

Clinical Study

4-Year Outcome Analysis of Endoscopic Vein Harvesting for Coronary Artery Bypass Grafting

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Objective. Despite increasing recognition that endoscopic vein harvesting (EVH) is associated with decreased leg wound morbidity, improved cosmetic results, and enhanced patient satisfaction, concerns persist regarding the safety and efficacy of EVH. This study compares in-hospital and midterm outcomes for EVH and open vein harvesting (OVH) at our institution. **Methods.** 772 patients with EVH were propensity matched to 772 patients who had OVH. Their data were prospectively entered into the cardiac surgery database (PATS; Dendrite Clinical Systems, Ltd., Oxford, UK) and analyzed, retrospectively. The mean duration of followup was 26.4 ± 10.3 months. **Results.** EVH was associated with a significant reduction in rate of donor site infection compared to OVH (0.39% versus 3.9%, $P < 0.001$). Short- and medium-term vein graft patency was similar. After adjusting for clinical covariates, EVH did not emerge as an independent predictor of readmission to hospital for cardiac causes (odds ratio (OR) 1.19, 95% confidence interval (CI) 0.96–1.58, and $P = 0.31$), medium-term mortality (hazard ratio (HR) 1.28, 95% CI 1.09–1.42, and $P = 0.92$), and need for reintervention (HR 1.21, 95% CI 0.98–1.32, and $P = 0.86$). Risk-adjusted survival was 94% for EVH patients and 93% for OVH patients ($P = 0.96$) during the medium-term followup. **Conclusion.** Our analysis confirms the short- and medium-term safety and efficacy of EVH.

1. Introduction

The choice of the graft conduit is crucial to the success of coronary artery bypass grafting (CABG) because the patency of a coronary conduit is closely associated with an uneventful postoperative course and better long-term patient survival [1]. The internal mammary artery has been the primary conduit for CABG patients, given its association with long-term patency and survival [2, 3]. However, great saphenous vein (GSV) continues to be utilized universally as patients presenting for CABG often have multiple coronary territories requiring revascularization [1]. Traditionally, the GSV has been harvested by creating incisions from the groin down to the ankle, but such harvesting methods are associated with incisional pain and leg wound infections. In addition, patients find such large incisions to be cosmetically unappealing. These concerns regarding wound morbidity and patient satisfaction led to the emergence of endoscopic vein harvesting (EVH) [4].

Emerging evidence from several randomized controlled trials [5–8], observational studies [9, 10], and meta-analyses [11, 12] suggests that compared with traditional open vein harvest (OVH), EVH is associated with decreased wound-related complications, improved patient satisfaction, shorter hospital stay, and reduced postoperative pain at the harvest site. However, despite these reported advantages concerns regarding risk of injury at the time of harvest with its potential detrimental effect on vein graft patency and clinical outcomes [13–15] have prevented universal adoption of EVH. In addition, there is a paucity of data on midterm safety and efficacy of EVH [10]. We undertook this study to compare in-hospital and midterm outcomes for EVH and OVH at our institution.

2. Materials and Methods

2.1. Study Sample. This study comprised a retrospective analysis of a prospectively collected cardiac surgery database

(PATS; Dendrite Clinical Systems, Ltd., Oxford, UK) as well as a followup questionnaire approved by the institutional ethics committee; informed consent was waived for this study. The PATS database captures detailed information on a wide range of preoperative, intraoperative, and hospital post-operative variables (including complications and mortality) for all patients undergoing cardiac surgery in our institution. The database was collected and reported in accordance with The Society for Cardiothoracic Surgery in Great Britain and Ireland database criteria. In addition, the medical notes and charts of all the study patients were reviewed. For information on medium-term outcomes, a questionnaire was mailed to all surviving patients or to the general practitioners of those patients who had died during the followup period. From January 2008 to October 2011, 772 patients underwent isolated or combined CABG utilizing EVH. During the same period, 1219 patients underwent similar surgery utilizing OVH. Choice of vein harvesting technique was influenced by individual surgeon's preference. Factors influencing surgeon's preference to EVH or OVH may have included availability of equipment and skilled vein harvesting personnel, time constraints, propensity of patient for leg wound complications, and preconceptions regarding the safety and efficacy of EVH. Patient characteristics of both groups are shown in Table 1. Indications for CABG were determined at a weekly review involving cardiologists, cardiac surgeons, and cardiac radiologists. Patients were placed on a specific waiting list according to the urgency of their procedure. All patients who underwent isolated or combined CABG utilizing GSV harvested by either EVH or OVH were included in this study. Patients receiving veins using both EVH and OVH were excluded, and conversions from EVH to OVH were classified as EVH.

2.2. Operative Technique. Nine surgeons performed the 1991 operations during the study period. All interventions were performed via a midline sternotomy. The choice of on- or off-pump strategy for CABG was based on surgeon's preference. Left and right internal mammary arteries (IMA) were harvested with minimal trauma as pedicled or skeletonized grafts, based on surgeon's preference, and treated with papaverine solution prior to use.

Conventional CABG on cardiopulmonary bypass (CPB) was performed at 34°C. CPB was instituted with single two-stage right atrial cannulation or bicaval cannulation for intervention on mitral valve and an ascending aorta perfusion cannula. Standard bypass management included membrane oxygenators, arterial line filters, and nonpulsatile flow of 2.4 L/min/m², with a mean arterial pressure greater than 50 mm Hg. The myocardium was protected by using intermittent antegrade cold blood cardioplegia (4:1 blood to crystalloid ratio). Anticoagulation was achieved using 300 U/kg of heparin. If required, heparin was supplemented to maintain the activated clotting time above 480 seconds and was reversed by protamine at the end of the procedure.

