J Surg Med. 2021;5(8):807-812.
DOI: 10.28982/josam.969519

Research article

Journal of Surgery and Medicine
e-ISSN=2602-2079

Learning process and results in endoscopic saphenous vein harvesting technique

Tuncay Erden [1], Yıldırım Gültekin [2]

[1] Giresun Private Ada Hospital, Cardiovascular Surgery Clinic, Giresun, Turkey
[2] Kırıkkale University, School of Medicine, Department of Cardiovascular Surgery, Kırıkkale, Turkey

ORCID ID of the author(s)
TE: 0000-0002-9384-0556
YG: 0000-0003-1711-1834

Corresponding Author
Yıldırım Gültekin
Kirikkale University, Medical School, Cardiovascular Surgery, Yenisehir, Ankara Yolu 7.Km. Kırıkkale Üniversitesi, Tıp Fakultesi Hastanesi. 71450 Yahsihan, Kırıkkale, Turkey
E-mail: dr.ygultekin@hotmail.com

Ethics Committee Approval
The study was approved by Karadeniz Technical University Scientific Research Ethics Committee. (Tarih: 31.12.2018, No: 2018/247).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

Financial Disclosure
The authors declared that this study has received no financial support.

Previous Presentation
This study was presented as an oral presentation at the 15th Turkish Cardiovascular Surgery Congress held in Antalya between 26-29 October 2018.

Published
2021 August 28

Abstract

Background/Aim: Endoscopic saphenous vein graft harvesting (EVH) has been increasingly used in coronary bypass graft (CABG) surgery in recent years due to its cosmetic advantage and reduced morbidity. However, for the successful application of this technique, a learning process is required. In this study, we aimed to compare the results of the experience we obtained in the initial phase and later periods of the EVH technique.
Methods: Forty patients who underwent elective CABG between July 2015 and April 2017 were included in this retrospective cohort study. The first 20 patients (Group 1) and the next 20 patients (Group 2), whose saphenous vein graft (SVG) was prepared with the EVH technique were compared. The length and preparation time of SVGs prepared with EVH, local findings such as hematoma, necrosis, wound infection, and healing, demographic data, comorbidity, intraoperative and postoperative data, postoperative intensive care and hospitalization times, cosmetic satisfaction and wearing compression stockings were recorded.
Results: While the mean operation time was 201.4 (25.0) minutes in Group 1, it was 184.6 (17.1) minutes in Group 2 (P=0.018). There was no difference in the mean SVG lengths between the groups (P>0.05). While SVG preparation time was 75.3 (26.2) minutes in Group 1, it was 35.4 (6.0) minutes in Group 2 (P<0.001). The number of minor branch injuries in the SVG in Groups 1 and 2 were eight (40%), and two (10%), respectively, and all underwent primary repair (P<0.001). Mean length of hospital stay was similar between the groups (P=0.955). No hematoma, infection or necrosis requiring surgical intervention was observed in the extremity from which the SVG was taken. The use of compression stockings was longer in group 1 than in group 2 for the reduction or complete disappearance of edema (56.4 (23.3) vs 42.0 (19.4) days, P=0.040). No patient in any of the groups required rehospitalization due to infection at the saphenous vein incision site and incision healing problem. According to the satisfaction survey, cosmetic satisfaction was high in both groups (P=0.530).
Conclusion: We think that after the completion of the learning process on twenty patients, the EVH technique can be used more widely, with much better results in terms of both patient cosmetic satisfaction and reducing morbidity.

Keywords: Coronary artery bypass, Vena saphena magna, Endoscopic graft harvesting, Learning process

How to cite: Erden T, Gültekin Y. Learning process and results in endoscopic saphenous vein harvesting technique. J Surg Med. 2021;5(8):807-812.

Introduction

Coronary artery bypass surgery (CABG) is widely used in coronary artery disease (CAD) [1]. Autogenous grafts are generally used for bypass during surgery, mostly including the vena saphenous magna (VSM), internal mammary artery (IMA) and radial arteries [2].

Since it is a vein, VSM has a lower long-term patency rate than other arterial grafts, primarily because of intimal hyperplasia and thrombus [3]. Despite this, the fact that VSM is easily accessible and easy to prepare still makes it an indispensable graft [4]. It is possible to obtain an average 60-70 cm long graft by extending to the inguinal region with an incision starting from the anterior side of the SVG medial malleolus [5]. Complications such as pain, edema, surgical site infection, bleeding, hematoma, fat necrosis, keloid, seroma, and opening in the incision can be seen in the incision sites after SVG preparation with the conventional surgical method [6].

