



Clinical Abstracts

Topics in Endoscopic Vessel Harvesting

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Innovation for better outcomes

Endoscopic vessel harvesting

Advances in surgical technology make it possible to perform vessel harvesting procedures for coronary artery bypass graft (CABG) surgery in ways that result in reduced pain and less scarring—while also leading to faster recovery, better clinical outcomes, reduced costs, and enhanced patient satisfaction.

The endoscopic vessel harvesting (EVH) procedure enables saphenous vein and radial artery bypass conduits to be obtained using smaller incisions than with traditional, open vessel harvesting (OVH) procedures. The first EVH system was launched in 1997.

With over 2,500,000 Vasoview procedures performed through 2018, Getinge has led the efforts to establish endoscopic vessel harvesting as the standard of care.*



*Data on file, Maquet Cardiovascular; 2018.

The clinical advantages of EVH

Clinical studies demonstrate significant advantages of EVH. These patient benefits and advantages in cost savings are obtained without sacrificing conduit quality or long-term clinical outcomes.

The advantages of EVH

- Reduced wound complications and infection¹
- Reduced postoperative pain¹
- Reduced time to ambulation and hospital length of stay²⁻³
- Reduced hospital readmission⁴
- Reduced wound-related postoperative care and costs^{3,5-6}
- Equivalent conduit quality and graft patency^{3,7-10}
- Equivalent long-term revascularization outcomes¹¹⁻¹²
- Improved patient satisfaction¹
- Superior conduit quality and postoperative recovery vs. bridging technique¹³⁻¹⁴

The clinical advantages of EVH

Reduced wound complications and infection

Results from numerous studies show that EVH significantly decreases the incidence of wound complications when compared with open vessel harvesting (OVH) and bridging techniques.

Open vessel harvesting: wound complications are common

Impaired healing of saphenous vein graft (SVG) harvest wounds has been reported in up to 24% of CABG patients.¹⁵ These complications represent a significant cause of patient discomfort, prolonged postoperative length of stay, hospital readmission, and increased healthcare expenditures.

EVH reduces leg wound complications and infections

A comprehensive review and meta-analysis published by the International Society for Minimally Invasive Cardiac Surgery (ISMICS)¹ concluded that EVH reduces post-harvest leg wound complications and infections by 71% compared with OVH ($p < 0.001$).

EVH reduces leg wound complications and infections by 71%

	Odds Ratio	
Wound Complications	0.29	[95% CI 0.22-0.37]
Infection	0.29	[95% CI 0.22-0.39]

Odds ratio for wound complications is based on pooled analysis of 29 studies (11 919 patients). Odds ratio for infection is based on pooled analysis of 42 studies (31 677) patients. For a complete list of citations for studies included in these analyses, please see additional references on page 51.

Odds Ratio: The odds of event occurring in one group versus the odds of event occurring in another.

OR = 1.0 indicates event equally likely.

OR > 1.0 indicates event more likely.

OR < 1.0 indicates event less likely.

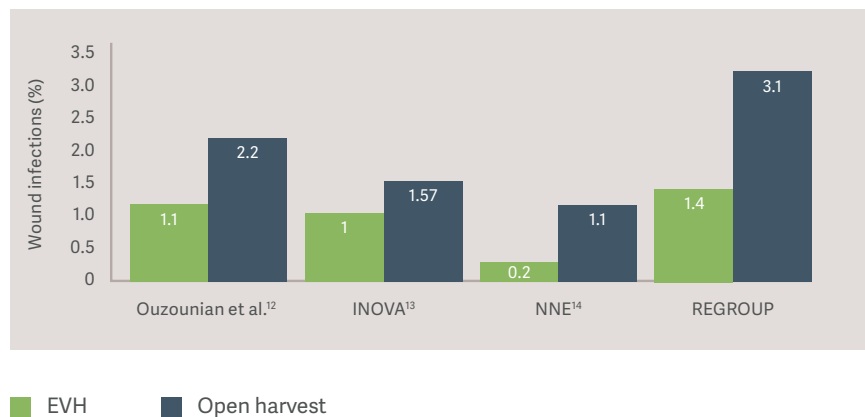
The clinical advantages of EVH

Reduced postoperative pain

Large single- and multi-center studies also support EVH advantage

The significant reduction in wound complications achieved by EVH is substantiated by six (6) large single- and multi-center studies published between 2010 and 2018. Four (4) of these studies demonstrated a 50% or greater reduction in wound complications as assessed across a total of 17,729 patients.^{6, 16-18}

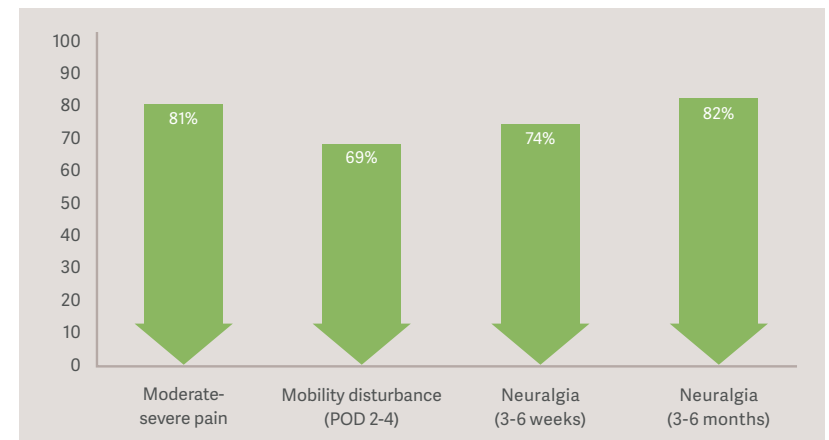
50% or > reduction in wound complications in studies of >17,000 patients



Several studies have documented that patients who undergo EVH report less postoperative pain than patients who undergo OVH. This reduction in pain has important implications for patient comfort and mobilization as well as for expediting hospital discharge.

The ISMICS systematic review and meta-analysis reported that EVH reduced the incidence of moderate to severe post-saphenectomy pain by 81%. In addition, disturbances in mobility resulting from pain were reduced by 69%, and postoperative neuralgia was reduced by 74% at 3-6 weeks and 82% at 3-6 months.¹

EVH reduces postoperative pain, discomfort-related mobility, disturbance, and neuralgia



The clinical advantages of EVH

Reduced time to ambulation and reduced length of stay

EVH improves mean time to ambulation and reduces hospital length of stay.

Reduced time to ambulation

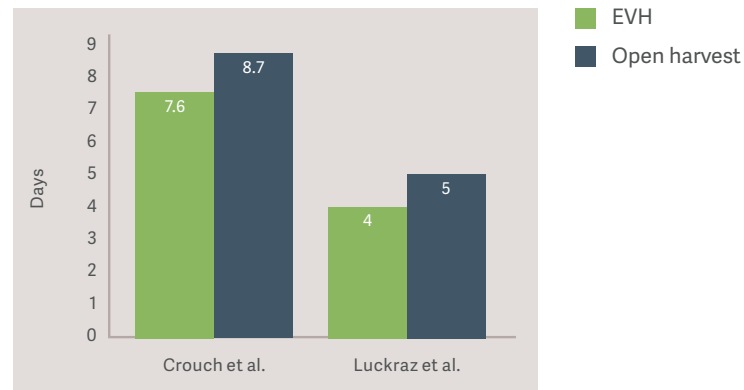
Morris et al. reported that, on average, EVH allowed patients to ambulate to a pre-discharge goal of 300 feet 2 days earlier than patients who underwent OVH.²

Reduced length of stay

Significant reduction in hospital length of stay is another important benefit of EVH.

In 1999, Crouch et al. reported an approximate 1 day reduction in total length of stay ($p = 0.08$) for patients who underwent EVH compared with OVH.³ More recently, results from a United Kingdom study published by Luckraz et al. in 2016 documented a similar 1 day shorter length of stay attributable to EVH among CABG patients at high risk for leg wound infection ($p = 0.01$)⁵

Comparison of length of stay (mean days) between EVH and OVH



The clinical advantages of EVH

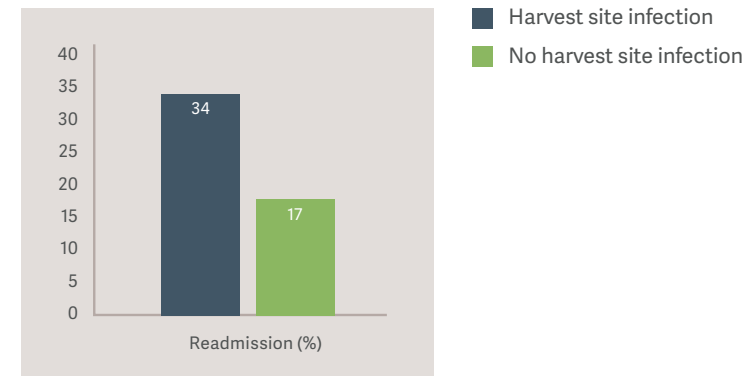
Reduced readmissions and postoperative wound-related care

EVH patients experience lower rates of hospital readmission and postoperative wound care visits when compared to patients treated using open vessel harvesting.