All patients underwent conventional CABG using varying combinations of left and/or right IMA and saphenous vein grafts. All distal and proximal anastomoses on CPB were performed during a period of single aortic cross-clamping.

TABLE 1: Patient characteristics of endoscopic vein harvesting group versus open vein harvesting group in 1,991 unmatched cases.

Preoperative demographics	EVH group <i>n</i> = 772 (%)	OVH group <i>n</i> = 1219 (%)	<i>P</i> value
Age (years, mean ± SD)	66.2 ± 10.3	66.4 ± 9.8	0.82
Sex (female)	218 (28.2)	317 (26)	0.76
Diabetes	297 (38.5)	349 (28.7)	0.03
Hypertension	365 (47.3)	596 (48.9)	0.87
Hypercholesterolemia	411 (53.2)	525 (43.1)	0.02
Smoking history	496 (64.2)	802 (65.8)	0.81
PVD	121 (15.7)	115 (9.4)	0.04
Previous stroke/TIA	48 (6.2)	89 (7.3)	0.89
COPD	136 (17.6)	189 (15.5)	0.73
Serum creatinine ≥ 200 μmol·L ⁻¹	56 (7.3)	49 (4.0)	0.04
Prior PCI	112 (14.5)	194 (15.9)	0.71
Recent MI	116 (15.0)	196 (16.1)	0.84
LVEF > 50%	527 (68.3)	901 (73.9)	0.67
LVEF < 50%	245 (31.7)	318 (26.1)	0.71
Elective	514 (66.6)	824 (67.6)	0.87
Urgent	258 (33.4)	395 (32.4)	0.84
Isolated CABG	576 (74.6)	869 (71.3)	0.69
CABG + AVR	111 (14.4)	207 (17.0)	0.56
CABG + MVR	85 (11.0)	143 (11.7)	0.91
Single vessel	96 (12.4)	162 (13.3)	0.84
Two vessels	251 (32.5)	380 (31.2)	0.84
Three vessels	425 (55.1)	677 (55.5)	0.98
Logistic EuroSCORE (mean ± SD)	8.3 ± 8.4	8.6 ± 8.8	0.32

AVR: aortic valve replacement; CABG: coronary artery bypass grafting; COPD: chronic obstructive pulmonary disease; EVH: endoscopic vein harvesting; LVEF: left ventricle ejection fraction; MI: myocardial infarction; MVR: mitral valve repair; OVH: open vein harvesting; PCI: percutaneous coronary intervention; PVD: peripheral vascular disease; SD: standard deviation; and TIA: transient ischemic attack.

In case of combined valve repair/replacement and CABG, the intervention on the valve followed construction of distal anastomosis.

For off-pump CABG, the heart was stabilized using the suction-irrigation tissue stabilisation system. A deep pericardial retraction suture helped position the heart for grafting. Anticoagulation was achieved with 150 U/kg of heparin. If required, heparin was supplemented to maintain the activated clotting time above 250 seconds and was reversed by protamine at the end of the procedure. Blood pressure was continually optimized during the procedure, and the mean arterial pressure was maintained above 50 mm Hg by repositioning the heart and by intravenous fluids or selective use of vasoconstrictors, or both. The proximal graft anastomoses to the aorta were performed with partial cross-clamping of the ascending aorta. Each distal anastomosis was followed by the construction of the corresponding proximal anastomosis.

The OVH was performed by either a continuous, longitudinal incision, or through multiple smaller incisions (open, bridging technique) under direct vision. An experienced surgeon or nurse practitioner performed EVH using the Vasoview Hemopro Endoscopic Vessel Harvesting System (Maquet Medical Systems, NJ, USA) with sealed carbon dioxide insufflation. The vein was harvested through a subcutaneous tunnel with endoscopic bipolar cautery scissors to divide side branches. Heparin 5000 units was administered systemically at the commencement of EVH. After harvesting, all veins were stored in autologous heparinized blood.

2.3. Postoperative Management. All patients received intravenous nitroglycerin (0.1 to $8 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) infusions for the first 24 hours unless hypotensive (systolic blood pressure <90 mm Hg). The choice of inotropic agents was dictated by the hemodynamic data. Other routine medications included daily aspirin and resumption of cholesterol-lowering agents and β -blockers. Other medications were added as indicated.

2.4. Assessment of Graft Patency. Intraoperative graft patency was assessed using the transit-time flowmetry (TTFM) QuickFit flow probes (Medistim ASA, Norway). Patient data were entered into the transit-time flowmeter (BF 2004), and the integrated chart recorder on the monitor displayed the flow waveform and its analysis and simultaneously recorded the electrocardiogram and systemic arterial pressure. The ultrasound couplant (gel) was applied to the flow probe lumen before it was positioned on the graft such that the graft occupied at least 75% of the flow probe lumen. TTFM provides a flow waveform profile and mean graft flow (MGF) values. MGF values more than 40 mL/min indicate satisfactory flow, and values less than 5 mL/min are considered unsatisfactory and prompt revision [16]. Certain derived values, such as pulsatility index (PI) and diastolic flow index, are also displayed. PI is an absolute number (defined as the difference between maximum and minimum flows divided by the mean flow) that indicates the resistance to graft flow, and a value more than 5 is considered unsatisfactory [17]. A diastolic flow index value of more than 50% indicates a predominantly diastolic graft flow profile and is recognized as normal, akin to native coronary artery blood flow [18].

