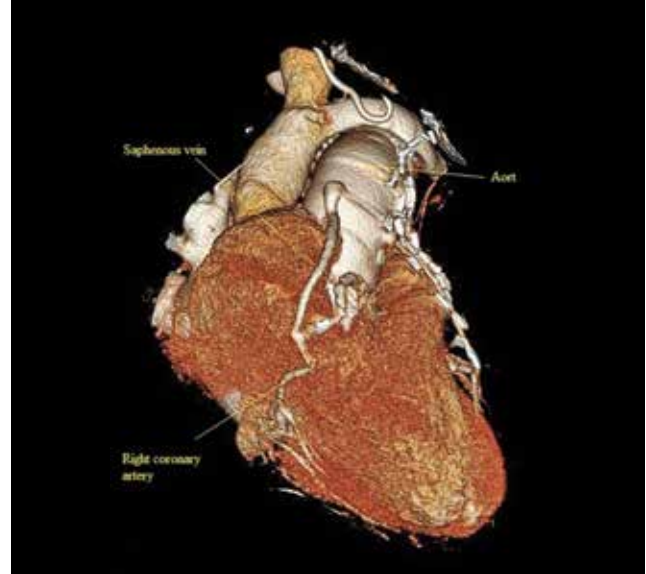


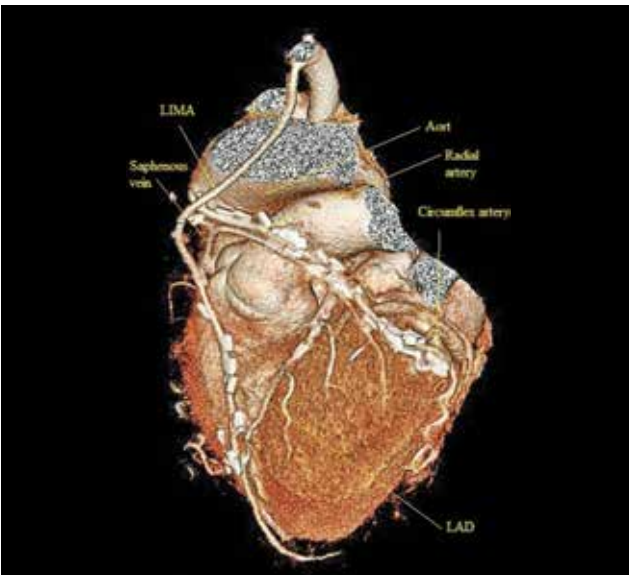**Figure 3.** Right coronary artery anastamosis with saphen vein is shown.



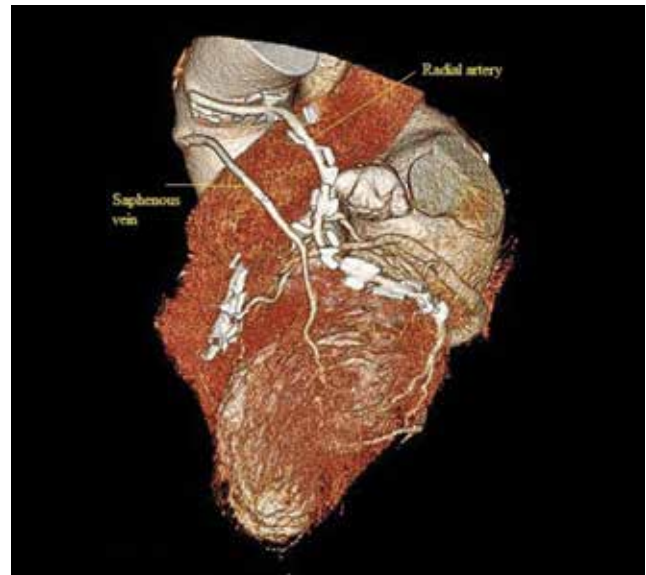**Figure 2.** All anastamoses including saphenous vein, radial artery, and LIMA.