Reduced hospital readmissions

SVG harvest site infections are a significant cause of hospital readmission. A multicenter study of 2,174 patients documented that OVH doubled the risk of SVG harvest site infection after accounting for patient risk factors (adjusted hazard ratio 2.12; 95% confidence interval 1.28-3.48), with 86% of infections being diagnosed after discharge. Hospital readmission was doubled among CABG patients who developed harvest site infections compared with those who did not, with a median readmission length of stay of 7 days.⁴

Patient readmission due to wound complications



Gulack BC et al. J Thorac Cardiovasc Surg. 2018 Apr.

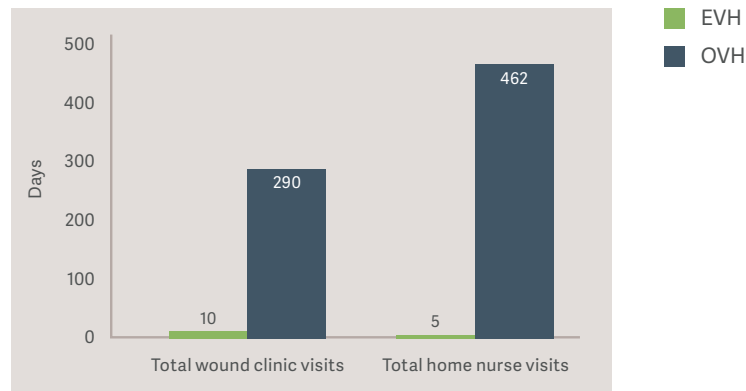
Reduced wound care

Several studies document that EVH is associated with reduced need for postoperative harvest site wound care.

Crouch et al. showed that the reduction in wound complications achieved by EVH was accompanied by an 82% reduction in inpatient antibiotics (1.1% vs. 6.2%, $p = 0.003$) and a 72% reduction in outpatient antibiotics (3.2% vs. 11.6%, $p = 0.007$).³

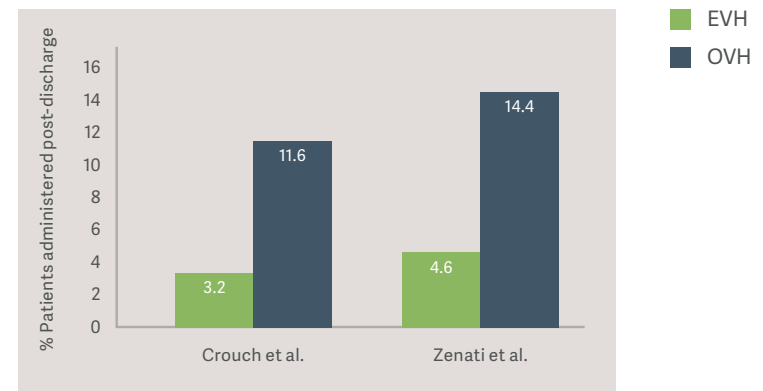
In a prospective study of 100 patients at high risk for leg wound infection conducted by Luckraz et al., CABG patients treated using EVH made 97% fewer total wound clinic visits (10 vs. 290, $p < 0.01$) and received 99% fewer home nursing visits (5 vs. 462, $p < 0.01$) than comparable patients treated using OVH.⁵ (chart below)

EVH reduces wound care visits



Most recently, a randomized comparison conducted at 16 Veterans Affairs cardiac centers demonstrated a 68% reduction in requirements for both antibiotics and home nursing care among patients whose CABGs were performed using EVH vs. OVH.⁶

Antibiotic administration is reduced with EVH



The clinical advantages of EVH

Reduced complications translate into cost savings

Recent evidence confirms that EVH is not only cost-effective but that the cost of EVH devices is offset by the savings accrued from the reduction in wound care, additional medications and supplies, and readmissions stemming from significantly fewer wound complications.

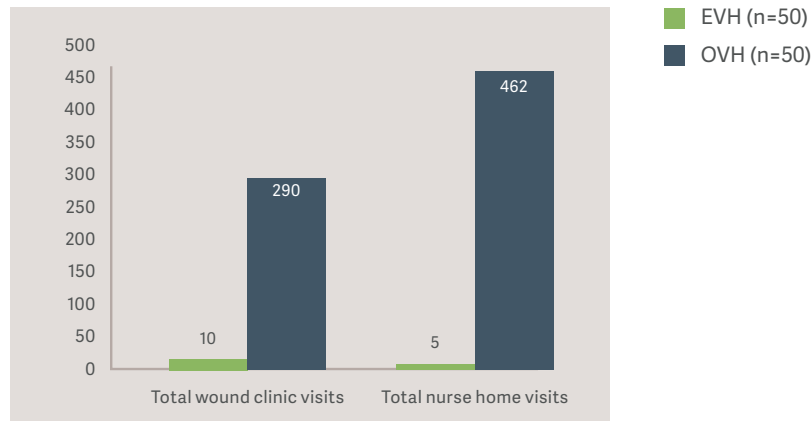
Reduced complications translate into reduced costs

Because the majority of wound complications occur after discharge and may not be treated by the original cardiac surgery center, it has been difficult to precisely quantify cost savings associated with EVH. To address this, the Cardiothoracic Surgery, Heart & Lung Centre, Wolverhampton, UK prospectively tracked costs of care in 100 CABG patients (50 EVH, 50 OVH) deemed to be high risk for wound complications.⁵ Patients were evaluated pre-discharge, then followed at the outpatient wound clinic until their leg wounds had completely healed. Costs of treatments, wound care supplies, medications, and home nursing were collected, along with hospital length of stay and readmissions.

Compared with OVH patients with comparable risk factors, patients who underwent EVH had:

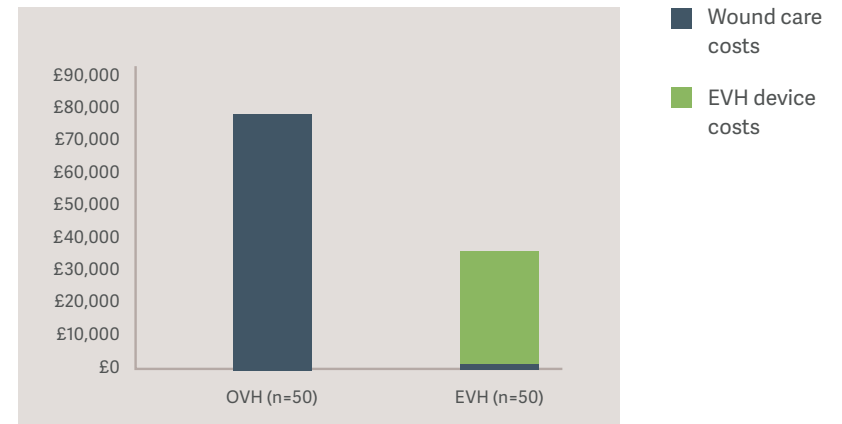
- 92% fewer wound complications (4% vs. 48%, $p < 0.01$)
- 1 day shorter postoperative lengths of stay (4 vs. 5, $p = 0.01$)
- 97% fewer total wound clinic visits (10 vs. 290, $p < 0.01$)
- 99% fewer total home nursing visits (5 vs. 462, $p < 0.01$)

EVH reduction in wound care visits



As a result of reduced treatment requirements, total wound care costs were 96% lower for EVH patients. After accounting for the additional cost of the device (£650/kit), EVH was associated with a net cost savings of £856 per patient.

EVH is associated with significant reduction in wound care costs



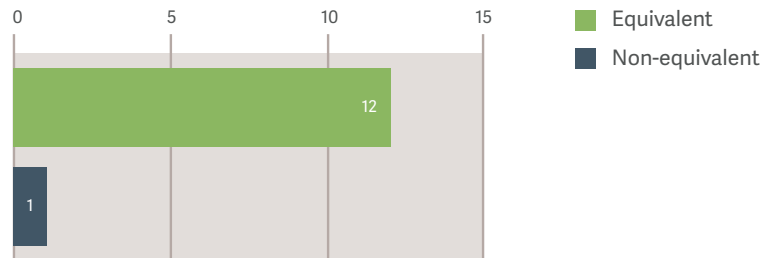
The clinical advantages of EVH

Equivalent conduit quality and early graft patency

EVH preserves endothelial integrity

The preponderance of studies show that EVH preserves endothelial integrity.