Followup angiography was scheduled at 6 weeks, 6 months, and 24 months after the operation by using the standard percutaneous transfemoral technique or computerized tomography (CT). All angiograms were reviewed independently by 1 interventional cardiologist and 1 interventional radiologist who were blinded to the vein-harvesting technique. Graft patency was assigned as patent with unimpaired runoff, patent but with disease producing greater than 50% stenosis of the graft, or occluded. When there was a difference of opinion on patency and disease, the worst-case scenario was used in the analysis. The 2 reviewers were in agreement 97% of the time.

2.5. Variables and Data Collection. Preoperative variables of interest included age, sex, smoking history, chronic obstructive pulmonary disease, diabetes, hypercholesterolemia, renal

insufficiency (preoperative serum creatinine $\geq 200 \mu\text{mol}\cdot\text{L}^{-1}$), hypertension, peripheral vascular disease, cerebrovascular disease, left ventricular ejection fraction, urgency (operation performed <24 h versus >24 h from time of referral), prior percutaneous coronary interventions, recent myocardial infarction (MI), number of diseased vessels, additional procedures, and logistic EuroSCORE. Intraoperative variables of interest included types of grafts used, grafts/patient, cardiopulmonary bypass (CPB) time, aortic cross-clamp time, conversion to CPB, conversion from EVH to OVH, and type of prosthetic valve used. Postoperative variables of interest included in-hospital mortality, intraoperative or postoperative intra-aortic balloon pump (IABP), postoperative MI, stroke or transient ischemic attack (TIA), prolonged ventilation >24 hours, atrial fibrillation, superficial sternal wound infection, deep sternal infection, leg wound infection, blood products, inotropes leaving operating room (OR), chest infection, return to OR for bleeding, length of intensive care unit (ICU) stay, and length of hospital stay. The medium-term outcomes of interest were all-cause mortality following discharge from hospital and readmission for any cardiac cause defined by the following codes from the 9th revision of the International Classification of Disease, Clinical Modification [19]: 410 (acute MI), 411 (unstable angina), 412 (old MI), 413 (angina pectoris), 414 (other forms of chronic ischemic heart disease), 426 (conduction disorders), 427 (cardiac dysrhythmias), 428 (heart failure), 429 (ill-defined descriptions and complications of heart disease), and coronary reintervention (percutaneous or CABG).

2.6. Statistical Analysis. Patients, who underwent CABG with EVH, were compared to those who had CABG with OVH, using t -tests and Kruskal-Wallis tests for continuous variables and χ^2 tests for categorical variables. A propensity analysis was performed modeling the probability of receiving EVH. Briefly, a nonparsimonious multivariate logistic regression model using clinically relevant variables was generated to compute a propensity score for each patient (see the appendix). All clinically relevant variables were included in the model. The propensity score (or probability of receiving EVH) was then used to obtain a one-to-one match of all EVH cases with OVH cases by a "greedy matching" technique [20]. In-hospital outcomes were compared between these matched groups.

Logistic regression was used to examine the association of EVH with in-hospital adverse events including leg wound infection (leg incision site needing debridement, positive wound cultures, or treatment with antibiotics) and a composite outcome consisting of in-hospital mortality, perioperative MI (documented by electrocardiogram or biochemical changes), and repeat revascularization (percutaneous and/or CABG) before discharge from hospital, after adjusting for differences between patients on the basis of each of the above-mentioned preoperative variables. The association between EVH and the midterm outcomes of interest was analyzed using adjusted survival curves and Cox proportional hazards modeling techniques. All baseline characteristics were included in the fully adjusted multivariate Cox models.

TABLE 2: Patient characteristics of endoscopic vein harvesting group versus open vein harvesting group in 1,544 matched cases.

Preoperative demographics	EVH group <i>n</i> = 772 (%)	OVH group <i>n</i> = 772 (%)	<i>P</i> value
Age (years, mean ± SD)	66.2 ± 10.3	66.0 ± 10.2	0.78
Sex (female)	218 (28.2)	229 (29.7)	0.81
Diabetes	297 (38.5)	302 (39.1)	0.76
Hypertension	365 (47.3)	381 (49.4)	0.78
Hypercholesterolemia	411 (53.2)	406 (52.6)	0.81
Smoking history	496 (64.2)	501 (64.9)	0.89
PVD	121 (15.7)	101 (13.1)	0.67
Previous stroke/TIA	48 (6.2)	51 (6.6)	0.89
COPD	136 (17.6)	119 (15.4)	0.54
Serum creatinine ≥ 200 μmol·L ⁻¹	56 (7.3)	42 (5.4)	0.31
Prior PCI	112 (14.5)	121 (15.7)	0.67
Recent MI	116 (15.0)	122 (15.8)	0.71
LVEF > 50%	527 (68.3)	549 (71.1)	0.64
LVEF < 50%	245 (31.7)	236 (30.6)	0.81
Elective	514 (66.6)	529 (68.5)	0.67
Urgent	258 (33.4)	267 (34.6)	0.69
Isolated CABG	576 (74.6)	581 (72.3)	0.54
CABG + AVR	111 (14.4)	121 (15.7)	0.61
CABG + MVR*	85 (11.0)	89 (11.5)	0.93
Single vessel	96 (12.4)	97 (12.6)	0.91
Two vessels	251 (32.5)	257 (33.3)	0.81
Three vessels	425 (55.1)	418 (54.1)	0.79
Logistic EuroSCORE (mean ± SD)	8.3 ± 8.4	8.5 ± 8.6	0.54

AVR: aortic valve replacement; CABG: coronary artery bypass grafting; COPD: chronic obstructive pulmonary disease; EVH: endoscopic vein harvesting; LVEF: left ventricle ejection fraction; MI: myocardial infarction; MVR: mitral valve repair; OVH: open vein harvesting; PCI: percutaneous coronary intervention; PVD: peripheral vascular disease; SD: standard deviation; and TIA: transient ischemic attack.