**Figure 4.** Circumflex artery anastamosis with radial artery and the branch of LAD anastamosis with saphenous vein.

## RESULTS

### Group 1 Characteristics

There were 40 patients in Group 1, and 33 (82.5%) of them were male with a mean age (± standard deviation) of 60.2 ± 10.2 y; the mean BMI (± standard deviation) was 39.8 ± 7.2 kg/m², mean preoperative EF (± standard deviation) was 50 ± 9.1%, the number of patients with stenosis (≥ 70% or < 100%) in the right carotid artery was 0 (0%), and the number of patients with stenosis (≥ 70% or < 100%) in the left carotid artery was 0 (0%). Further, there were 2 (6.1%) subjects with peripheral arterial disease (PAD).

For the females of Group 1, it was determined that the number was 7 (17.5%), mean age (± standard deviation) was 61.4 ± 7.6 years, mean BMI (± standard deviation) was 38.8 ± 7.4 kg/m², mean preoperative EF (± standard deviation) was 45.5 ± 11.2, the number of patients with stenosis (≥ 70% or < 100%) in the right carotid artery was 0 (0%), and the number of patients with stenosis (≥ 70% or < 100%) in the left carotid artery was 0 (0%). Further, there was no (0%) subject with PAD.

### Group 2 Characteristics

For the males of Group 2, it was determined that the number was 24 (72.7%), mean age (± standard deviation) was 64 ± 9.1

years, the mean BMI (± standard deviation) was $39.4 \pm 6.3$ kg/m$^2$, mean preoperative EF (± standard deviation) was $50.4 \pm 7.9$, the number of patients with stenosis (≥ 70% or < 100%) in the right carotid artery was 0 (0%), and the number of patients with stenosis (≥ 70% or < 100%) in the left carotid artery was 0 (0%). Further, it was observed that there were 3 (12.5%) subjects with PAD.

**Group 2 Characteristics**

For the females of Group 2, it was determined that the number was 9 (27.3%), mean age (± standard deviation) was $63.4 \pm 8.2$ y, the mean BMI (± standard deviation) was $37.2 \pm 7.4$ kg/m$^2$, mean preoperative EF (± standard deviation) was $46.7 \pm 10.9$, the number of patients with stenosis (≥ 70% or < 100%) in the right carotid artery was 0 (0%), and the number of patients with stenosis (≥ 70% or < 100%) in the left carotid artery was 0 (0%). Further, there was no (0%) subject with PAD.

**Group 3 Characteristics**

For the males of Group 3; it was determined that the number was 40 (78.4%), mean age (± standard deviation) was $60.2 \pm 12.4$ y, the mean BMI (± standard deviation) was $40.9 \pm 6.1$ kg/m$^2$, mean preoperative EF (± standard deviation) was $52.7 \pm 8.4$, the number of patients with stenosis (≥ 70% or < 100%) in the right carotid artery was 0 (0%), and the number of patients with stenosis (≥ 70% or < 100%) in the left carotid artery was 0 (0%). Further, there were 3 (7.5%) subjects with PAD.

For the males of Group 3, it was determined that the number was 11 (21.6%), the mean age (± standard deviation) was $63.4 \pm 7.5$ y, mean BMI (± standard deviation) was $35.9 \pm 8.5$ kg/m$^2$, mean preoperative EF (± standard deviation) was $46.7 \pm 11.6$, the number of patients with stenosis (≥ 70% or < 100%) in the right carotid artery was 0 (0%), and the number of patients with stenosis (≥ 70% or < 100%) in the left carotid artery was 0 (0%). Further, there was no (0%) subject with PAD.