Classically, the SVG is removed subfascially by making a skin incision along its anatomical trace, tying its branches, and separating it from the surrounding tissues. The SVG requires much manipulation during preparation, which causes intimal damage and reduces the long-term graft patency rate [7]. Therefore, it has led to the search for different methods for reducing complications and longer-term graft patency. Other methods are the no-touch method (removal of the vessel with peripheral supporting tissues), the in-situ method (no graft transection until anastomosis), and SVG preparation with intermittent skin incision [8]. However, it has been shown that each method has advantages and disadvantages in terms of complications and graft quality [9]. Recently, due to these incision site problems, endoscopic non-touch SVG preparation with a small incision has come to the fore as an alternative method [10]. In this method, VSM is followed through a small 2-3 cm incision made in the knee region with the help of endoscopy, its branches are cauterized, and SVG is prepared with less manipulation and complications [11]. EVH technique is performed using special systems. Complications such as graft injury and hematoma may develop during SVG preparation, especially if the personnel are inexperienced. Despite the advantages of EVH over other methods, it has not been widely used in practice [12].

In this study, we aimed to share our results obtained by evaluating the surgical morbidity in the initial and progressive stages of the learning process of the EVH technique and the findings in the grafted extremities.

Materials and methods

Forty patients who underwent elective CABG at Giresun Private Ada Hospital Cardiovascular Surgery Clinic between July 2015 and April 2017 were included in this retrospective cohort study. The study was approved by Karadeniz Technical University Scientific Research Ethics Committee (Date: 31.12.2018, No: 2018/247). The study was approved by the university/local human research ethics committee and all procedures were conducted in accordance with institutional and national research committee ethical standards, the 1964 Declaration of Helsinki and subsequent amendments. All patients included in the study signed the consent forms for the operation.

Based on a statistical power analysis, a total sample size of twenty participants (ten per group) was needed to achieve a statistical power of 0.8 and a large effect size for total SVG harvest time (i.e., within-between groups) at an alpha level of 0.05. The sample size computation was based on the study by Davis et al. [13]. The first (Group 1) and last 20 patients (Group 2) in which full length SVGs were prepared using carbon dioxide insufflation with the EVH technique (The VasoViewTM HemoPro II System, MAQUET Getinge Group, Getinge AB, Gothenburg, Sweden) were compared. All operations were carried out by the same team.

Patients who had previous cardiac surgery, off-pump surgery, reoperation, emergency surgery and short segment saphenous vein grafts were not included in the study. The EVH method was not used in patients with a known history of venous insufficiency (deep or superficial) and who had undergone surgery on the extremity where SVG was to be prepared. Patients in which the SVGs had to prepared with the classical surgical technique during EVH were excluded from the study.

Patients' age, gender, body mass index (BMI), EUROSKORE (European System for. Cardiac Operative Risk Evaluation), ejection fraction (EF), presence of diabetes mellitus, hypertension, hyperlipidemia, chronic obstructive pulmonary disease, cerebrovascular disease, peripheral artery disease and chronic renal failure were recorded. SVG harvesting time and SVG length, operation time, cardiopulmonary bypass time, cross clamp time, number of bypass anastomoses, time on the mechanical ventilator, atrial fibrillations, ventricular arrhythmias, acute renal failure, cerebrovascular events, perioperative myocardial infarction, amount of blood drainage, intraoperative and postoperative findings such as the amount of hospitalization, intensive care unit length of stay, length of hospital stay, and mortality were recorded. Local findings such as hematoma, burn, necrosis, minor branch injury, incision infection, lymphangitis, seroma, keloid in the extremity from which the saphenous vein graft was prepared with EVH technique were noted.

Pain, hyperemia, temperature increase, swelling and purulent discharge at the incision site were considered surgical site infection. After the patients were discharged in the postoperative period, control examinations were performed on the 10th day, 1st month and 3rd month.

The cosmetic satisfaction survey results of the EVH procedure at the follow-up after the patients were discharged (patients were questioned whether they had small incisions and leg wounds) were evaluated on a patient-rated scale, as follows: 1- Not at all satisfied, 2- Not satisfied, 3- Satisfied, 4- Very satisfied.

Surgical method

VSM tracings, flow, and structural characteristics of the patients for whom SVG was to be prepared were evaluated with Doppler ultrasonography in the radiology clinic one day before the operation or in the operation room on the day of the operation. The mapping was done by marking the traces of the saphenous veins.