*Includes 27 versus 33 mitral valve replacements.

Statistical significance was indicated by a two-tailed *P* value < 0.05. All analyses were performed with the Statistical Analysis Systems software package (Release 9.1.3; SAS Institute, Cary, NC, USA). The authors had full access to the data and take responsibility for its integrity. All authors have read and agreed on the manuscript as written.

3. Results

A total of 1991 patients formed the final study population. Compared to patients who had OVH, those receiving EVH

TABLE 3: Intraoperative data for 1,544 propensity-matched cases.

Variable	EVH group <i>n</i> = 772 (%)	OVH group <i>n</i> = 772 (%)	<i>P</i> value
GSV only	96 (12.4)	97 (12.6)	0.91
LIMA	492 (63.7)	556 (72.0)	0.06
RIMA	11 (1.4)	9 (1.2)	0.89
Bilateral IMAs	106 (13.7)	51 (6.6)	<0.001
Radial artery	67 (8.7)	59 (7.6)	0.71
OPCAB	536 (69.4)	223 (28.9)	<0.0001
Aortic cross-clamp time	69.4 ± 27.5	70.3 ± 28.2	0.79
CPB time	122.7 ± 55.2	121.3 ± 53.1	0.63
Conversion to CPB	9 (1.2)	—	—
Conversion to OVH	6 (0.8)	—	—
Grafts/patient	2.7 ± 0.4	2.7 ± 0.8	0.56
Bioprosthetic valve	103 (13.3)	111 (14.4)	0.76
Mechanical valve	35 (4.5)	43 (5.6)	0.81
MGF (mL/min, mean ± SD)	32.8 ± 4.5	31.6 ± 5.1	0.67
Pulsatility index	2.1 ± 0.5	2.1 ± 0.1	0.81

CPB: cardiopulmonary bypass; EVH: endoscopic vein harvest; LIMA: left internal mammary artery; MGF: mean graft flow; OPCAB: off-pump coronary artery bypass; OVH: open vein harvest; RIMA: right internal mammary artery; and SD: standard deviation.

were more likely to have diabetes, hypercholesterolemia, renal insufficiency, and peripheral vascular disease (Table 1). Unadjusted in-hospital mortality was 2.8% for EVH group and 3.4% for OVH group (*P* = 0.42). The overall mortality for the entire cohort was 3.2%.

The propensity score model included 19 patient variables that are listed along with their confidence intervals in the appendix. The *c* statistic for this model was 0.81 (Hosmer-Lemeshow goodness-of-fit, *P* = 0.31). All 772 EVH cases could be matched to 772 OVH patients. The two groups were well matched for all the patient variables (Table 2). EVH patients also received more bilateral IMAs than OVH group (13.7% versus 6.2%, *P* < 0.001) and had significantly more off-pump CABG than on-pump CABG (69.4% versus 28.9%, *P* < 0.001) (Table 3).

The in-hospital mortality for the propensity-matched EVH group was similar to the control group (2.8% versus 2.6%, *P* = 0.81). EVH was associated with a significant reduction in rate of donor site infection compared to OVH (0.39% versus 3.9%, *P* < 0.001) as shown in Figure 1. The remaining major in-hospital clinical outcomes were found to be similar. After adjusting for baseline covariates, EVH remained associated with reduced leg infections (odds ratio (OR) 0.42, 95% confidence interval (CI) 0.34 to 0.79, and *P* = 0.01), but did not emerge as an independent predictor of in-hospital composite outcome (OR 1.11, 95% CI 0.96 to 1.35, and *P* = 0.87).

A total of 199 patients (10%) underwent graft patency assessment. One hundred and six patients had intraoperative graft patency assessment using TTFM. Of these, 59 were

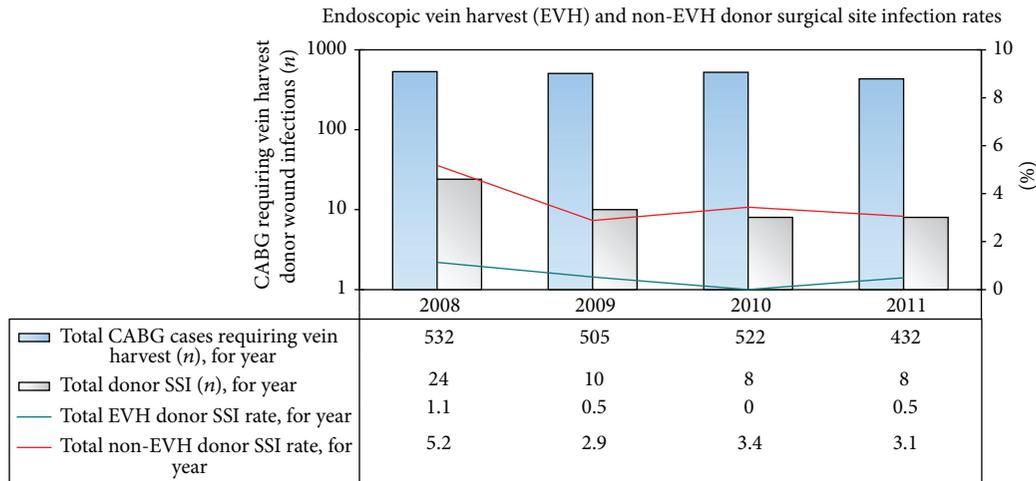


FIGURE 1: Comparison of leg wound infection rates after endoscopic vein harvesting and open vein harvesting.