### DISCUSSION

Conventional coronary angiography is the gold standard technique for evaluating coronary artery diseases[3]. Although its invasiveness and serious complications are rare, it necessitates the development of noninvasive, effective, and reliable alternative diagnostic methods. Along with the development of multislice computed tomography (MSCT) systems, CT coronary angiography has become one of the most common fields of practice[4]. The most significant advantages of CT coronary angiography as compared with those of the conventional angiography are the ease of application, the elimination of preparation period, follow-up, or hospitalization, patient comfort, and the most important being the absence of risk for serious complication as it is noninvasive. Owing to their large diameters, less prevalence of calcification, and it being relatively motionless, bypass grafts, compared with coronary arteries, are the configurations that can be visualized more easily by CT. Venous grafts in particular can be clearly visualized. The sensitivity and specificity of MSCT in detecting graft occlusion are 100% for each[4]. The sensitivity and specificity of MSCT angiography in detecting severe stenosis in graft was reported to be 96% and 100%, respectively[4]. Although there are differences between the studies in general, there are studies and information that in the early-phase (first one-year period), saphenous vein patency is similar to that of RA, but in the late-phase (after one year), RA patency is better[5]. While choosing the conduit, surgeons should consider the suitability for anatomic structure, the patient characteristics, the availability for grafting, and his/her own surgical experience.

Limited long-term patency of the veins used in coronary bypass surgery has been very clearly demonstrated[6-8]. Veins are prone to early atherosclerosis due to their flow characteristics and exposure to aortic pressure. In addition, they are different from the arteries as they contain valve and due to their endothelium and wall structure. The definite cause of early atherosclerosis, however, is unclear. Standardly, the resistance and elasticity of the valves reversely interposed in the veins against arterial pressure and their effect on thrombosis is not well documented.

The studies demonstrating RA patency are inadequate or superficial. While early studies have reported the patency rate of RA between ITA and saphenous vein, recent studies emphasize the opposite. In a recent study, based on angiography results, Khot et al. reported that RA patency is poorer than that of ITA and saphenous vein[8,9]. All studies reported that LIMA patency is higher in all periods. The duration of remaining patency in the postoperative period for RA and great saphenous vein, which are used as the second and third choices of graft, respectively, has always been a matter of debate. Although early studies emphasized that the rate of patency is better for RA, recent studies opine that the rate of patency is better for great saphenous vein.

Whitney et al. demonstrated that reversely interposed valve areas of saphenous vein cause turbulent flow and dilation[10]. Chaux et al. conducted an experimental study in the valve area of jugular veins of hypercholesterolemic rabbits and demonstrated that the valve area created turbulent and a focus for atherosclerosis, and atrophied valve area posed a potential for endothelial injury, the formation of microthrombi, and thrombocyte aggregation[11]. Based on the experimental and clinical data, Lojas et al. called the veins without valve as "good veins", recommended their use in bypass surgeries, and suggested that there is long patency in arterial grafts, except for ITA[12].

On combining their findings with those of earlier publications, Cohen et al. suggested that RA graft is better than saphenous vein in coronary bypass surgeries and that it has higher rate of patency comparable with that of the right ITA[13]. Athanasiou et al. performed a meta-analysis and systematic review between 1965 and 2009 comprising 35 publications and stated that

early-phase (before the first one year) patency rates of RA and saphenous vein are similar, but late-phase (1-5 years) patency is better for RA; they also stated that RA graft should be the first choice in coronary bypass surgeries[5].

In a study conducted in 2004, RA occlusion was detected by 8.2% and saphenous vein occlusion was detected by 13.6%[14]. The rate of string sign appearance was 7% in RA and 0.9% in saphenous vein. In the same study, it was observed that RA occlusion was equal in males and females and that the patency of RA that bypassed to the circumflex coronary artery is similar to that bypassed to the right coronary artery. Saphenous vein occlusion was reported to be more prevalent in females. The rate of RA patency was determined to be higher in diabetic patients and in those with peripheral vascular disease[14].

