

**New  
Methods**

# Endoscopic Pedicle Saphenous Vein Graft Harvesting

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The excellent long-term patency of no-touch (NT) saphenous vein grafts (SVGs) makes the grafts very attractive for coronary artery bypass grafting; however, NT-SVG harvesting has a greater incidence of wound complications than conventional methods. Since 2009, we have performed endoscopic vein harvesting (EVH) in our department with very few major wound complications. Because NT-SVG harvesting is expected to provide long-term patency, if performed with EVH, the incidence of wound complications will be reduced. Thus, we began performing endoscopic pedicle SVG harvesting (Pedicle-EVH) in March 2019. Herein, we report the early results obtained using our current Pedicle-EVH procedure. No major wound complications were reported, and the early results, including patency, were satisfactory. To harvest the pedicle SVG, however, we used a different method than the NT-SVG procedure, so careful monitoring will be needed to assess long-term outcomes.

**Keywords:** endoscopic vein harvesting, no-touch saphenous vein graft, coronary artery bypass grafting, Pedicle-EVH

## Introduction

There are two types of conduits used for coronary artery bypass grafting (CABG): arterial and vein grafts. Arterial grafts have long-term survival and patency advantages<sup>1,2</sup> but also some limitations.<sup>3</sup> Vein grafts are used in many cases because of ease of use and versatility.<sup>4</sup>

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Samano et al.<sup>5</sup> reported good long-term patency of no-touch (NT) saphenous vein grafts (SVGs), but wound complications are a drawback.<sup>6</sup> To overcome these issues, we reasoned that endoscopic pedicle SVG harvesting (Pedicle-EVH) would achieve both long-term patency and improved wound healing.

## Case Report

### Patients

SVGs were used in 148 of 184 patients undergoing CABG from September 2019 to January 2023; Pedicle-EVH was performed in 72 patients (63 males and 9 females). The average patient age was 67.9 years. Preoperative comorbidities were diabetes mellitus, 37 (51.4%); chronic obstructive pulmonary disease, 5 (6.9%); chronic kidney disease, 13 (18.1%); maintenance hemodialysis, 7 [9.7%]; and peripheral arterial disease, 7 (9.7%) (Table 1).

### Surgical data

Sixty-eight and 4 patients underwent elective and urgent CABG, respectively (intra-aortic balloon pumping

**Table 1 Patient characteristics**

Pedicle-EVH (September 2019–January 2023)	
Variables	
Case, n	72
Age, years: mean	67.9
Female, n (%)	9 (12.5)
Diabetes, n (%)	37 (51.4)
COPD, n (%)	5 (6.9)
Dialysis, n (%)	7 (9.7)
PAD, n (%)	7 (9.7)

EVH: endoscopic vein harvesting; COPD: chronic obstructive pulmonary disease; PAD: peripheral arterial disease

support, 3 [4.2%]). Fourteen patients (19.4%) underwent combined surgery, and all isolated CABG patients (58 [80.6%]) underwent an off-pump procedure. The mean number of bypasses in patients who underwent Pedicle-EVH was 2.8. The mean operative time was 337 min. Two surgeons performed the majority of Pedicle-EVH procedures. One of the two surgeons performed 54 cases from September 2019 to March 2022, and the other performed 16 cases from April 2022 to January 2023. Two cases were performed by other experienced surgeons. The mean pedicle SVG harvesting time was 88.3 min (25 consecutive cases measured from June 2020 to December 2021); the mean pedicle SVG harvesting time for the five cases performed in January 2023 was 74.6 min. Pedicle SVGs were obtained from the thigh in all cases; 68 cases were unilateral (right, 64; left, 4) and 4 cases bilateral. A drain was placed in the pedicle SVG harvesting site in 10 of 72 patients (13.9%). Eighty-three pedicle SVGs were used (single, 77; double-sequential, 5; triple-sequential, 1), with 90 anastomoses (mean, 1.25 anastomoses/case). Coronary artery targets were right coronary artery, 41; left circumflex branch, 34; and high lateral branch/diagonal branch, 15 (**Table 2**).