EVH patients and 47 were OVH patients. The MGF and PI were similar for the two groups, and five patients (8.5%) in the EVH group and five patients (10.6%) in the OVH group required graft revision ($P = 0.47$) in the OR. One patient from EVH group had to be returned to OR for bleeding and required graft revision within the first 12 hours as an additional procedure due to the occlusion of vein graft caused by mechanical compression by Surgicel. Thirty-eight patients had elective angiography at 6 weeks. Twenty-two patients with 46 EVH grafts had 6 completely occluded grafts (13%) and 4 grafts with >50% occlusion (8.7%). Sixteen patients with 38 OVH grafts had 4 (10.3%) and 5 grafts with >50% occlusion (13.2%). Thirty patients, fifteen each in the EVH and OVH groups, underwent elective graft patency assessment at 6 months. A total of 15.2% (5/33) grafts were occluded in the EVH group and 18.8% (6/32) grafts were occluded in the OVH group ($P = 0.51$). Four grafts in each group had >50% occlusion ($P = 0.91$). Twenty-five patients underwent voluntary graft patency assessment at 24 months. Fourteen patients in the EVH group had 7.7% (3/39) and 11 patients in the OVH group had 9.1% (2/22) occluded grafts at 2 years ($P = 0.76$) with 5.1% grafts in EVH group and 4.5% in OVH group showing >50% occlusion ($P = 0.84$). Short- and medium-term vein graft patency was similar (Tables 3 and 4).

The mean duration of followup was 26.4 ± 10.3 months with 100% complete followup. Over the entire followup period, 12 (1.6%) patients died in the EVH group and 17 (1.4%) in the control group ($P = 0.89$). After adjusting for clinical covariates, EVH did not emerge as an independent predictor of medium-term mortality (hazard ratio (HR) 1.28, 95% CI 1.09–1.42, and $P = 0.92$). Risk-adjusted survival was 94% for EVH patients and 93% for OVH patients ($P = 0.96$) during the medium-term followup (Figure 2). After discharge, 3.1% of EVH patients and 3.2% of OVH patients were readmitted to hospital for cardiac reasons ($P = 0.96$). These included 12 (1.6%) EVH and 18 (1.5%) OVH patients who were readmitted for repeat revascularization (percutaneous or CABG, $P = 0.91$) (Table 5); repeat CABG was performed in 6 (0.7%) EVH patients and 9 (0.7%) OVH patients ($P = 1.00$). After

TABLE 4: Perioperative outcomes for 1,544 propensity-matched cases.

Perioperative outcome	EVH group <i>n</i> = 772 (%)	OVH group <i>n</i> = 772 (%)	<i>P</i> value
In-hospital mortality	22 (2.8)	20 (2.6)	0.81
Perioperative MI	7 (0.9)	6 (0.7)	0.89
Stroke/TIA	5 (0.6)	7 (0.9)	0.76
Ventilation > 24 hours	11 (1.4)	15 (1.9)	0.69
Atrial fibrillation	163 (21.1)	176 (22.8)	0.74
Chest infection	39 (5.1)	43 (5.6)	0.86
Superficial sternal infection	10 (1.3)	14 (1.8)	0.76
Deep sternal infection	7 (0.9)	8 (1.0)	0.89
Leg wound infection	3 (0.39)	30 (3.9)	<0.001
Blood products	58 (7.5)	88 (11.4)	0.09
Return to OR for bleeding	13 (1.7)	15 (1.9)	0.81
Inotropes	92 (11.9)	107 (13.9)	0.56
Hemofiltration	22 (2.8)	34 (4.4)	0.42
Postoperative IABP	8 (1.0)	12 (1.6)	0.61
ICU stay (days, IQR)	1 (2–7)	1 (2–8)	0.78
Hospital stay (days, IQR)	7 (5–11)	7 (5–12)	0.89
Graft assessment	51 (6.6)	42 (5.4)	0.81

CPB: cardiopulmonary bypass; IABP: intra-aortic balloon pump; ICU: intensive care unit; IQR: interquartile range; MI: myocardial infarction; OR: operating room; and TIA: transient ischemic attack.

adjusting for clinical covariates, EVH did not emerge as an independent predictor of readmission to hospital for cardiac causes (OR 1.19, 95% CI 0.96–1.58, and $P = 0.31$) and need for reintervention (HR 1.21, 95% CI 0.98–1.32, and $P = 0.86$). Risk-adjusted freedom from readmission for any cardiac reason is illustrated in Figure 3.

4. Discussion

This large observational study confirms that EVH is not independently associated with either in-hospital or midterm

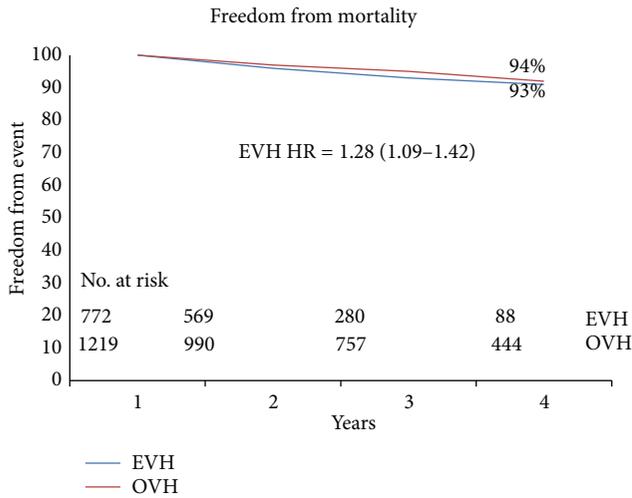


FIGURE 2: Comparison of risk-adjusted freedom from mortality between endoscopic vein harvesting and open vein harvesting groups.