Number of studies



Equivalent EVH conduit quality

- Morris RJ et al. *Ann Thorac Surg.* 1998;66:1026–1028
- Patel AN et al. *Am J Surg.* 2001;182:716–719
- Aziz O et al. *Ann Thorac Surg.* 2005;80:2407–2414
- Crouch JD et al. *Ann Thorac Surg.* 1999;68:1513–1516
- Griffith GL et al. *Ann Thorac Surg.* 2000;69:520–523
- Meyer DM et al. *Ann Thorac Surg.* 2000;70:487–491
- Kiaii B et al. *J Thorac Cardiovasc Surg.* 2002;123:204–212
- Alrawi SJ et al. *Heart Surg Forum.* 2000;3:241–245
- Alrawi SJ et al. *Heart Surg Forum.* 2001;4:47–52
- Alrawi SJ et al. *Heart Surg Forum.* 2001;4:120–127
- Alrawi SJ et al. *JSLs.* 2002;6:5–9
- Alrawi SJ et al. *JSLs.* 2001;5:37–45
- Nowicki M et al. *Eur J Vasc Endovasc Surg.* 2004;27:244–250

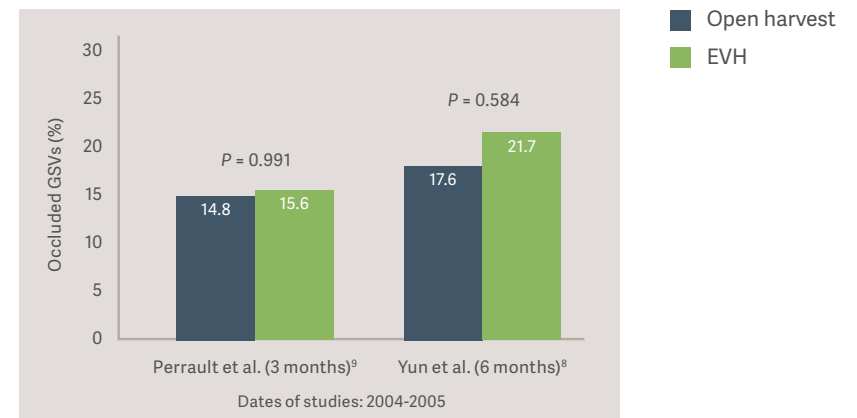
Non-equivalent conduit quality

- Rousou LJ et al. *Ann Thorac Surg.* 2009;87:62–70

A 200-patient randomized trial conducted by Yun et al. documented that EVH reduces leg wound complications compared with open vein harvest without compromising 6-month angiographic patency rates.⁹

Similarly, a randomized study by Perrault et al. found that angiographic patency and stenosis rates did not differ for SVGs harvested endoscopically compared with those harvested using an open incision. OVH.¹⁰

Randomized studies show equivalent early patency for endoscopically harvested SVGs



The clinical advantages of EVH

The right solution for high-risk patients

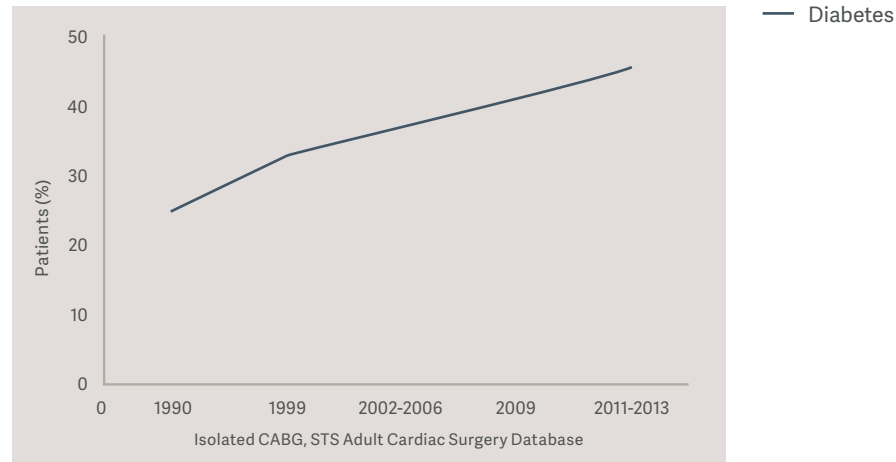
EVH is ideal for patients at greater risk for developing leg wound complications

CABG patients who are obese or diabetic are at elevated risk for surgical wound infections.^{15,19} These high-risk patients experience four (4) times fewer infections with EVH compared with open harvest.²⁰

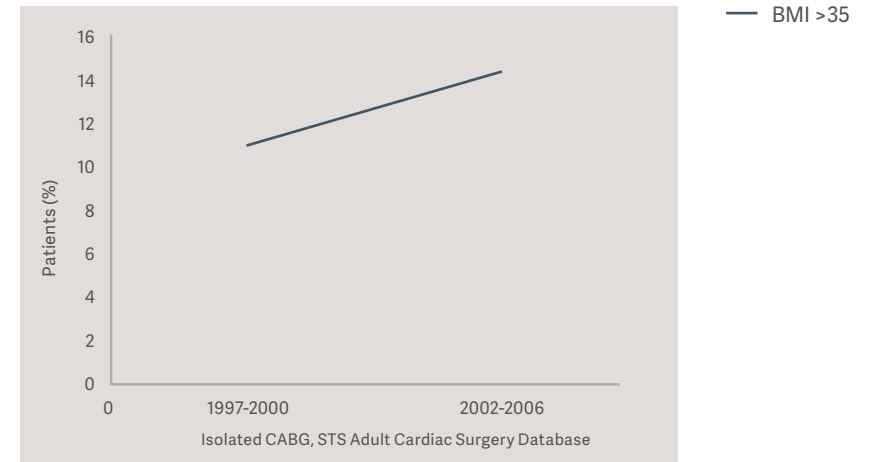
An increasing number of CABG patients are at high risk for wound complications

As diabetes and obesity become increasingly prevalent, a growing proportion of CABG patients are at high risk for saphenectomy wound complications and infections.²¹⁻²⁵

Prevalence of diabetes among isolated CABG patients

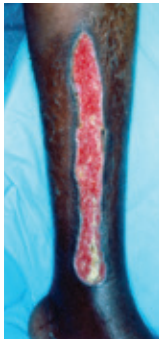


Prevalence of obesity (BMI >35) among isolated CABG patients



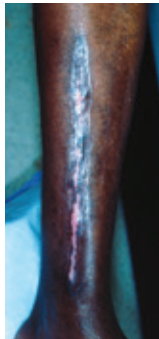
Wound complications in high-risk patients can have serious repercussions

Unhealed leg wound in 67-year-old female insulin-dependent diabetic CABG patient:²⁶



Saphenectomy site 1.5 months post-op following return to wound clinic and debridement.

1.5 months



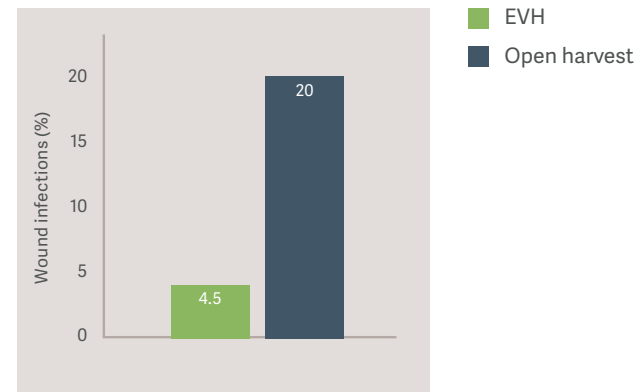
Saphenectomy site approximately 6 months post-op after debridement and application of bioengineered skin replacement graft.

6 months

Reducing wound infections in patients with diabetes or obesity

Carpino et al. randomized 132 high-risk patients (diabetic, obese, or both) to undergo vein harvest via EVH (n = 66) or OVH (n = 66). EVH reduced infections by 78%, with 4.5% of patients who underwent EVH experiencing wound infections versus 20% of patients who underwent open vessel harvest (P = 0.01).²⁰

EVH reduced wound infections in diabetic and/or obese patients by 78%



The clinical advantages of EVH

Excellent long-term outcomes

Multiple studies have confirmed excellent long-term clinical outcomes following EVH

Negative clinical outcomes associated with EVH were reported by two post hoc analyses of previously conducted randomized trials: PREVENT IV and ROOBY.²⁷⁻²⁸ Because neither was designed to evaluate EVH, both of these trials have significant design shortcomings that limit the validity of their findings regarding EVH.

PREVENT IV: understanding the study context and limitations

The EVH subset analysis of the PREVENT IV study published in 2009 reported higher rates of vein graft failure and mortality for patients who underwent EVH compared with open vein harvest, raising concern about the safety of the EVH procedure. However, it is important to keep a number of considerations in mind when interpreting the results of this analysis as they apply to EVH.

- The EVH analysis was a post hoc analysis of the PREVENT IV data – not a randomized comparison of endoscopic vs. open vessel harvesting.
- The PREVENT IV trial was designed to evaluate the effect of a gene therapy drug (edifoligide) on SVG patency; it was not designed to study EVH. As a result, patients were randomized to drug vs. placebo, not EVH vs. OVH.
- Resulting EVH and OVH patient groups differed significantly on risk factors known to impact long-term outcomes.
- There was no standardization of harvest technique, harvester experience, or center volume. Further, bridging techniques were categorized under EVH.
- There have been significant advances in both EVH technology and technique since PREVENT IV patients were enrolled in 2002–2003.

ROOBY: understanding the study context and limitations

A sub-analysis of the ROOBY off-pump vs. on-pump CABG trial published in 2011 reported that EVH was associated with lower 1-year saphenous vein graft patency and higher 1-year revascularization rates compared with open vein harvest. Similar to PREVENT IV, ROOBY was not designed to compare EVH with OVH and, therefore, suffers from a number of the same design shortcomings.