### Indications for Pedicle-EVH

At the time the Pedicle-EVH procedure was implemented in our hospital, patients with severe diabetes, patients  $\geq 80$ -years old, and patients requiring multivessel bypass were excluded from the Pedicle-EVH indications due to the increased risk of wound infection and prolonged operative time. Because no major wound complications in patients undergoing Pedicle-EVH were reported for 3 years and the procedure was stable, except for the patients in whom the greater saphenous vein (GSV) was treated as an extra-indication due to anatomic reasons (complication of deep vein thrombosis,

**Table 2 Surgical characteristics**

Pedicle-EVH (September 2019–January 2023)	
Variables	
Urgent operation, n (%)	4 (5.6)
IABP support	3 (4.2)
Combined surgery, n (%)	14 (19.4)
OPCAB, n (%)	58 (80.6)
Number of bypasses, n: mean	2.8
Operative time, min: mean	337
Pedicle SVG harvest site	
Thigh, n (%)	72 (100)
Unilateral	68 (94.4): right 64 (88.9), left 4 (5.6);
Bilateral	4 (5.6)
Drain to the harvest site, n (%)	10 (13.9)
Number of pedicle SVGs, n	83: single, 77, double-sequential, 5, triple-sequential, 1
Target coronary artery, n	RCA 41, LCx 34, HL/Dx 15

EVH: endoscopic vein harvesting; IABP: intra-aortic balloon pumping; OPCAB: off-pump coronary artery bypass grafting; SVG: saphenous vein graft; RCA: right coronary artery; LCx: left circumflex branch; HL: high lateral branch; Dx: diagonal branch

varicose veins, epifascial veins, and veins  $< 2$  mm in diameter), all patients were considered suitable candidates for the Pedicle-EVH procedure. Specifically, Pedicle-EVH can be offered to patients with comorbidities, such as severe diabetes, and to those who have hesitated to undergo NT-SVG due to wound infection risk.

### Pedicle-EVH procedure

The purpose of this procedure was to preserve the perivascular adipose tissue (PVAT) on both sides of the GSV. The procedure was performed using a Vasoview Hemopro 2 (Getinge AB, Göteborg, Sweden), as follows:

1. Under general anesthesia, the lower extremity was placed in a slightly flexed position (hip and knees).
2. Echo-guided GSV marking was required to mark the epifascial vein +/- branches and the sapheno-femoral junction.
3. A small incision (3 cm) was made in the lower thigh. (The GSV is often close to the skin and not suitable for endoscopic harvesting near the knee, especially below the knee.) Care should be taken with the incision length, as an incision  $> 3$  cm will result in poor fixation of the blunt tip trocar port, which can result in CO<sub>2</sub> leakage.
4. Pedicle GSV taping: The GSV was dissected proximally until at least the length of the jaw of the Kelly

forceps was under direct view (>6 cm), which is a key maneuver to complete the Pedicle-EVH.

The endoscopic procedures were as follows:

5. Posterior dissection: 1) The layer almost directly below the GSV was dissected using a dissector. The landmarks of this procedure were the vasa vasorum (GSV) and the deep fascia. 2) Dissection was carried out using a harvester (cautery). This dissection with cautery was completed before the anterior dissection.
6. Anterior dissection: 1) The layer almost directly above the GSV was dissected using a dissector. Landmarks: vasa vasorum (GSV) and saphenous fascia. 2) the anterior space was connected to the posterior space at several places using the dissector.

Posterior→Anterior or Anterior→Posterior

Although either order is acceptable, if an anterior dissection is performed first, a posterior dissection using cautery would be difficult to perform.

7. Lateral and remaining tissue dissection: The lateral PVAT, 0.5–1.0 cm away from the GSV, was dissected using the cautery. The connection (6-2) makes this dissection easier.
8. Removing the GSV: A small puncture (stab incision) was made in the groin directly over the GSV and exteriorized under endoscopic guidance, as in the original endoscopic vein harvesting (EVH) (3–8: **Movie**; The movie is available online). If there are any remaining parts that cannot be dissected, dissection should be performed under direct view with an additional small incision.

### Postoperative harvest site management

A drain is generally not placed in a conventional EVH. Because postoperative wound infections and delayed wound healing rarely occurred in Pedicle-EVH; hence, routine placement of a drain was not deemed necessary and was not performed. We only placed a drain if there was a residual area where hemostasis was not achieved during the procedure or if there was a risk of postoperative hematoma formation at the time of wound closure.