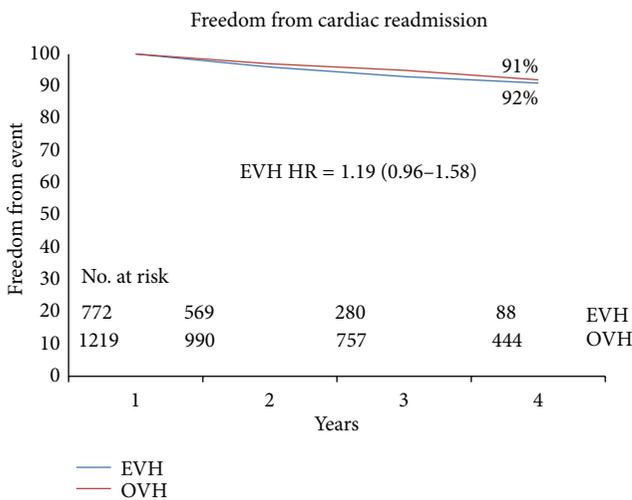


FIGURE 3: Comparison of risk-adjusted freedom from readmission to hospital from cardiac causes between endoscopic vein harvesting and open vein harvesting groups.

adverse events following CABG or combined valve/CABG surgery. Similar results have recently been described by Ouzounian et al. [10] and Kirmani et al. [21]. Furthermore, it validates that EVH is associated with a reduced incidence of leg wound infections as previously reported [5–12]. This study is unique as it reports one of the largest clinical experiences to date of EVH from a more recent era using the latest technology with both intraoperative as well as postoperative assessments of vein graft patency.

We have attempted to make meaningful comparisons between the EVH group and a contemporaneous group of OVH control patients. To do this, we have used two statistical approaches based on propensity modeling, a technique that has been strongly advocated in several recent publications [22], in an effort to better evaluate treatment comparisons

TABLE 5: Angiographic findings in patients readmitted for cardiac causes.

Cause	EVH 12 (1.6%)	OVH 18 (1.5%)
Total grafts performed	40	52
Vein grafts	31	38
Occluded vein grafts	22 (74.2%)	29 (76.3%)
>50% stenosis	5 (16.1%)	6 (15.8%)

EVH: endoscopic vein harvesting; OVH: open vein harvesting.

from nonrandomized clinical experiences. The propensity score is the probability of a patient receiving a given intervention (in this case EVH) based on a nonparsimonious model derived from preoperative patient variables. The propensity model, thus, reduces many variables to a single balancing score, facilitating meaningful intergroup comparisons. We used two approaches, namely, the creation of matched pairs based on propensity score and logistic regression analysis of outcomes in which propensity score participated as a variable.

Using the propensity matching technique, the EVH and OVH groups were remarkably well matched in terms of known risk predictors of outcomes after CABG surgery. The overall mortality and major morbidity between groups were not statistically different. However, the incidence of leg wound infection was significantly less with EVH compared to OVH ($P < 0.001$). Recognition of this benefit might have resulted in patients with diabetes, hypercholesterolemia, renal insufficiency, and peripheral vascular disease; all well-established factors associated with increasing occurrence of surgical site infection, preferentially receiving EVH. OVH uses a long incision and has been found to lead to significant wound morbidity. EVH minimizes the length of incisions. Furthermore, the advantage of EVH over the multiple bridging techniques is that it avoids traction on the vein while being harvested, thus minimizing trauma to the endothelium. In addition, the videoscopic vision (although two-dimensional) allows the surgeon to dissect under vision throughout the procedure. Another potential advantage of EVH is the amount of blood loss from the vein harvest site. EVH is associated with minimal blood loss, potentially reducing the exposure to blood products. In this study, there was a difference in the amount of blood products usage between the two groups although not statistically significant.

Another, interesting finding of this study was the increased use of bilateral IMAs and off-pump CABG in patients who underwent EVH. The most plausible explanation for this finding is that surgeons who adopted EVH in their routine clinical practice were perhaps more open to embrace change as reflected by their choice of bilateral IMAs and off-pump CABG for routine grafting compared to their peers who preferred OVH, use of single IMA, and CABG over CPB.

A distinguishing feature of this study is the assessment of intraoperative graft patency using TTFM as well as postoperative patency using conventional or CT angiography at varying intervals ranging from 6 weeks to 24 months after surgery. In contrast to the numerous studies reporting improved

TABLE 6: Logistic regression model to generate propensity scores for EVH group ($n = 772$) versus control group ($n = 1,219$).