- Patients were not randomized to EVH vs. OVH, but rather to off-pump vs. on-pump CABG.
- Surgeons were encouraged to use whichever SVG harvest method they preferred, leaving open the possibility of selection bias and the impact of confounding patient factors.
- There was no standardization of harvester experience, harvest technique, or center volume.
- Data collection regarding SVG harvest technique began in 2003, a time when EVH adoption was low and both EVH technology and technique were in their early stages. As a result, study findings may not be representative of contemporary EVH practices and outcomes.

Key points for clinicians

Because of study design shortcomings, it is important to consider negative EVH outcomes from the PREVENT IV and ROOBY EVH analyses in the context of other clinical studies.²⁹⁻³⁰ Since publication of the PREVENT IV and ROOBY analyses, the safety and effectiveness of EVH have been confirmed by several large studies and meta-analyses.^{1,6,11-12,16-18,30-33}

EVH long-term clinical outcomes reaffirmed by six large studies: no increased mortality or adverse cardiac events

Since publication of the PREVENT IV subset analysis, EVH safety and effectiveness have been reaffirmed by six studies (one randomized multicenter trial and five large population studies) that conducted longitudinal follow-up of more than 257,000 patients. These studies documented no increase in mortality or other adverse cardiac outcomes associated with EVH. Further, a significant reduction in wound complications was documented with EVH in all studies that examined this outcome.^{6, 16-18,30-32}

»Endoscopic vein - graft harvest is safe for CABG surgery — Dacey 2012«

First Author Study Group	Study Type	Number of Patients	Publication Date	Average Follow-Up	Findings
Ouzounian et al. ¹² Queen Elizabeth II Health Sciences Center Halifax, Nova Scotia	Non-Randomized	5825	February 2010	2.6 years	No ↑ Mortality Wound infection ↓50%
Ad et al. ¹³ INOVA Heart and Vascular Inst. Falls Church, VA	Non-Randomized	1988	June 2010	1.8 years	No ↑ Mortality Wound infection ↓38%
Dacey et al. ¹⁴ Northern New England Cardiovascular Disease Group	Non-Randomized	8542	January 2011	4 years	No ↑ Mortality Wound infection ↓82%
Grant et al. ²² Manchester Academic Health Science Centre Manchester, UK	Non-Randomized	4709	January 2012	1.8 years	No ↑ Mortality Wound infection not assessed
Williams et al. ²³ Duke Cardiovascular Research Institute Analysis of STS & CMS Databases	Non-Randomized	235,394	July 2012	3 years	No ↑ Mortality Wound infection ↓17%
Zenati et al. REGROUP Trial Conducted at 16 US Veterans Affairs Cardiac Surgery Centers	Randomized	1,188	November 2018	2.78 years	No ↑ Mortality Wound infection ↓55%

- A total of 257,646 patients with an average follow-up of 1.8 to 4 years
- No increased mortality
- ↓ Wound complications

The clinical advantages of EVH

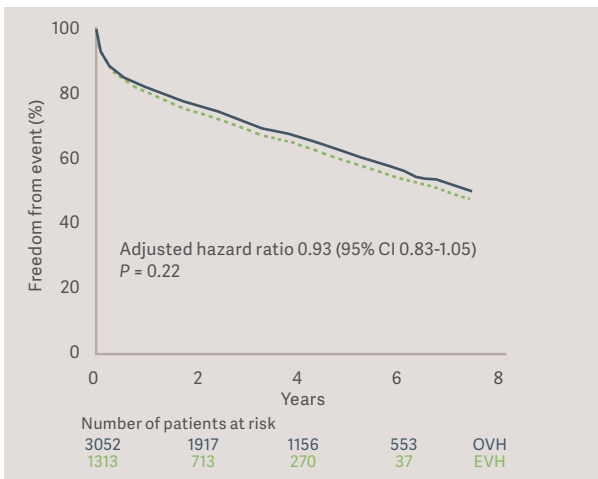
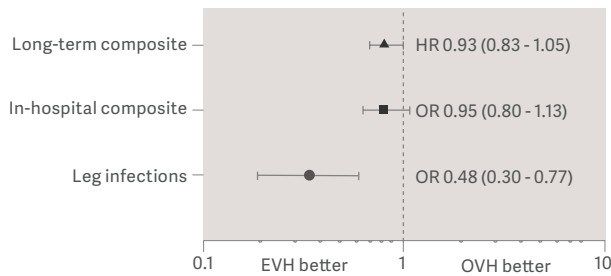
Comparable long-term outcomes

Ouzounian et al.: EVH shows reduced infections and equivalent long-term survival¹⁶

In this retrospective, observational study, 5825 patients were observed for an average of **2.6 years**. **34.4%** of these patients (n = 2004) had EVH procedures, while **65.6%** (n = 3821) underwent open vessel harvesting.

The results showed that EVH was associated with significantly lower rates of leg infection (OR 0.48, P = 0.003). Specifically, patients who underwent EVH had half the risk of infection of OVH patients.

Additionally, EVH and OVH patients did not differ on in-hospital adverse outcomes (OR 0.93, P = 0.56) or midterm freedom from death and readmission (hazard ratio [HR] 0.93, P = 0.22).



The clinical advantages of EVH

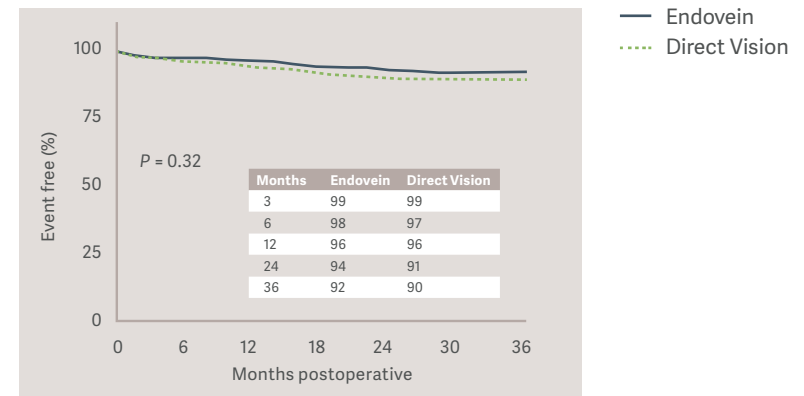
Comparable long-term outcomes

Ad et al.: EVH shows reduced infections and equivalent long-term morbidity and mortality¹⁷

In this retrospective, observational study, 1988 CABG patients were followed for 2 years (n = 1734 EVH, n = 254 OVH).

The findings demonstrated that EVH patients had significantly fewer infections. Additionally, EVH was not associated with increased morbidity or mortality as assessed by the number of vein closures, incidence of myocardial infarction, or the rate of death.

Survival to MI/death after discharge¹⁷



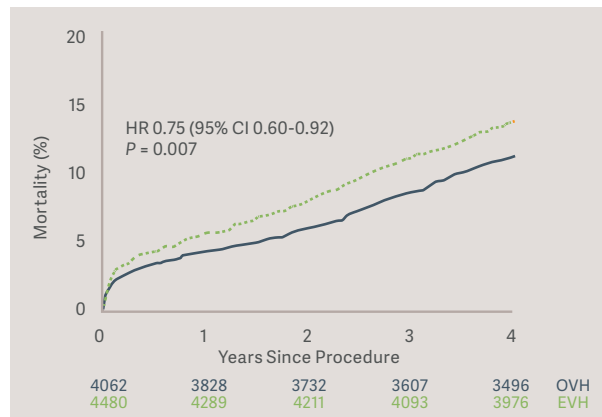
The clinical advantages of EVH

Comparable long-term outcomes

Dacey et al.: EVH shows reduced infections and no increased mortality¹⁸

In this retrospective, observational, propensity-adjusted study, 8542 patients were followed for **5.4** years. EVH leg wound infections were **5** times lower (0.2% versus 1.1%, $P < 0.001$), and there was **no** increase in mortality and **no** significant difference in repeat revascularization.

Importantly, it should be noted that long-term outcomes were excellent during a time when EVH adoption more than doubled (35% to 75%).



The clinical advantages of EVH

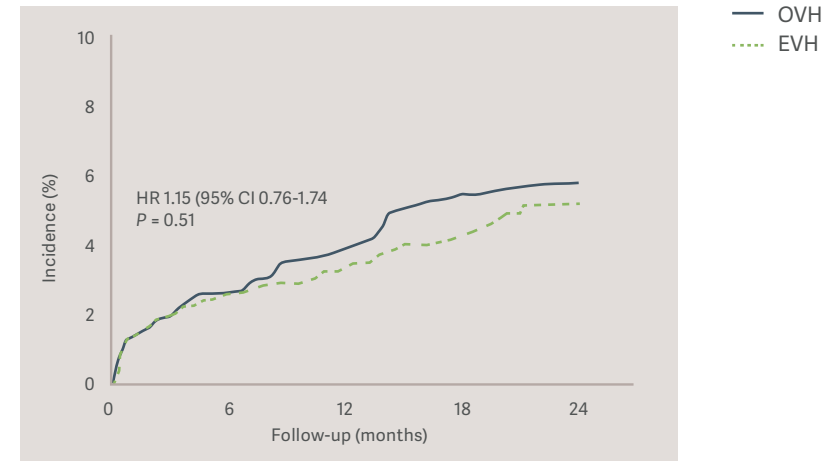
Comparable long-term outcomes

Grant et al.: impact of EVH on clinical outcomes following CABG³¹

"This multi-centre study demonstrates that at a median follow-up of 22 months, EVH was not associated with adverse short-term or mid-term clinical outcomes."