The VSM was found with an oblique 2-3 cm incision below the knee following the VSM trace. After the subcutaneous tunnel was prepared by moving distally and proximally, the port was placed, and the balloon was inflated. The dissector device placed inside the endoscope was inserted into the tunnel by passing through the port, and carbon dioxide (CO2) insufflation (with 10-12 mmHg pressure and 4-5 l/min volume flow) began. With the endoscopic dissector, the VSM was released from the subcutaneous tissues along the desired length and its lateral branches were determined. The trunk of the VSM was preserved with the C-arm, and all lateral branches were cauterized and cut. The VSM seen from the camera was captured with a clamp advanced through 0.5 cm incisions made from the most proximal and distal points. Intravenous heparin was administered according to the patient's weight before transecting the VSM with its proximal and distal parts tied. Injuries in the SVG were repaired with 7-0 propylene suture. With the help of endoscope and C-arm, the leg was removed from the knee level incision and the lateral branches were ligated with 4/0 silk sutures (Figure 1a). SVG was kept in a mixture of physiological saline and autologous blood prepared with 5,000 IU heparin until anastomosis began. The 2 cm incision in the knee area was sutured one by one with 3/0 vicryl subcutaneous continuous and 3/0 propylene skin sutures, then, the proximal incision, 1 cm in length, was sutured with 3/0 propylene. The leg was wrapped with an elastic bandage from the ankle to the groin. After the bands of the patients were removed after 48 hours, compression stockings were put on until the groin. The patients were followed up for at least three months to terminate the use of compression stockings due to reduction or complete resolution of edema.

Figure 1: a) Full length SVG with EVH technique, b) Incision healing in the first month postoperatively

Figure 2: EVH application in an obese patient

Statistical analysis

Statistical analysis of the patients included in the study was performed with the SPSS version 21.0 (SPSS Inc., Chicago, IL, USA) statistical program. Results were reported as mean (standard deviation (SD)) for numeric variables and as percentage (%) for categorical variables. Shapiro Wilk test was used to examine the distributions of the variables. Student's t-test was used to compare independent and numerical variables, while the Chi-square test was used to compare independent and categorical variables. A *P*-value of <0.05 was considered statistically significant.

Results

Of the 40 patients who participated in the study, 18 (45%) were female and 22 (55%) were male. The mean age of the patients was 66.5 (18.2) years in Group 1 and 65.1 (17.9) years in Group 2. There was no statistical difference between the preoperative characteristics of the patients (Table 1).

Table 1: Preoperative characteristics of patients

	Group 1 (n=20)	Group 2 (n=20)	*P*-value
Age (year), (mean (sd))	66.5 (18.2)	65.1 (17.9)	0.807
Gender (famale/male), n (%)	8 (40%) / 12 (60%)	10 (50%) / 10 (50%)	0.765
BMI (kg/m^2), (mean (sd))	27.3 (5.5)	28.2 (6.6)	0.917
EF (%), (mean (sd))	53.3 (7.7)	52.9 (8.6)	0.972
DM, n (%)	6 (30%)	8 (40%)	0.805
HT, n (%)	11 (55%)	12 (60%)	0.956
HL, n (%)	7 (45%)	11 (55%)	0.850
COPD, n (%)	3 (15%)	1 (5%)	0.742
CVD, n (%)	2 (10%)	1 (5%)	0.842
PAD, n (%)	7 (35%)	6 (30%)	0.768
CRF, n (%)	3 (15%)	2 (10%)	0.830
EuroSCORE, (mean (sd))	4.7 (0.9)	4.6 (1.1)	0.944

EF: Ejection fraction, DM: Diabetes mellitus, HT: Hypertension, HL: Hyperlipidemia, COPD: Chronic obstructive pulmonary disease, CVD: Cerebrovascular disease, PAD: Peripheral artery disease, CRF: Chronic renal failure, EUROSCORE: European System for Cardiac Operative Risk

SVG preparation time was 75.3 (26.2) minutes in Group 1 and 35.4 (6.0) minutes in Group 2 (*P*<0.001). Operation time was 201.4 (25.0) minutes in Group 1 and 184.6 (17.1) minutes in Group 2 (*P*=0.018). None of the patients died. Intraoperative and postoperative data are shown in Table 2.