Effect	Point estimate	95% Wald confidence limits		P value
		Lower	Upper	
Age	0.781	0.591	1.117	0.21
Gender	0.743	0.598	1.051	0.20
Diabetes	0.786	0.611	1.087	0.17
Hypertension	1.112	0.976	1.637	0.41
Hypercholesterolemia	1.596	1.231	2.101	0.54
PVD	0.896	0.659	1.114	0.27
Previous stroke/TIA	1.113	0.832	1.987	0.63
COPD	0.986	0.732	1.347	0.47
Creatinine $\geq 200 \mu\text{mol}\cdot\text{L}^{-1}$	0.943	0.755	1.121	0.24
Prior PCI	1.751	1.431	2.321	0.59
Recent MI	0.849	0.623	1.297	0.22
LVEF $> 50\%$	0.977	0.722	1.143	0.27
LVEF $< 50\%$	1.446	1.331	1.921	0.43
Elective	0.724	0.665	1.033	0.21
Urgent	0.674	0.475	1.011	0.22
Single vessel	1.128	0.822	1.984	0.61
Two vessels	1.012	0.776	1.356	0.47
Three vessels	0.997	0.782	1.134	0.24
Logistic EuroSCORE	0.921	0.747	1.151	0.27

COPD: chronic obstructive pulmonary disease; EVH: endoscopic vein harvest; LVEF: left ventricle ejection fraction; OVH: open vein harvest; PVD: peripheral vascular disease; and TIA: transient ischemic attack.

short-term and wound-related outcomes after EVH, there is a paucity of data regarding graft patency after open or EVH. Yun and associates [8] randomized 200 patients to EVH or OVH and reported 6-month overall occlusion rates of 21.7% for EVH and 17.6% for OVH (OR 1.15, $P = 0.63$). In contrast, the PREVENT IV multicenter CABG trial assessed 1-year patency rates in more than 4,000 saphenous vein grafts and found EVH to be an independent predictor of graft failure as compared with OVH (OR 1.35, $P < 0.001$) [14].

In our study, at a mean duration of followup of 26.4 ± 10.3 months, vein graft occlusion rate was 11.3%, with an additional 6.3% demonstrating stenotic regions of greater than 50% for those patients who underwent voluntary graft patency assessment. Inclusion of 30 patients who underwent symptom-guided graft patency assessment of their 60 vein grafts, with subsequent repeat revascularization, increased the vein graft occlusion rate to 11.5% with 9.5% grafts demonstrating stenotic regions of greater than 50%. More importantly, no significant patency differences were noted between EVH and OVH veins.

In this study, the overall 6-month vein graft occlusion rate was 14.1%, with an additional 11.4% demonstrating stenotic regions of greater than 50%. No significant patency differences were noted between EVH and OVH veins. These figures are similar to those reported by Perrault and colleagues [23] and better than those reported by Yun and associates [8]. On the other hand, our graft patency rates for EVH cohort are superior to the graft patency rates from PREVENT IV trial [14], which reports graft failure rates of $>25\%$ at 1 year. The multicentric nature of the PREVENT IV trial with variation in technology used for vein harvesting as well as learning

curve status of contributing centers could partly explain this difference in graft patency. Another possible explanation for the improved graft patency rate in our study could be the use of dual antiplatelet therapy for a minimum of six months for the majority of our patients. There is evidence to support this practice [24, 25] with improved vein graft patency reported in the randomized controlled trial setting [25].

The primary limitation of the study is its retrospective nature. Propensity score adjustment is no substitute for a properly designed, randomized, controlled trial. The retrospective nature of the study cannot account for the unknown variables affecting the outcome that are not correlated strongly with measured variables. However, retrospective comparisons with propensity score adjustment are more versatile and offer a useful way of interpreting large amounts of audit data and of seeking answers to questions that may present insuperable difficulties in the design of randomized, controlled trials. Despite the retrospective and observational nature of the study, we provided data on a large cohort of exclusively EVH patients undergoing CABG for comparison with OVH control group. Graft patency data for 376 vein grafts is the largest data outside trial setting albeit limited by the inherent limitations of the patency assessment techniques used.

In summary, our analysis confirms the short- and mid-term safety and efficacy of EVH.

Appendix

For more details, see Table 6.

Conflict of Interests

The authors declare that they have no conflict of interests.