Modine et al. conducted a study in > 65-year-old elderly patients and reported that using RA in such patients is practical and harmless, and it does not enhance morbidity or mortality[15]. Engoren et al. reported that RA outcomes were better in elderly at the end of a 12-year period than those in the other age groups[16]. Georghiou et al. reviewed many studies and suggested that saphenous vein patency ranks second after RA and that the RA can be readily used for stenosis with thin native coronary structure[17].

As per the result of angiography performed a week after and a year after the CABG surgery, Goldman et al. indicated no difference between saphenous vein and RA groups in terms of the rate of remaining patency[18]. The same study reported that the rate of remaining patency is better in the saphenous veins removed by open surgery as compared to the veins endoscopically removed and that the rate of remaining patency was better at the end of one year for the saphenous veins implemented by on-pump surgery. String sign appearance due to the degree of coronary artery stenosis was observed to be more prevalent in the RA grafts[18]. While there was no difference between the radial arteries removed by endoscopic or open surgical methods in terms of the rate of remaining patency, the rates of remaining patency were the same also between the subjects who underwent on-pump or off-pump CABG surgery. The study emphasized that the rate of remaining patency at the end of one year was better for RA versus that of saphenous vein in type 2 diabetic patients[18]. Acar et al. reported the late-phase rate of the remaining patency at the end of 5 years to be 83% for the left internal mammary artery, 87% for the right internal mammary artery, 83% for RA, and 81% for great saphenous vein. The rate of remaining patency for the RA anastomosed to the LAD branches was 93%, anastomosed to the circumflex coronary artery was 82.5%, and anastomosed to the right coronary artery was 77.6%. The most significant finding of this study is that the rate of remaining patency was better for RIMA than that for LIMA, which was not found in any study[19]. Yie et al. conducted a study between 2002

and 2006 in 123 patients and reported RA patency to be 92% at the end of 32 weeks and stated that RA patency is better in the coronary arteries with serious degree of stenosis[20].

Considering the studies up to now, LIMA patency is better in coronary bypass surgeries and is independent of time. As the second choice graft, it is observed that RA patency in the intermediate- and late-phases is superior to saphenous vein patency.

## CONCLUSION

The rate of remaining patency for the other grafts in decreasing order was as following: RA (87.5%), great saphenous vein without valve (82.4%), and great saphenous vein with valve (78.8%).

The fact that the rate of remaining patency is the highest for LIMA is consistent with the results of the studies conducted until today. However, the superiority of RA and great saphenous vein with or without valve conduits in terms of remaining patency has not been clearly identified. We believe that the mentioned outcome may be supported in large-scale studies.

**Study Limitations**

In the present study, all study participants were Caucasians and did not represent any other ethnic groups. The patients that would impair the similarity between the groups, including those with renal insufficiency, dialysis patients, and redo CABG cases, have not been included in the study. This study did not include power analysis. Statistical insignificance was observed because of the low number of participants.

## CONFLICT of INTEREST

The authors reported no conflict of interest related to this article.

## AUTHORSHIP CONTRIBUTIONS

*Concept/Design:* MÖ
*Analysis/Interpretation:* MÖ
*Data Acquisition:* BEÇ
*Writting:* MÖ
*Critical Revision:* FA
*Final Approval:* All of authors

## REFERENCES

1.  Goldman S, Zadina K, Moritz T, Ovitt T, Sethi G, Copeland J, et al. Long-term patency of saphenous vein and left internal mammary artery grafts after coronary artery bypass surgery: results from a Department of Veterans Affairs Cooperative Study. J Am Coll Cardiol 2004;44:2149-56.

2.  Reiner Z, Catapano AL, Backer GD, Graham I, Taskinen MR, Wiklund O, et al. The Task for the management of dyslipidaemias of th European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS). Eur Heart J 2011;32:1769-818.

3.  Lim MJ, White CJ. Coronary angiography is the gold standard for patients with significant left ventricular dysfunction. Prog Cardiovasc Dis 2013;55:504-8.