Table 2: Intraoperative and postoperative data

	Group 1 (n=20)	Group 2 (n=20)	*P*-value
SVG harvesting time (minute), (mean (sd))	75.3 (26.2)	35.4 (6.0)	<0.001
SVG length (centimetre), (mean (sd))	51.3 (6.8)	54.1 (5.2)	0.745
Operation time (minute), (mean (sd))	201.4 (25.0)	184.6 (17.1)	0.018
CPB time (minute), (mean (sd))	85.6 (15.6)	89.1 (20.3)	0.892
CC time (minute), (mean (sd))	51.8 (9.7)	53.2 (10.5)	0.922
Number of bypass anastomosisn, n, (mean (sd))	3.9 (1.3)	4.2 (1.2)	0.866
Inotropic support, n (%)	8 (40%)	7 (35%)	0.790
Mechanical ventilator time (hour), (mean (sd))	9.8 (4.7)	9.5 (3.8)	0.960
Atrial fibrillation, n (%)	4 (20%)	7 (35%)	0.712
Ventricular arrhythmia, n (%)	1 (5%)	2 (10%)	0.842
Acute renal failure, n (%)	2 (10%)	1(5%)	0.842
Cerebrovascular event, n (%)	0 (0%)	1(5%)	0.954
Perioperative myocardial infarction, n (%)	0 (0%)	1(5%)	0.954
Blood transfusion (unit), (mean (sd))	3.5 (1.9)	3.3 (2.3)	0.946
Drainage amount (millilitre), (mean (sd))	720.0 (250.0)	710.0 (300.0)	0.979
Intensive care stay (day), (mean (sd))	2.1 (1.3)	2.2 (1.2)	0.955
Postoperative hospital stay (day), (mean (sd))	7.1 (2.6)	6.0 (2.4)	0.757

SVG: Saphenous vein graft, CPB: Cardiopulmonary bypass, CC: Cross clamp

During EVH, there were 8 minor VSM branch injuries in Group 1, and 2 minor VSM branch injuries in Group 2 (*P*<0.001). Compression stockings were used for 56.4 (23.3) days in Group 1, and 42.0 (19.4) days in Group 2 (*P*=0.40). No hematoma, necrosis, wound infection during hospitalization or that requiring hospitalization, wound dehiscence or lymphangitis were observed in either group. The findings in the SVG-harvested extremity are shown in Table 3.

Table 3: Postoperative findings of the saphenous vein graft harvested extremity

	Group 1 (n=20)	Group 2 (n=20)	*P*-value
Burned (n)	3	0	0.712
Minor branch injury (n)	8	2	<0.001
Seroma (n)	1	0	0.954
Keloid (n)	1	0	0.954
Compression stocking time (day), (mean (sd))	56.4 (23.3)	42.0 (19.4)	0.040
Patient cosmetic satisfaction (point), (mean (sd))	3.7 (0.3)	3.9 (0.1)	0.530

Discussion

The results of this retrospective study showed us that the EVH technique in CABG can be applied effectively as a result of a learning process. There are several factors that prevent or prolong the full recovery of patients after CABG surgery and thus reduce the benefit of CABG. CABG surgery is a major surgery in which large and deep incisions are made. This makes wound healing one of the most important problems that need to be tackled in the postoperative period [14]. Although SVG preparation in CABG is an important step of the surgery, it is traditionally prepared with long incisions or bridged incisions [15]. When performed with the conventional surgical method, the incision in each leg can be up to 85 cm long, making it one of the longest incisions of any routine surgery [16]. Various complications can be seen in the incision area after SVG preparation, especially in patients with risk factors such as obesity (BMI> 30), diabetes mellitus, peripheral vascular disease and female patient. Many complications such as edema, hematoma, non-healing incision site, keloid, fat necrosis, long incision scar, and surgical site infections may be encountered, especially after VSM removal [17]. As this situation may require re-hospitalization and revision in patients, it may keep the surgical team busy for a longer time, prolong the hospital stay and increase hospitalization costs. This impairs the patient's quality of life and reduces patient satisfaction [18].

Chernyavskiy et al. reported that wound complications, cosmetically unsatisfactory results may occur, and wound complications are seen in 2-24% of the cases, since large incisions are made in SVG preparation methods with the traditional surgical method [19]. There are studies showing that the incision sizes are shorter than the traditional method and the presence of intact tissues between the incisions reduces postoperative morbidity in the SVG harvesting technique with the bridged method [20]. However, it is known that this method has various technical difficulties and moreover, lateral branch injuries and vein dissections are frequently observed during traction of the saphenous vein. This, in turn, affects mid- and long-term graft patency [21]. In our study, wound complications in the extremity harvested with SVG were observed at a much lower rate in both groups when compared to the surgery methods.

Therefore, studies to develop an SVG preparation technique that is both less invasive and at least as safe as the traditional method, endoscopic interventions have begun to come to the fore, and the EVH technique in CABG surgery has begun to attract the attention of surgeons [22]. In this system, the subcutaneous tissue is inflated with carbon dioxide through a small incision made in the extremity and endoscopic SVG preparation is performed with the help of the tunnel formed [23]. This method is used in 80% of patients undergoing CABG surgery in the United States. Interestingly, the use of this technique in Europe has remained quite low, probably due to the high cost of endoscopic devices [24]. The reasons for this situation are unclear, but it has been stated that senior surgeons' resistance to change or reluctance to retrain may be associated with long operation time and additional cost [25].