- 4709 consecutive isolated CABG patients
EVH (n = 586)
OVH (n = 4123)
- EVH was **not** associated with increased risk of death/repeat revascularization/myocardial infarction (MI) at 22 months (HR 1.15, 95% CI 0.76–1.74)
- EVH was **not** associated with increased risk of in-hospital morbidity, in-hospital mortality (0.9% versus 1.1%, $P = 0.71$), or midterm mortality (HR 1.04, 95% CI 0.65–1.66)

Mortality, repeat revascularization, and MI (%)³¹



The clinical advantages of EVH

Comparable long-term outcomes

Williams et al.: EVH shows no increase in mortality or adverse cardiac events in nearly a quarter million patients at 3 years³²

"Our observational study found no evidence of an association of endoscopic vein-graft harvest with long-term mortality or a composite of death, MI, or repeat revascularization. Endoscopic technique was found to be associated with significantly reduced wound complications."³²

- Commissioned by the US Food and Drug Administration (FDA) to evaluate EVH safety in direct response to the EVH subset analysis of PREVENT IV
- Followed nearly a quarter million Medicare patients who underwent isolated CABG for a median of 3 years:
EVH (n = 122,899)
OVH (n = 112,495)
- **No difference in mortality** between EVH and OVH (hazard ratio = 1.0, P > 0.99)
- **No difference in the combined endpoint of death, MI, or repeat revascularization** between EVH and OVH (HR = 1.0, P = 0.34)
- EVH was associated with a **significantly lower rate of wound complications** compared to OVH (HR = 0.83, P < 0.001)

This study provides strong reassurance that EVH reduces wound complications without compromising long-term patient outcomes.

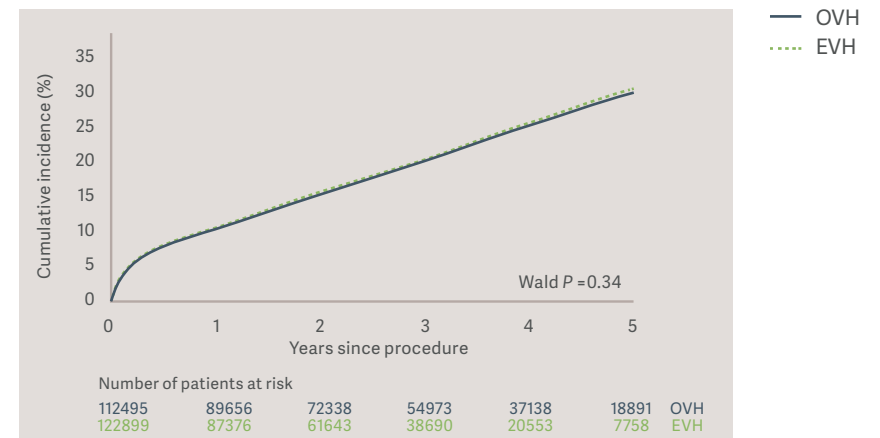
The clinical advantages of EVH

Comparable long-term outcomes

Risk-adjusted mortality: EVH vs. open for CABG patients³²



Risk-adjusted outcomes of death, MI, or revascularization: EVH vs. open for CABG patients³²



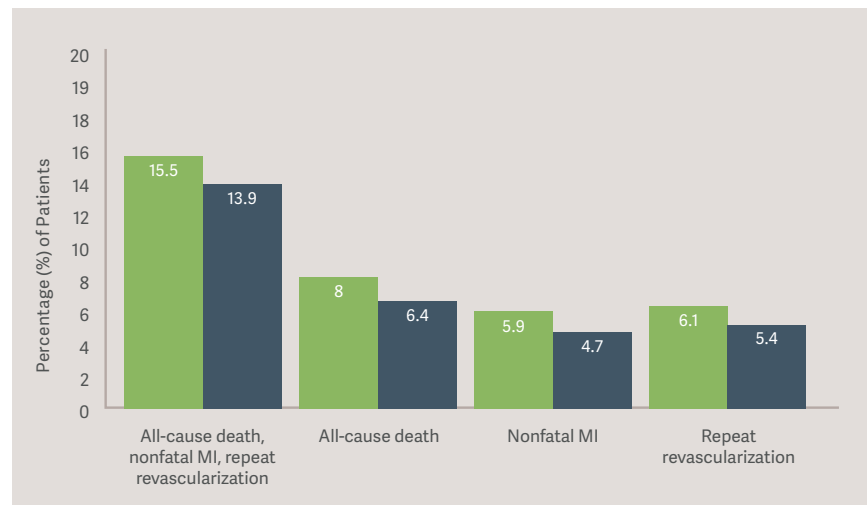
The clinical advantages of EVH

Comparable long-term outcome

Zenati et al.: EVH significantly reduces wound infections without increasing adverse cardiac events⁶

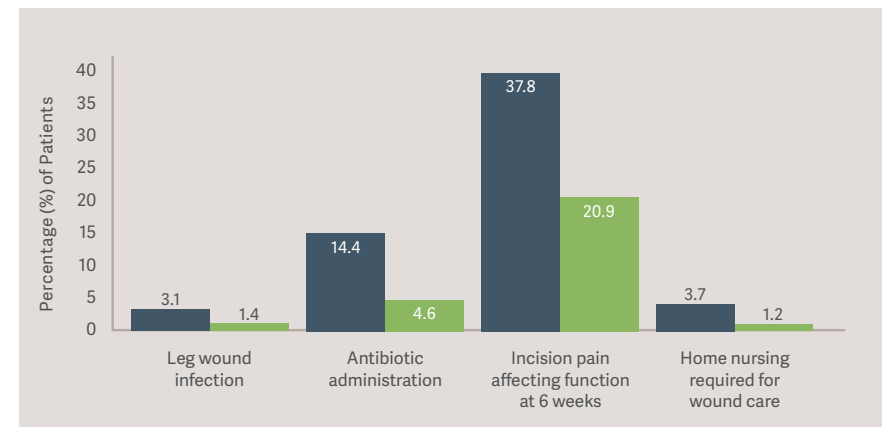
REGROUP was a randomized trial comparing EVH with OVH in 16 US Veterans Affairs cardiac surgery centers. A total of 1,188 patients (574 OVH, 576 EVH) were followed for a median duration of 2.7 years.

EVH was not associated with a statistically significant increase in the composite endpoint of all-cause mortality/non-fatal myocardial infarction/repeat revascularization (hazard ratio, 1.12; 95% CI 0.83 to 1.51; P = 0.47) or any individual adverse cardiac event. EVH reduced postoperative leg wound infection by 55%.



■ EVH ■ Open harvest

The beneficial impact of EVH on infection was accompanied by a 68% reduction in antibiotic administration, a 45% reduction in reported decrease in physical function due to incision pain, and a 68% reduction in home nursing visits for leg wound care.



■ OVH (n=574) ■ EVH (n=576)

The clinical advantages of EVH

Superior to bridging

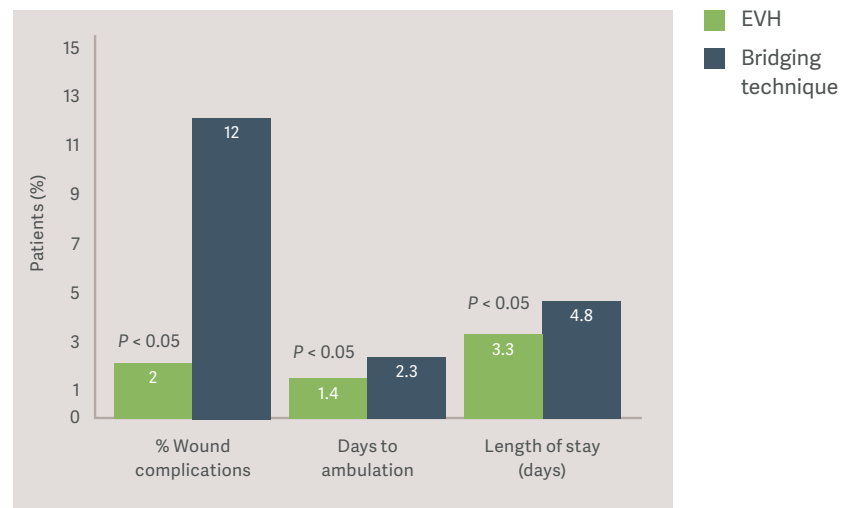
Studies have shown the bridging technique to be inferior to the EVH technique in many aspects. The bridging approach, which replaces one long incision with a series of small incisions, is not clinically equivalent to EVH.