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References

- [1] S. G. Raja, Z. Haider, M. Ahmad, and H. Zaman, "Saphenous vein grafts: to use or not to use?" *Heart Lung and Circulation*, vol. 13, no. 4, pp. 403–409, 2004.
- [2] B. W. Lytle, E. H. Blackstone, J. F. Sabik, P. Houghtaling, F. D. Loop, and D. M. Cosgrove, "The effect of bilateral internal thoracic artery grafting on survival during 20 postoperative years," *Annals of Thoracic Surgery*, vol. 78, no. 6, pp. 2005–2014, 2004.
- [3] B. Gansera, F. Schmidtler, I. Angelis, T. Kiask, B. M. Kemkes, and F. Botzenhardt, "Patency of internal thoracic artery compared to vein grafts—postoperative angiographic findings in 1189 symptomatic patients in 12 years," *Thoracic and Cardiovascular Surgeon*, vol. 55, no. 7, pp. 412–417, 2007.
- [4] S. Kiani and R. Poston, "Is endoscopic harvesting bad for saphenous vein graft patency in coronary surgery?" *Current Opinion in Cardiology*, vol. 26, no. 6, pp. 518–522, 2011.
- [5] K. B. Allen, G. L. Griffith, D. A. Heimansohn et al., "Endoscopic versus traditional saphenous vein harvesting: a prospective, randomized trial," *Annals of Thoracic Surgery*, vol. 66, no. 1, pp. 26–32, 1998.
- [6] B. Kiaii, B. C. Moon, D. Massel et al., "A prospective randomized trial of endoscopic versus conventional harvesting of the saphenous vein in coronary artery bypass surgery," *The Journal of Thoracic and Cardiovascular Surgery*, vol. 123, pp. 204–212, 2002.
- [7] J. D. Puskas, C. E. Wright, P. K. Miller et al., "A randomized trial of endoscopic versus open saphenous vein harvest in coronary bypass surgery," *Annals of Thoracic Surgery*, vol. 68, no. 4, pp. 1509–1512, 1999.
- [8] K. L. Yun, Y. Wu, V. Aharonian et al., "Randomized trial of endoscopic versus open vein harvest for coronary artery bypass grafting: six-month patency rates," *Journal of Thoracic and Cardiovascular Surgery*, vol. 129, no. 3, pp. 496–503, 2005.
- [9] J. M. Bitondo, W. M. Daggett, D. F. Torchiana et al., "Endoscopic versus open saphenous vein harvest: a comparison of postoperative wound complications," *Annals of Thoracic Surgery*, vol. 73, no. 2, pp. 523–528, 2002.
- [10] M. Ouzounian, A. Hassan, K. J. Buth et al., "Impact of endoscopic versus open saphenous vein harvest techniques on outcomes after coronary artery bypass grafting," *Annals of Thoracic Surgery*, vol. 89, no. 2, pp. 403–408, 2010.
- [11] T. Athanasiou, O. Aziz, P. Skapinakis et al., "Leg wound infection after coronary artery bypass grafting: a meta-analysis comparing minimally invasive versus conventional vein harvesting," *Annals of Thoracic Surgery*, vol. 76, no. 6, pp. 2141–2146, 2003.
- [12] D. Cheng, K. B. Allen, W. Cohn et al., "Endoscopic vascular harvest in coronary artery bypass grafting surgery: a meta-analysis of randomized trials and controlled trials," *Innovations*, vol. 1, no. 2, pp. 61–74, 2005.
- [13] R. D. Lopes, G. E. Hafley, K. B. Allen et al., "Endoscopic versus open vein-graft harvesting in coronary-artery bypass surgery," *The New England Journal of Medicine*, vol. 361, no. 3, pp. 235–244, 2009.
- [14] M. J. Magee, J. H. Alexander, G. Hafley et al., "Coronary artery bypass graft failure after on-pump and off-pump coronary artery bypass: findings from PREVENT IV," *Annals of Thoracic Surgery*, vol. 85, no. 2, pp. 494–500, 2008.
- [15] L. J. Rousou, K. B. Taylor, X. G. Lu et al., "Saphenous vein conduits harvested by endoscopic technique exhibit structural and functional damage," *Annals of Thoracic Surgery*, vol. 87, no. 1, pp. 62–70, 2009.
- [16] L. Balacumaraswami and D. P. Taggart, "Digital tools to facilitate intraoperative coronary artery bypass graft patency assessment," *Seminars in Thoracic and Cardiovascular Surgery*, vol. 16, no. 3, pp. 266–271, 2004.
- [17] G. D'Ancona, H. Karamanoukian, M. Ricci, A. Kawaguchi, J. Bergsland, and T. Salerno, "Myocardial revascularization on the beating heart after recent onset of acute myocardial infarction," *Heart Surgery Forum*, vol. 4, no. 1, pp. 74–79, 2001.
- [18] G. D'Ancona, H. L. Karamanoukian, M. Ricci, S. Schmid, J. Bergsland, and T. A. Salerno, "Graft revision after transit time flow measurement in off-pump coronary artery bypass grafting," *The European Journal of Cardio-thoracic Surgery*, vol. 17, no. 3, pp. 287–293, 2000.
- [19] "International classification of diseases, ninth revision, clinical modification (ICD-9-CM)," 2012, <http://www.cdc.gov/nchs/icd/icd9cm.htm>.
- [20] L. S. Parsons, "Reducing bias in a propensity score matched-pair sample using greedy matching techniques," in *Proceedings of the 26th Annual SAS Users Group International Conference*, SAS Institute, Cary, NC, USA, April 2001.
- [21] B. H. Kirmani, J. B. Barnard, F. Mourad, N. Blakeman, K. Chetcuti, and J. Zacharias, "Mid-term outcomes for Endoscopic versus Open Vein Harvest: a case control study," *Journal of Cardiothoracic Surgery*, vol. 5, article 44, 2010.
- [22] P. C. Austin, "Propensity-score matching in the cardiovascular surgery literature from 2004 to 2006: a systematic review and suggestions for improvement," *Journal of Thoracic and Cardiovascular Surgery*, vol. 134, no. 5, pp. 1128.e3–1135.e3, 2007.
- [23] L. P. Perrault, H. Jeanmart, L. Bilodeau et al., "Early quantitative coronary angiography of saphenous vein grafts for coronary artery bypass grafting harvested by means of open versus endoscopic saphenectomy: a prospective randomized trial," *Journal of Thoracic and Cardiovascular Surgery*, vol. 127, no. 5, pp. 1402–1407, 2004.
- [24] C. Gao, C. Ren, D. Li, and L. Li, "Clopidogrel and aspirin versus clopidogrel alone on graft patency after coronary artery bypass grafting," *Annals of Thoracic Surgery*, vol. 88, no. 1, pp. 59–62, 2009.
- [25] G. Gao, Z. Zheng, Y. Pi, B. Lu, J. Lu, and S. Hu, "Aspirin plus clopidogrel therapy increases early venous graft patency after coronary artery bypass surgery a single-center, randomized, controlled trial," *Journal of the American College of Cardiology*, vol. 56, no. 20, pp. 1639–1643, 2010.



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