The success of CABG depends on the long-term patency of the conduit used for revascularization [26]. However, it was concluded that this method may be associated with acute endothelial damage of the graft and endoscopic graft harvesting may promote a thrombogenic environment leading to a reduction in graft patency, which requires further investigation of the long-term patency of vascular grafts. This was seen as one of the factors preventing its widespread use by surgeons [27]. The effect of surgical graft harvesting with EVH on CABG outcomes in a meta-analysis study involving 26.525 patients, it was shown that no significant difference was found in terms of mortality, myocardial infarction, revascularization, angina recurrence, and vein graft stenosis during a mean follow-up period of 2.6 years [28]. In our study, there was no finding suggesting early graft failure such as ventricular rhythm disorder, myocardial infarction and mortality in both groups.

In a study, it was shown that the prolongation of the operation time causes the prolongation of the anesthesia period, and this may be associated with morbidity in the postoperative period [29]. According to the data obtained in our study, the mean operation time was significantly shortened in Group 2 as a result of the learning process. This operation time is similar to that of CABG operations, in which SVG is prepared by the classical surgical method [30].

In the study of Tamim et al. [31] using the EVH technique on 36 patients, the mean SVG harvesting time was 43.5 (9.5) minutes. This time decreased over time from 90 minutes to 25 minutes. The mean graft length obtained from the proximal limb was 45.0 (12.6) cm. In another study by Chiu et al. [32] on 1348 patients, they stated that the SVG harvesting time was 68 minutes on average in the first 50 cases and 23 minutes for the last 200 cases. The average SVG preparation time was 45 minutes in all cases. In our study, at the end of the learning process, the SVG preparation time was much shorter in Group 2 than in Group 1. It was halved in accordance with the literature and the process was completed before cannulation started. There was no difference in the mean lengths of the grafts prepared between the groups, and the necessary grafts were prepared for multiple bypass.

It has been reported in studies that the application of the EVH technique requires an important learning process. It is known that endoscopic vessel harvesting by inexperienced surgeons, more individual graft injuries and more tissue damage than EVH performed by experienced surgeons [33]. In our study, while there were 8 minor branch injuries in Group 1, 2 minor branch injuries were detected in Group 1. We think that the significant reduction in this injury is related to gaining the ability to maneuver more easily, to work faster and to solve potential problems by mastering the instruments used during EVH application with experience. In addition, it has been shown that gaining surgical skills to prepare endoscopic SVG and knowing in detail about the anatomy of the VSM facilitate the procedure [34]. In our study, we preferred to use preoperative and intraoperative ultrasonography for less manipulation of tissues and SVG.

EVH is known as a cost-effective method in CABG because it reduces wound complications and shortens hospital stay. The cost can be an important consideration when choosing an endoscopic approach for SVG harvesting. This method, along with the initial investment required for equipment, requires additional costs for each operation due to the expense of disposable equipment. However, shortened hospital stays, savings due to improved wound healing and therefore less additional treatment can offset the additional cost of equipment [35, 36]. In our study, no difference was found between the postoperative hospital stay in Group 1 and Group 2. While there were skin burns in 3 patients, seroma in 1 patient and keloid in 1 patient in Group 1 in the SVG incision area, no hematoma, necrosis, hospital infection, wound healing problem, and infection requiring re-inpatient treatment were observed in both groups (Figure 1b).

It has been shown in many studies that the EVH technique is as safe as classical methods and significantly increases the cosmetic effect of the operated extremity [37]. It has been reported that EVH technique improves physical, social, emotional and mental health conditions and reduces physical role limitations [38]. Although there was no difference between the groups in our study, a high level of cosmetic satisfaction was found in both groups.

In the extremity for which SVG was harvested, edema may develop due to trauma, venous and lymphatic system circulatory disorders [39]. Morris et al. [40] revealed that there was more edema in the legs prepared with SVG with the classical surgical method. They stated that minimally invasive removal of the saphenous vein by endoscopic technique is more atraumatic for tissues. In our study, the duration of wearing compression stockings due to edema was found to be longer in Group 1. We think that this result is due to the fact that as the experience increases at the end of the learning process, the shortening of the procedure time is due to less trauma to the tissues.