Separate studies confirms the following for EVH compared to bridging:¹³⁻¹⁴

- Lower wound complication rate
- Better endothelial quality
- Reduced time to ambulation
- Shorter hospital stays
- Improved cosmesis

Patel et al. showed that EVH patients experienced significantly fewer wound complications, fewer average days to ambulation, and a shorter total length of hospital stay ($P < 0.05$) when compared to bridging.¹³

Bridging provides reduced clinical benefit compared to EVH



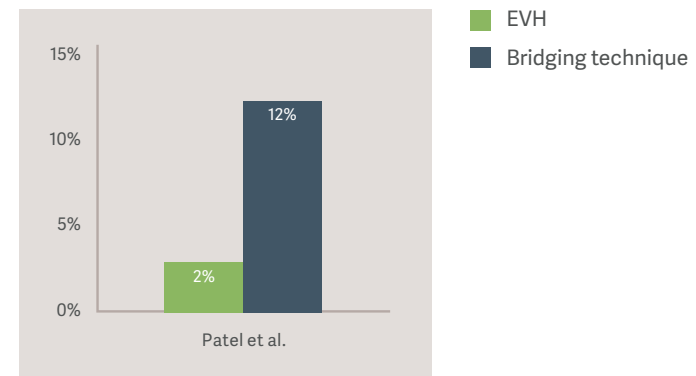
The clinical advantages of EVH

Superior to bridging

Fewer wound complications

Patel et al. demonstrated that the bridging technique had a wound complication rate of 12% compared to 2% with EVH.¹³

Percentage of patients with wound complications



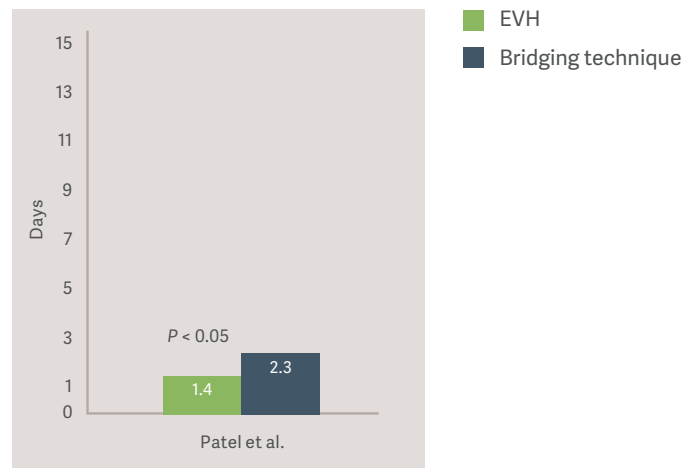
The clinical advantages of EVH

Superior to bridging

Reduced time to ambulation

Patel et al. showed that patients who had EVH ambulated **1 day** sooner than patients who underwent vessel harvesting using the bridging technique. On average, EVH patients ambulated **1.4 days** postoperatively while patients who had the bridging technique ambulated on average **2.3 days** postoperatively.¹³

EVH reduced days to ambulation



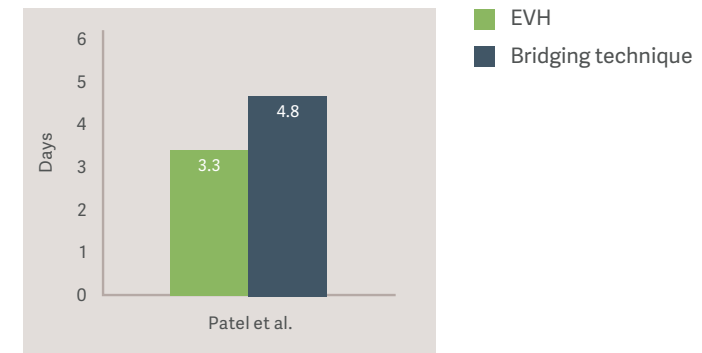
The clinical advantages of EVH

Superior to bridging

Shorter hospital stays

EVH has been shown to reduce the length of hospital stay by **1.5 days**. Patel et al. reported an average length of stay of **4.8 days** for patients undergoing the bridging technique versus an average of **3.3 days** for patients who had EVH.¹³

Comparison of length of stay (days)



The clinical advantages of EVH

Superior to bridging

Improved cosmesis

Requiring only a single 2-cm incision close to the patient's knee, EVH offers less scarring than bridging. Bridging requires multiple incisions along the patient's leg.

Bridging vessel harvesting



Endoscopic vessel harvesting (EVH)



The clinical advantages of EVH

Superior to bridging

Better endothelial quality

Studies have indicated less endothelial damage when the EVH technique was used for vein harvesting compared to the bridging technique. A study by Cook et al. revealed impaired endothelial function of the vein following harvesting with the bridging technique. This result was attributed to application of high traction forces on the vein with the bridging method.¹⁴



Operative photo of the bridging technique during a saphenous vein harvest. Note that the vein is wrapped around the finger to expose it through a small incision in the leg.

Photo reprinted from *The Journal of Thoracic and Cardiovascular Surgery*, Volume 127, Number 1, Cook RC, Crowley CM, Hayden R, Gao M, Fedoruk L, Lichtenstein SV, van Breemen C, "Traction injury during minimally invasive harvesting of the saphenous vein is associated with impaired endothelial function," page 66, ©2004, with permission from the American Association for Thoracic Surgery.

The clinical advantages of EVH

Expanded patient benefits with endoscopic radial artery harvesting (ERAH)

The clinical benefits of EVH can also be applied to harvesting the radial artery



Photo courtesy of Wausau Heart & Lung Surgeons/Wausau Heart Institute (Wausau, WI).

ERAH

Traditional Open Harvest

There is a growing interest in the radial artery as a conduit in CABG surgery due to its potential for superior long-term angiographic and clinical outcomes. Multiple practice guidelines currently recommend the use of radial artery as an additional conduit.³⁴⁻³⁵

Endoscopic radial artery harvest is safe, reduces wound complications and increases patient satisfaction

Clinical studies have shown that endoscopic radial artery harvest (ERAH) can be performed safely with only infrequent, minor complications. In addition to improved patient satisfaction due to superior cosmetic results, ERAH reduces wound infections and decreases neurologic complications compared to the open harvest technique.³⁶⁻⁴⁰

Wound infection following open radial artery harvest is underestimated

Recent evidence suggests that the incidence of infection following conventional radial artery harvest are dependent on the intensity and duration of post-discharge surveillance.⁴¹ Infection rates were assessed in 309 CABG patients who underwent open radial artery harvesting during periods of routine vs. heightened post-discharge surveillance. The rate of radial artery harvest site infections detected during heightened surveillance was four times greater than was detected during routine surveillance (12.3% vs. 3.1%; RR 3.9; $p = 0.002$). These results indicate that radial artery harvest site infections are a frequent complication of CABG surgery and may occur at a rate as high as 12%.

ERAH reduces wound infection, hematoma formation and paresthesia compared with open radial artery harvest

A 2014 meta-analysis of 12 studies involving 3,314 patients concluded that patients who undergo ERAH are nearly two thirds less likely to have a wound infection (RR 0.36; 95% CI 0.16-0.82; $p = 0.01$), less than half as likely to have hematoma formation (RR 0.45; 95% CI 0.26-0.77; $p = 0.004$), and nearly one quarter less likely to have postoperative paresthesia (RR 0.77; 95% CI 0.61-0.99; $p = 0.04$) compared with patients who undergo open radial artery harvest. Overall mortality, incidence of myocardial infarction and graft patency were comparable for the two surgical techniques.⁴⁰

»...existing evidence suggests that endoscopic harvesting of the radial artery is a safe procedure that can potentially offer superior perioperative outcomes related to wound infection, hematoma formation, and paresthesia, without clearly demonstrating any increased major adverse events such as mortality, myocardial infarction, and graft occlusion. — Cao et al., 2014«

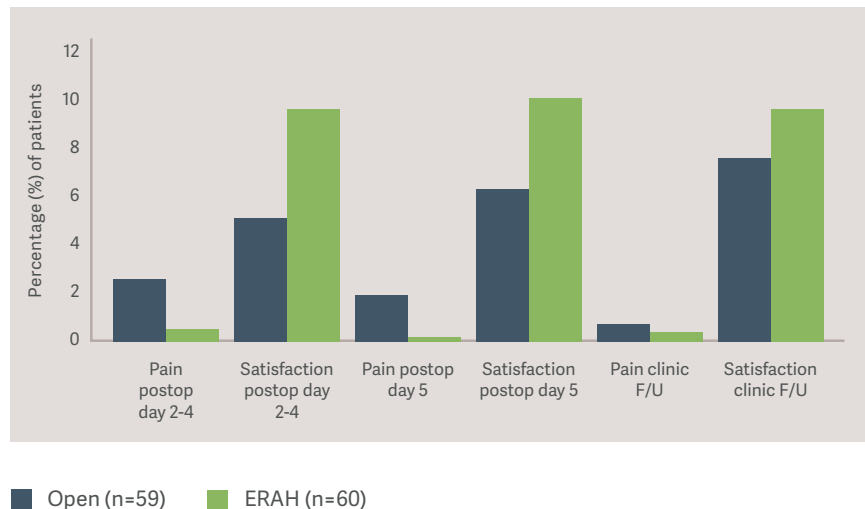
ERAH reduces postoperative pain and improves patient satisfaction

In 2017, Kiaii et al. published the results of a prospective, randomized comparison of ERAH vs. conventional radial artery harvesting conducted in 119 CABG patients (60 ERAH, 59 conventional).³⁹

Wound infection occurred in 10.2% of the conventional harvest group compared with 1.7% of the ERAH group ($p = 0.061$). ERAH patients reported significantly less pain than conventional harvest patients during hospitalization ($p < 0.001$) and at discharge ($p < 0.001$).