Elastic bandage: The thigh was wrapped from the knee to the inguinal area with equal pressure (Elascot-Tension Guide; Alcare Co., Ltd., Tokyo, Japan). The elastic bandage was removed on the third postoperative day; however, if a drain was placed, the drain should be removed on the third postoperative day, and the elastic bandage should remain in place for an additional 2 days. Furthermore, if there is a concern about the development of lymphorrhea or a lymphatic cyst, the duration of elastic bandage compression should be prolonged for approximately 1 week.

## Results

There was one surgical death due to an acute exacerbation of interstitial pneumonia (30-day mortality rate = 1.4%). There were no postoperative complications, such as cerebral infarction, reoperation for bleeding, or sternal wound infections, but a permanent pacemaker was implanted in one patient for postoperative sick sinus syndrome. There were no major wound complications at the pedicle SVG harvest site. Lymphorrhea was a minor wound complication in two patients. Coronary computed tomographic angiography (CCTA) confirmed early patency in 69 out of 72 patients (95.8%) and 87 out of 90 anastomoses prior to hospital discharge. CCTA was performed based on patient consent. Patient deaths, patient refusal, and deteriorating renal function were excluded, but maintenance dialysis patients were included. Early patency of the pedicle SVG was 97.7% (85 of 87 anastomoses). No cases had twisting of the pedicle SVG. CCTA was performed as an outpatient procedure 1 year postoperatively (42.3% [22 of 52 patients and 27 of 67 grafts]). Although stenosis was noted in two cases, all cases remained patent (3-year patency = 95.9%) (**Table 3**).

## Discussion

We introduced the Pedicle-EVH procedure in March 2019. Notably, there have been changes in the harvesting method based on our experience and outcomes. Although we have performed several methods, including location of the initial incision, routine use of an additional incision, and direction of the endoscopic dissection, we believe that it would be better to keep the method simple to standardize the technique. Therefore, we began with the same incision that was used in the original EVH, and the direction and distance of the endoscopic dissection were the same as the original EVH; the only difference between the original EVH and the Pedicle-EVH was whether the dissection was stripped or a pedicle. Because the initial incision is made in the lower thigh, the endoscopic harvesting is limited above the knee. If more grafts are needed, an additional incision is made below the knee and harvested under direct vision; this is a limitation of Pedicle-EVH.

We determined that there are several key procedures to stabilize and shorten the time of the Pedicle-EVH procedure, which resulted in the current procedure (see the Pedicle-EVH procedure). Although the Pedicle-EVH procedure takes more time to learn than the original EVH,

**Table 3 Clinical results from Pedicle-EVH**

Pedicle-EVH (September 2019–January 2023)	
Variables	
Operative mortality, n (%)	1 (1.4): acute exacerbation of interstitial pneumonia
Postoperative morbidities, n (%)	
Stroke	0
Bleeding reoperation	0
Sternal wound infection	0
Perioperative myocardial infarction	0
Permanent pacemaker implantation	1 (1.4): SSS
SVG harvest site wound complication, n (%)	
Major	0
Minor	2 (2.8): lymphorrhea
Patency of pedicle SVGs	
Early, %	97.7
3-year <sup>a</sup> , % (follow-up: mean $\pm$ SD, months)	95.9 (6.0 $\pm$ 9.1)

<sup>a</sup>3-year patency was summarized using Kaplan–Meier analysis with EZR. EVH: endoscopic vein harvesting; EZR: EZR version 1.54 (Saitama Medical Center, Jichi Medical University, Saitama, Japan); SSS: sick sinus syndrome; SVG: saphenous vein graft; SD: standard deviation

the learning curve for the Pedicle-EVH procedure will not be as long for cardiac surgeons who are already familiar with the EVH procedure. The harvester should not insist on completing the endoscopic dissection until becoming proficient using the Pedicle-EVH technique. If there is a difficult dissection area, an additional small incision should be made and dissected under direct vision. The additional small incision does not affect wound healing. The purpose of the Pedicle-EVH procedure is to obtain a good quality pedicle SVG in a shorter amount of time without wound complications, and there is no need to hesitate to make an additional incision. After becoming familiar with the technique, a pedicle SVG can be obtained through the same incision as the original EVH without the need for an additional incision. As a precaution, however, the additional incision must be made after the endoscopic procedure is completed. Otherwise, the additional incision results in CO<sub>2</sub> leakage, rendering further endoscopic procedures impossible. Therefore, if encountering a difficult dissection area, it is advisable to skip that area and proceed with endoscopic dissection, and then make an additional small incision to dissect under direct vision after completing the endoscopic procedure.