Arıtürk et al. [41] in their study using the EVH technique on 100 patients, stated that after the completion of the SVG preparation learning process, technical and practical problems will be overcome, SVG preparation times will be shortened, and SVGs will be prepared in terms of quality as those prepared by the open method. In addition, the current literature suggests that surgeons with 100 or more EVH experience can prepare SVGs in shorter times with better graft quality and morbidity [42]. In this study, which we conducted on 40 patients, we think that this education process can be completed on fewer patients and that it can be applied with results compatible with the literature.

The first limitation of this study is that it is retrospective, the second limitation is that it is single-centered, and the third limitation is the inability to distinguish between risk factors for wound healing, such as diabetic, obes (BMI> 30), and female patients.

It is known that the EVH technique has very good results in patients with risk factors for the incision site [43]. Considering the costs, EVH may be preferred by surgeons, especially in patients with risk factors such as obesity, diabetes mellitus, peripheral artery disease and female patients (Figure 2). At the same time, we think that patients should be given a chance to choose by informing them about this alternative method.

Conclusion

As a result of this study, we think that after the completion of the learning process twenty patients, the EVH technique can be used more widely, with much better results in terms of both patient cosmetic satisfaction and reducing morbidity.

Acknowledgements

We would like to thank Atike Tekeli Kunt for her support in the writing of the article.