Patient satisfaction was significantly greater for ERAH compared with open harvest at all time points assessed ($p < 0.001$).

Six-month angiographic patency did not differ for endoscopically vs. conventionally harvested radial artery grafts. Five-year follow up of these patients showed continued equivalence of graft patency.⁴²



ERAH demonstrates graft patency and revascularization outcomes comparable to open harvest

Dimitrova et al. reported a series of 1,577 consecutive CABG patients who underwent ERAH between January 2000 and October 2012. In the isolated primary CABG patients, survival at 1, 5, and 10 years was 99%, 95%, and 90%. Angiographic follow up of symptomatic patients conducted at a mean of 3.3 ± 2.7 years documented a radial artery graft patency rate of 82%.⁴³

Based on their meta-analysis of 12 studies (3,314 patients), Cao et al. concluded that graft patency (RR 1.03; 95% CI 0.97-1.11), mortality (RR 0.67; 95% CI 0.17-2.55) and myocardial infarction (RR 0.79; 95% CI 0.30-2.04) were comparable for ERAH and conventional open radial artery harvest.⁴⁰

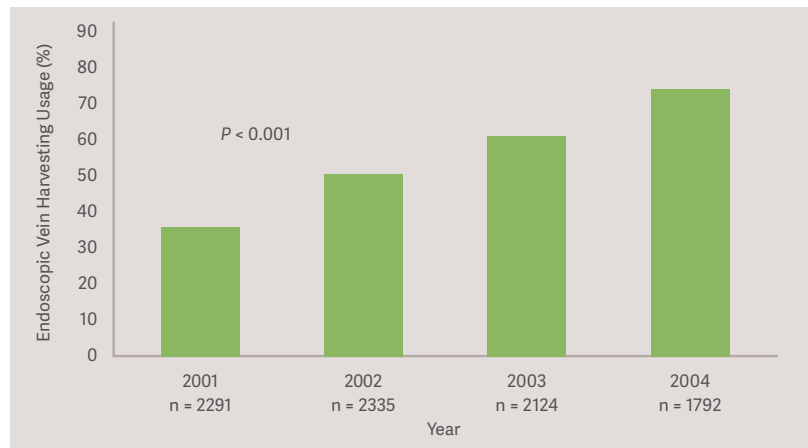
»...endovascular harvest of the RA is a technically feasible method that provides a superb arterial conduit for coronary revascularization, excellent cosmesis, and rapid return to normal activity. — Dimitrova et al., 2013 «

Intraoperative considerations

As with all surgical procedures, there is a learning curve for EVH.⁴⁴ This learning curve can be overcome safely without compromising conduit quality or long-term outcomes when adhering to the following principles:

- Procedure volume, frequency, and commitment to the technology are critical to successfully mastering the procedure
- During the early portion of the learning curve, patient selection is key to harvester confidence and good patient outcomes
- Structured training, progressive learning and supervision lead to successful adoption
- EVH is most successfully introduced by training a single champion—he or she can then train others
- Specialized non-surgeon personnel can serve as dedicated harvesters
- Surgeon support of new harvesters is important during the learning curve

Percentage of isolated CABG procedures using EVH between 2001 and 2004 across eight medical centers in Northern New England with 95% CI¹⁸



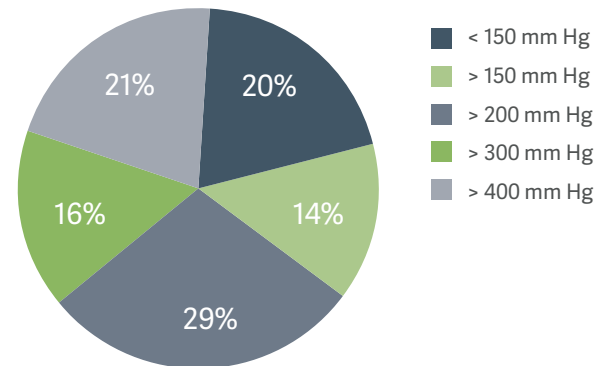
The Northern New England Study confirmed that in time of rapid adoption, mortality was NOT increased.¹⁸

Maintaining conduit quality by avoiding overdistension

Distending the harvested vessel by flushing it with solution prior to grafting is a common practice. Overdistension of the vessel, however, can damage the endothelium and reduce graft patency.⁴⁵⁻⁴⁶

As a result, maintenance of controlled, low-level irrigation pressure is now advised.

Internal pressure during graft preparation⁴⁶



80% of SVGs were exposed to distension pressures in excess of 150 mm HG

Low-dose heparin

Many clinicians have incorporated routine administration of low-dose heparin at the start of the EVH procedure based on evidence that this practice limits retained clot in the vessel lumen and is associated with improved EVH graft patency.⁴⁷

Innovation for better outcomes

EVH and ERAH as standard of care

EVH is the standard of care for CABG in the United States, currently being performed in more than 90% of hospitals

Based on abundant clinical evidence that the procedure enhances clinical outcomes and patient satisfaction when compared with open vessel harvesting techniques without compromising clinical outcomes, several international practice guidelines for myocardial revascularization now recommend EVH.

EVH has been included in the ESC/EACTS Guidelines on Myocardial Revascularization as a Class IIa, Level A recommendation to reduce the incidence of wound complications since 2014.⁴⁸ In addition, the National Institute for Health and Care Excellence (NICE) reaffirmed its previous recommendation for EVH in its 2014 Guidance based on current evidence regarding the safety and efficacy of the procedure.⁴⁹

In 2017, the International Society for Minimally Invasive Cardiac Surgery (ISMICS) published a consensus statement on endoscopic harvesting of bypass conduit for CABG based on a systematic review of 76 studies across a total of 281,459 patients.¹ In addition to reaffirming the highly significant impact of endoscopic conduit harvest in reducing postoperative wound complications, the consensus panel concluded that EVH and ERAH were associated with significant reductions in postoperative pain and disability and superior patient satisfaction compared with traditional, open incisions. These benefits, in combination with an absence of detrimental impact on conduit quality and revascularization outcomes, led the panel to conclude that EVH and ERAH should be the standard of care in CABG patients who require saphenous vein and radial artery bypass conduits.

»...EVH and ERAH should be the standard of care for patients who require these conduits for coronary revascularization. — ISMICS, 2017 «

Innovation for better outcomes

Vasoview endoscopic vessel harvesting systems

With over 2,500,000 Vasoview procedures performed through 2018, Getinge has led the efforts to make endoscopic vessel harvesting the standard of care*

Getinge's endoscopic vessel harvesting systems are designed with unique features to meet the needs of both the most skilled and novice users.

Getinge Vasoview Hemopro 2 helps harvesters efficiently and safely acquire high-quality conduits to improve outcomes in cardiac surgery. It represents the gold standard in vessel harvesting for both the saphenous vein and radial artery. Vasoview Hemopro 2 is inspired by the hands-on experience of clinicians who performed vessel harvest procedures every day.

*Data on file, Maquet Cardiovascular; 2018.

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Clinical abstracts

Endoscopic versus direct vision for saphenous vein graft harvesting in coronary artery bypass surgery

Ad N, Henry L, Hunt S, Holmes S, et al.

Objective: Recent reports have suggested harvesting of the greater saphenous vein for coronary artery bypass (CABG) using endoscopic techniques (endoscopic) results in early graft closure, higher rates of myocardial infarction (MI) and death. We explored the impact of this technique performed by experienced operators on postoperative morbidities, MI and death in our CABG patients.

Methods: All non-emergent patients presenting for first time CABG surgery from 2006 to June 2009 were included. Data pertaining to surgery, readmissions, cardiac catheterization and interventions during long term follow-up were extracted from our local STS and ACC registries. Linear and logistic regressions with clinical covariates were conducted to determine if vein harvest technique group predicted the major outcomes. Propensity score matching (PSM) was completed to simulate randomization and improve covariate balance across the endoscopic and direct vision groups.

Results: One thousand nine hundred and eighty-eight (N = 1988) patients were evaluated in this study (N = 1734 endoscopic group and N = 254 direct vision group). The perioperative major adverse outcomes (mortality within 30 days, stroke, reoperation for bleeding, prolonged ventilation and readmission within 30 days) were 17.8% in the endoscopic group and 25.2% in the direct vision group. The rate of leg

infections was 0.3% for the endoscopic group and 1.6% for the direct vision group. After adjustment for covariates, the direct vision group had significantly greater risk for prolonged ventilation (P = 0.03), MACE (P = 0.02) and mortality within 30 days (P = 0.01), but only marginally greater risk for leg infections (P = 0.052). In the isolated CABG patients, operative death was 1% for the endoscopic group and 1.7% in the direct vision group (P = 0.62). After PSM the endoscopic group was similar on all outcomes except for having fewer MACE (P = 0.04). In a mean follow-up of 22.1 ± 10.5 months, there were no significant differences in the overall rate and time to event for repeat revascularization, death and myocardial infarction. With maximum follow up of 39.6 months, 84 deaths were documented (N = 67 endoscopic and N = 17 direct vision).