Pedicle-EVH is a technique aimed at reducing wound complications. To that end, some recommendations are discussed below. Patients undergoing CABG with SVG are often prescribed anticoagulants and antiplatelet agents, which increase the risk of postoperative bleeding and hematoma formation. Therefore, meticulous hemostasis is essential for preventing postoperative wound complications during Pedicle-EVH. During blunt

dissection with a dissector, small branches of the GSV are prone to pull-out damage and hemorrhage. In addition, during cauterization, the cautery tip may be a blind spot and hemorrhage due to inadequate cauterization of the branches is likely to occur. Furthermore, there was a case in our series of accidental cauterization involving the main trunk of the GSV. The surrounding fatty tissue makes it difficult to visualize the GSV. To prevent bleeding, hematoma formation, and injury to the GSV, it is essential to understand the precautions for each procedure and to ensure good visibility.

Two patients developed lymphorrhea in our series and were successfully managed with conservative treatment; however, lymphorrhea is an unacceptable wound complication requiring further surgical treatment when the volume is large and refractory. In the surgical treatment of lymphorrhea, indocyanine green lymphography has been reported useful in identifying ruptured lymphatic vessels that cause lymphorrhea.<sup>7)</sup> In the thigh, the collecting lymphatic vessels are white, transparent, and thin (mean diameter, approximately 0.2 mm); generally lie just beneath the superficial fascia; and run in the vicinity of the GSV.<sup>8)</sup> Therefore, one must be aware of the possibility of injuring these nearly invisible lymphatic vessels during Pedicle-EVH, especially during anterior dissection and in cases with thin subcutaneous adipose tissue because the collecting lymphatic vessels are generally more shallow than the GSV. In addition, because the collecting lymphatic vessels flow into the lymph nodes near the femoral artery and vein in the inguinal region, one of the recommendations for the prevention of lymphorrhea is to



complete the dissection of the GSV shortly before dissection of the inguinal region. The ruptured lymphatic vessels and spaces that allow leakage contribute to the development of lymphorrhea. Thus, appropriate compression therapy (uniform compression to eliminate dead space at the harvesting site) is the key to preventing lymphorrhea (see Section Postoperative harvest site management).

Our pedicle SVG differs from the previously reported NT-SVG with respect to both the harvest site and method. We harvested all pedicle SVGs from the thigh, which are larger in diameter than SVGs harvested from the lower leg. Notably, there is concern that this method may result in intimal hyperplasia and graft occlusion<sup>9)</sup>; however, Samano et al.<sup>5)</sup> reported that differences in patency by harvest site (diameter) were observed for conventional SVG, but not for NT-SVG, which is an important factor in developing an endoscopic harvest method for NT grafts. This report should be met enthusiastically among cardiac surgeons who perform Pedicle-EVH.

Unlike NT-SVGs, which are harvested under direct vision, the Pedicle-EVH is dissected endoscopically, which may result in partial PVAT loss. The NT-SVG PVAT has been reported to be a major source of nitric oxide production,<sup>10)</sup> which has an important role in the suppression of atherosclerosis. Indeed, the primary goal of the Pedicle-EVH procedure is to preserve the PVAT. The long-term outcome of pedicle SVGs, which differs from NT-SVGs in the harvesting method, must be followed carefully, including the effect of the partially missing portion of the PVAT.

Finally, a challenge of the Pedicle-EVH procedure is to shorten the harvesting time; otherwise, it will not be possible to harvest from bilateral thighs to accommodate multivessel bypass. When the technique is mastered, a pedicle SVG can be obtained from a unilateral thigh in approximately 60 min; however, both the time required for the learning curve and the harvest time after the learning curve are still longer than required for the original EVH. The reason for this finding is that the device currently in use is designed for stripped SVG harvesting. To shorten the harvesting time for the Pedicle-EVH procedure, a new or remodeled device must be developed.

## Conclusion

Pedicle-EVH was performed with no major wound complications and good early results, including patency. We plan to continue using this procedure. To harvest the pedicle SVGs, however, our department has used a

different method and harvest site than the NT-SVG procedure reported previously, so careful monitoring will be needed to assess long-term outcomes.

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## Disclosure Statement

The authors declare that there are no conflicts of interest.

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