References

1. Gültekin Y, Bolat A. Results of the first 200 open heart surgeries performed in a university hospital clinic: Kırıkkale University, Faculty of Medicine, Cardiovascular Surgery. KÜ Tıp Fak Derg. 2020;22(3):348-56. doi: 10.24938/kutfd.793704.
2. Aldea GS, Bakaeen FG, Pal J. Fremes S, Head SJ, Sabik J, et al. The society of thoracic surgeons clinical practice guidelines on arterial conduits for coronary artery bypass grafting. Ann Thorac Surg. 2016;101(2):801-9. doi: 10.1016/j.athoracsur.2015.09.100.
3. Motwani JG, Topol EJ. Aortocoronary saphenous vein graft disease: pathogenesis, predisposition, and prevention. Circulation 1998;97(9):916-31. doi: 10.1161/01.cir.97.9.916.
4. De Vries MR, Simons KH, Jukema JW, Braun J, Quax P. Vein graft failure: from pathophysiology to clinical outcomes. Nat Rev Cardiol. 2016;13(8):451-70. doi: 10.1038/nrcardio.2016.76.
5. Chukwuemekai A, Lindsay J. Modified incision for long saphenous vein harvest. Ann Thorac Surg. 1998;66(1):279-80. doi: 10.1016/s0003-4975(98)00410-x.
6. L'Ecuyer PB, Murphy D, Little JR, Fraser VJ. The epidemiology of chest and leg wound infections following cardiothoracic surgery. Clin Infect Dis. 1996;22(3):424-9. doi: 10.1093/clinids/22.3.424.
7. Hayward PAR, Gordon LR, Hare DL, Matalanis G, Horrigan ML, Rosalion A, et al. Comparable patencies of the radial artery and right internal thoracic artery or saphenous vein beyond 5 years: results from the radial artery patency and clinical outcomes trial. J Thorac Cardiovasc Surg. 2010;139(1):60-7. doi: 10.1016/j.jtcvs.2009.09.043.
8. Sen O, Gonca S, Solakoglu S, Dalcik H, Dalcik C, Ozkara A. Comparison of conventional and no-touch techniques in harvesting saphenous vein for coronary artery bypass grafting in view of endothelial damage. Heart Surg Forum. 2013;16(4):177-83. doi: 10.1532/hsf98.20131006.
9. Souza DS, Christofferson RH, Bomfim V, Filbey D. "No-touch" technique using saphenous vein harvested with its surrounding tissue for coronary artery bypass grafting maintains an intact endothelium. Scand Cardiovasc J. 1999;33(6):323-9. doi: 10.1080/14017439950141362.
10. Hayashi I, Kashima I, Eiji Yoshikawa E. The endoscopic no-touch saphenous vein harvesting technique. Multimed Man Cardiothorac Surg. 2020 Sep 25;2020. doi: 10.1510/mmcts.2020.049.
11. Bhuvaneswari K, Critchley WR, Glover AT, Nair J, Jones MT, Waterworth PD, et al. A randomized study comparing three groups of vein harvesting methods for coronary artery bypass grafting: endoscopic harvest versus standard bridging and open techniques. Interact Cardiovasc Thorac Surg. 2012;15(2):224-8. doi: 10.1093/icvts/ivs164.
12. Kiani S, Desai PH, Thirumvalavan N, Kurian DJ, Flynn MM, Zhao XQ, et al. Endoscopic venous harvesting by inexperienced operators compromises venous graft remodeling. Ann Thorac Surg. 2012;93:11-8. doi: 10.1016/j.athoracsur.2011.06.026.
13. Davis Z, Jacobs HK, Zhang M, Thomas C, Castellanos Y. Endoscopıc vein harvest for coronary artery bypass graftıng: technique and outcomes. J Thorac Cardiovasc Surg. 1998;116(2):228-35. doi: 10.1016/s0022-5223(98)70121-7.
14. Williams JB, Peterson ED, Brennan JM, Sedrakyan A, Tavris D, Alexander JH, et al. Association between endoscopic vs open vein-graft harvesting and mortality, wound complications, and cardiovascular events in patients undergoing CABG surgery. JAMA. 2012;308(5):475-84. doi: 10.1001/jama.2012.8363.
15. Patel AN, Hebeler RF, Hamman BL, Hunnicutt C, Williams MC, Liu L, et al. Prospective analysis of endoscopic vein harvesting. Am J Surg. 2001;182(6):716-9. doi: 10.1016/s0002-9610(01)00824-8.
16. Akowuah E, Burns D, Zacharias J, Kirmani BL. Endoscopic vein harvesting. J Thorac Dis. 2021;13(3):1899-908. doi: 10.21037/jtd-20-1819.
17. Paletta CE, Huang DB, Fiore AC, Swartz MT, Rilloraza FL, Gardner JE. Major leg wound complications after saphenous vein harvest for coronary revascularization. Ann Thorac Surg. 2000;70(2):492-7. doi: 10.1016/s0003-4975(00)01414-4.
18. Jonkers D, Elenbaas T, Terporten P, Nieman F, Stobberingh E. Prevalence of 90-days postoperative wound infections after cardiac surgery. European Journal of CardioThoracic Surgery 2003;23(1):97-102. doi: 10.1016/s1010-7940(02)00662-0.
19. Chernyavskiy A, Volkov A, Lavrenyuk O, Terekhov I, Kareva Y. Comparative results of endoscopic and open methods of vein harvesting for coronary artery bypass grafting: a prospective randomized parallel-group trial J Kardiyotorasik Cerrahi. 2015;10:163-71. doi: 10.1186/s13019-015-0353-3.
20. Wipke-Trevis DD, Stotts NA, Skov P, Carrieri-Kohlman V. Frequency, manifestations and correlates of impaired wound healing of saphenous vein harvesting incisions. Heart, Lung 1996;25(2):108-16. doi: 10.1016/s0147-9563(96)80112-9.
21. Caliskan E, de Souza DR, Böning A, Liakopoulos OJ, Choi YH, Pepper J. Saphenous vein grafts in contemporary coronary artery bypass graft surgery. Cardiology 2020;17(3):155-69. doi: 10.1038/s41569-019-0249-3.
22. Horvath KD, Gray D, Benton L, Hill J, Swanstroma LL. Operative outcomes of minimally invasive saphenous vein harvest. The American Journal of Surgery 1998;175(5):391-5. doi: 10.1016/S0002-9610(98)00044-0.
23. Kempfert J, Rastan A, Leontyev S, Luduena M, Van Linden A, Arsalan M, et al. Current perspectives in endoscopic vessel harvesting for coronary artery bypass grafting. Expert Rev Cardiovasc. Ther 2011;9(11):1481-8. doi: 10.1586/erc.11.151.
24. Grant SW, Grayson AD, Zacharias J, Dalrymple-Hay MRJ, Waterworth PD, Bridgewater B. What is the impact of endoscopic vein harvesting on clinical outcomes following coronary artery bypass graft surgery? Heart 2012;98(1):60-4. doi: 10.1136/heartjnl-2011-300600.
25. Kopjar T, Dashwood MR. Endoscopic versus "no-touch" saphenous vein harvesting for coronary artery bypass grafting: a trade-off between wound healing and graft patency. Angiology. 2016;67(2):121-32. doi: 10.1177/0003319715584126.
26. A. Cameron, Davis KB, Green G, Schaffet HV. Coronary bypass surgery with internal thoracic artery grafts effects on survival over a 15-year period. N Engl J Med. 1996;334:216-20. doi: 10.1056/NEJM199601253340402.
27. Brata R, Horacekb J, Sieja J. Endoscopic vs open saphenous vein harvest for coronary artery bypass grafting: A leg-related morbidity and histological comparison. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2013;157(1):70-74. doi: 10.5507/bp.2012.011.
28. Sastry P, Rivinius R, Harvey R, Parker RA, Rahm AK, Thomas D, et al. The influence of endoscopic vein harvesting on outcomes after coronary bypass grafting: a meta-analysis of 267,525 patients. Review Eur J Cardiothorac Surg. 2013;44(6):980-9. doi: 10.1093/ejcts/ezt121.
29. Sargın A, Aşkar FZ, Kocabaş SN. Açık kalp cerrahisinde postoperatif solunum sistemi komplikasyonlarının preoperatif, intraoperatif ve postoperatif belirleyicileri. GKDA Derg. 2013;19(4):175-83. doi: 10.5222/GKDAD.2013.175.