4.  Chiurlia E, Menozzi M, Ratti C, Romagnoli R, Modena MG. Follow-up of coronary artery bypass graft patency by multislice computed tomography. Am J Cardiol 2005;95:1094-7.

5.  Athanasiou T, Saso S, Rao C, Vecht J, Grapsa J, Dunning J, et al. Radial artery versus saphenous vein conduits fo r coronary artery bypass surgery:forty years of competition-which conduit offers betterpatency? A systematic review and meta-analysis. European Journal of Cardio-thoracic Surgery 2011;40:208-20.

6.  Breyer RH, Spray TL, Kastl DG, Roberts WC. Histological changes in saphenous vein aorta coronary bypass grafts. J Thorac Cardiovasc Surg 1976;72:916-24.

7.  Lawrie GM, Morris GC Jr, Chapman DW. Patterns of patency of 596 vein grafts up to seven years after aorta-coronary bypass. J Thorac Cardiovasc Surgery 1977;73:443-8.

8.  Beebe HG, Clark WF, DeWeese JA. Atherosclerotic change occurring in an autogenous venous arterial graft. Arch Surg 1970;101:85-8.

9.  Khot UN, Friedman DT, Petterson G, Smedira NG, Li J, Ellis SG. Radial artery bypass grafts have an increased occurrence of angiographically severe stenosis and occlusion compared with left internal mammary arteries and saphenous vein grafts. Circulation 2004;109:2086-91.

10. Whitney DG, Kahn EM, Estes JW. Valvular occlusion of the arterialized saphenous vein. Ann Surg 1976;42:879-87.

11. Chaux A, Ruan XM, Fishbein MC, Sandhu M, Matloff JM. Influence of vein valves in the development of arteriosclerosis in venoarterial grafts in the rabbit. J Thorac Cardiovasc Surg 1995;110:1389-90.

12. Lajos TZ, Robicsek F Thubrikar M, Urschel H. Improving patency of coronary conduits "valveless" veins and/or arterial grafts. J Card Surg 2007;22:170-7.

13. Cohen G, Tamariz MG Sever JY, Liaghati N, Guru V, Christakis GT, et al. The radial artery versus the saphenous vein graft in contemporary CABG: a case-matched study. Ann Thorac Surg 2001;71:180-5.

14. Desai ND, Cohen EA, Naylor CD, Fremes SE. A randomized comparison of radial-artery and saphenous-vein coronary bypass grafts. N Engl J Med 2004;351:2302-9.

15. Modine T, Al-Ruzzeh S, Mazrani W, Azeem F, Bustami M, Ilsley C. Use of radial artery graft reduces the morbidity of coronary artery bypass graft surgery in patients aged 65 years and older. Ann Thorac Surg 2002;74:1144-7.

16. Engoren M, Habib RH, Schwann TA. Late effects of radial artery versus saphenous vein grafting in patients aged 70 years or older. Ann Thorac Surg 2012;94:1478-84.

17. Georghiou GP, Vidne BA, Dunning J. Does the radial artery provide better long-term patency than the saphenous vein? Interact Cardiovasc Thorac Surg 2005;4:304-10.

18. Goldman S. Gulshan KS, William H, Thai, H, McFalls E, Herbert B, et al. Radial Artery Grafts vs Saphenous vein grafts in coronary artery bypass surgery: a randomized trial. JAMA 2011;305:167-74.

19. Acar C, Ramsheyi A, Pagny JY, Jebara V, Barrier P, Fabiani JN, et al. The radial artery forcoronary artery bypass grafting: clinical and angiographicresults at five years. J Thorac Cardiovasc Surg 1998;116:981-9.

20. Yie K, Na CY, Oh SS, Kim JH, Shinn SH, Seo HJ, et al. Angiographic results of the radial artery graft patency according to the degree of native coronary stenosis. Eur J Cardiothorac Surg 2008;33:341-8.