30. Güzela NÖ, Kaymakçı Ş. The effects of three dıfferent warmıng methods on preventıon of postoperatıve hypothermıa after coronary artery bypass surgery. Ege Üniversitesi Hemşirelik Yüksek Okulu Dergisi 2003;19:11-7.
31. Tamim M, Al-Sanei A, Bukhari E, Canver C. Endoscopic saphenous vein harvesting: results of our initial experience Turkish J Thorac Cardiovasc Surg. 2008;16(3):162-6.
32. KM Chiu, CL Chen, SH Chu, TY Lin. Endoscopic harvest of saphenous vein: a lesson learned from 1,348 cases. Surg Endosc. 2008;22(1):183-7. doi: 10.1007/s00464-007-9522-3
33. Krishnamoorthy B, Critchley WR, Venkateswaran RV, Barnard J, Caress A, Fildes JE, et al. A comprehensive review on learning curve associated problems in endoscopic vein harvesting and the requirement for a standardised training programme. J Cardiothorac Surg. 2016;11:45-53. doi: 10.1186/s13019-016-0442-y.
34. Lopes FC, Oliveira OWB, Moreira DG, Dos Santos MA, de Oliveira JLR, Cruz CB, et al. Use of doppler ultrasound for saphenous vein mapping to obtain grafts for coronary artery bypass grafting. Clinical Trial Braz J Cardiovasc Surg. 2018;33(2):189-93. doi: 10.21470/1678-9741-2017-0201.
35. Bitondo JM, Daggett WM, Torchiana DF, Akins CW, Hilgenberg AD, Vlahakes GJ, et al. Endoscopic versus open saphenous vein harvest: a comparison of postoperative wound complications. Ann Thorac Surg. 2002;73(2):523-28. doi: 10.1016/S0003-4975(01)03334-3.
36. Luckraz H, Cartwrigh C, Nagarajan K, Kaur P, Nevill A. Major adverse cardiac and cerebrovascular event (MACE) and patients 'quality of life after endoscopic vein harvesting as compared with open vein harvest (MAQEH): a pilot study. Open Heart 2018;5(1):694-4. doi: 10.1136/openhrt-2017-000694.
37. Fron K. Comparison of endoscopic and traditional saphenous vein harvesting used as coronary artery bypass grafting material in patients with increased risk of postoperative infection. Annales Academiae Medicae Silesiensis 2020;74:149-56.
38. Çitrak F, Alpar SE. Çiçek S. Koroner baypas cerrahisinde iki farklı yöntemle venöz greft hazırlanmasının postoperatif dönemde yaşam kalitesi üzerine etkisi. Damar Cer Derg. 2015;24(3):172-83.
39. Şen O, Kadiroğulları E. Koroner bypass operasyonlarında safen ven grefti hazırlama tekniklerinin karşılaştırılması. Turk J Clin Lab. 2018;9(2):110-3.
40. Morris RJ, Butler MT, Samuels LE. Minimally invasive saphenous vein harvesting. The Annals of Thoracic Surgery 1998;66(3):1026-8. doi: 10.1016/s0003-4975(98)00709-7.
41. Arıtürk C, Ökten M, Güllü Ü, Şenay Ş, Toraman F, Karabulut H, et al. Cerrah Deneyimi endoskopik safen ven grefti hazırlanmasında komplikasyon oranını azaltıyor. GKDA Derg. 2015 21(3):147-51. doi: 10.5222/GKDAD.2015.147.
42. Coppoolse R, Rees W, Krech R, Hufnagel M, Seufert K, Warnecke H. Routine minimal invasive vein harvesting reduces postoperative morbidity in cardiac bypass procedures. Clinical report of 1400 patients. European Journal of Cardio-Thoracic Surgery 1999;16(2):61-6. doi: 10.1093/ejcts/16.Supplement_2.S61.
43. Luckraz H, Kaur P, Bhabra M, Mishra KP, Nagarajan K,Kumari N, et al. Endoscopic vein harvest in patients at high risk for leg wound complications: A cost–benefit analysis of an initial experience. American Journal of Infection Control. 2016;44(12):1606-10. doi: 10.1016/j.ajic.2016.06.016.

This paper has been checked for language accuracy by JOSAM editors.
The National Library of Medicine (NLM) citation style guide has been used in this paper.