Conclusion: The outcomes captured by the number of postoperative morbidities, incidence of myocardial infarction and/or the rate of death for the endoscopic technique were comparable to patients in whom the open techniques was used. There was a trend towards a decrease in leg infections with the use of the endoscopic device. Based on this study we consider the device safe and effective with experienced operators.

Journal of Cardiovascular Surgery (Torino). 2011;52:739–748.

Long-term patency of endoscopically harvested radial arteries: from a randomized controlled trial

Burns DJ, Swinamer SA, Fox SA, et al.

Objective: From 2005 to 2007, 119 patients were enrolled in a prospective randomized controlled trial comparing open and endoscopically harvested radial arteries for coronary artery bypass grafting. The objective of the current study was to compare graft patency between intervention groups at more than 5 years from the initial trial. We hypothesized that endoscopically harvested radial arteries would show equivalent patency to those conventionally harvested.

Methods: At 5 years or greater from their operation, all consenting patients underwent a single-day anatomic and functional cardiac assessment with coronary computed tomography angiography and sestamibi myocardial perfusion scanning. Medical Outcomes Study 36-Item Short-Form Health Surveys and Seattle Angina Questionnaires were completed to assess the overall quality of life. All patients had received calcium channel blocker therapy for at least 6 months postoperatively.

Results: The mean (SD) duration of follow-up was 79.2 (8.6) months for all patients. One death occurred within 30 days of coronary artery bypass grafting in each treatment group, and eight additional noncardiac deaths occurred during the study time frame. Of 119 patients, 66 consented to follow-up. Thirty-two had open radial artery harvest, and 34 had endoscopic radial artery harvest. At more than 5 years, there were 28 patent conventionally harvested radial arteries (87.5%) and 31 patent endoscopically harvested radial arteries (91.2%) (P = 0.705). Measured quality of life was comparable between groups.

Conclusion: Endoscopic radial artery harvest is safe and effective when compared with open radial artery harvest, with excellent graft patency demonstrated at more than 5 years. Patency results are noninferior in endoscopic radial artery harvest.

Innovations (Phila). 2015 Mar-Apr;10(2):77-84

Incidence of residual clot strands in saphenous vein grafts after endoscopic harvest

Burris N, Schwartz K, Brown J, et al.

Objective: Strands of clot are frequently flushed out of saphenous vein grafts (SVG) during preparation for grafting, particularly those that are endoscopically harvested. However, saline distention at uncontrolled pressures increases graft thrombogenicity and the risk of early failure after coronary artery bypass grafting. The purpose of this prospective investigation was to define the incidence of intraluminal clot within endoscopically harvested SVG and the effect of attempted removal by saline distention.

Methods: Endoscopically harvested SVG were intraoperatively prepared for grafting by using saline distention at uncontrolled pressure (n = 24) or without distension (n = 20). Optical coherence tomography, a catheter-based infrared imaging system, was used to identify and characterize intraluminal clot strands in surplus SVG segments (average length for analysis, 4.9 ± 2.6 cm). These segments were also assessed for luminal tissue factor activity and percent endothelial integrity by CD31-directed immunohistochemistry.

Results: Clot strands were observed in 45.4% (20 of 44) of imaged SVG segments (severity of observed clots: 54%, mild; 32%, moderate; 14%, severe). Compared with grafts distended with saline, vein segments that were not distended displayed significantly higher endothelial integrity ($60.1\% \pm 27.2\%$ versus $24.7\% \pm 24.1\%$, $P < 0.05$) and lower tissue factor activity (1.28 ± 0.95 versus 12.3 ± 5.5 U/cm², $P < 0.001$) despite having a higher incidence of clot strands (65.0% versus 29.1%, $P < 0.02$, Fisher exact test). Static flow was observed in veins during endoscopic harvest.

Conclusion: Clot strands of varying severity are a common finding after endoscopic vein harvest. Saline distension is not completely effective in removing clot strands and increases overall graft thrombogenicity. Therefore, prevention of clot or less traumatic methods of removing clot are indicated.

Innovations. 2006;1:323–327.

A meta-analysis of endoscopic versus conventional open radial artery harvesting for coronary artery bypass graft surgery

Cao C, Tian DH, Ang SC, et al.

Objective: The radial artery has been demonstrated to provide superior long-term patency outcomes compared with saphenous veins for selected patients who undergo coronary artery bypass graft surgery. Recently, endoscopic radial artery harvesting has been popularized to improve cosmetic and perioperative outcomes. However, concerns have been raised regarding the effects on long-term survival and graft patency of this relatively novel technique. The present meta-analysis aimed to assess the safety and the efficacy of endoscopic radial artery harvesting versus the conventional open approach.

Methods: A systematic review of the current literature was performed on five electronic databases. All comparative studies on endoscopic versus open radial artery harvesting were included for analysis. Primary endpoints included mortality and recurrent myocardial infarction. Secondary endpoints included graft patency, wound infection, hematoma formation, and paresthesia.

Results: Twelve studies involving 3,314 patients were included for meta-analysis according to predefined selection criteria. There were no statistically significant differences in overall mortality, recurrent myocardial infarction, or graft patency between the two surgical techniques. However, patients who underwent endoscopic harvesting were found to have significantly lower incidences of wound infection, hematoma formation, and paresthesia.

Conclusion: Current literature on endoscopic harvesting of the radial artery for coronary artery bypass graft surgery is limited by relatively short follow-up periods as well as differences in patient selection and surgical techniques. In addition, there are currently no randomized controlled trials to provide robust clinical data. However, the available evidence suggests that the endoscopic approach is associated with superior perioperative outcomes without clear evidence demonstrating compromised patency or survival outcomes.

Innovations (Phila). 2014 Jul-Aug;9(4):269-75.

Clinical benefits of endoscopic vein harvesting in patients with risk factors for saphenectomy wound infections undergoing coronary artery bypass grafting

Carpino PA, Khabbaz KR, Bojar RM, et al.

Objective: The influence of endoscopic harvesting techniques on the prevalence of leg-wound complications after coronary artery bypass grafting remains to be defined for patients at high risk for the development of wound infections.

Methods: Among 1473 patients undergoing coronary artery bypass grafting who had the saphenous vein harvested by either a continuous incision or skip incisions leaving intact skin bridges, Carpino et al determined the prevalence of wound infections to be 9.6%. The following variables were entered into logistic regression analysis to identify significant risk factors that might be predictive of wound infection: diabetes, peripheral vascular disease, obesity, renal failure, steroid use, age, sex, and type of closure. The authors then prospectively randomized 132 patients found to be at high risk of wound infection to either endoscopic vein harvesting or a continuous open incision.

Results: Univariate analysis showed female sex ($p = .04$), diabetes ($p < .001$), and obesity ($p < .001$) to be predictors of wound infection. In a multivariate model diabetes ($p = .02$) and obesity ($p = .001$) were independent predictors. In patients at high risk, the prevalence of wound infection was 4.5% for the endoscopic group versus 20% for the open group ($p = .01$). Vein procurement time was greater in the endoscopic group (65 minutes versus 32 minutes, $p < .001$), as was the number of vein repairs required (2.5 versus 0.6, $p < .001$).

Conclusion: The use of endoscopic vein harvesting decreases the prevalence of postoperative leg-wound infections in high-risk patients with diabetes and obesity. Whether this translates into an economic benefit that justifies the additional cost of that technology requires further analysis.

Journal of Thoracic and Cardiovascular Surgery. 2000;119:69–76.

Endoscopic radial artery harvesting: results of first 300 patients

Connolly MW, Torrillo LD, Stauder MJ, et al.

Background: With the expanded use of the radial artery as a bypass conduit in patients undergoing coronary artery bypass grafting, an endoscopic radial artery harvesting method was used to improve esthetics and patient acceptance, and possibly, to decrease hand neurologic complications.

Methods: After informed consent and confirmation of adequate ulnar collateral blood flow, 300 consecutive patients undergoing coronary artery bypass grafting had their nondominant radial artery endoscopically removed through a small 3-cm incision just proximal to the radial styloid prominence. Standard endoscopic vein equipment (30-degree 5-mm endoscope, subcutaneous retractor, and vessel dissector) with ultrasonic harmonic coagulating shears were used. After radial artery isolation, the radial artery was proximally clipped and transected 1 to 2 cm distal to the visualized ulnar artery origin to the inferior end of the wrist incision.

Results: The mean age was 62.2 years; 23% of the patients were women, 39% had diabetes mellitus, and 28% had peripheral vascular disease. All 300 endoscopic radial arteries were grossly acceptable and used for grafting. Early in the series, 29 patients

(9.7%) required a second 3-cm incision proximally for vascular control. Only one wrist incision was required at the last 200 cases. The conduit length varied between 18 and 24 cm. Occurring early in the series, hospital complications were two tunnel hematomas requiring drainage and one brachial artery clipping repaired primarily without sequela. At 30 days postoperative follow-up, 5 patients (1.6%) had been treated with oral antibiotics for incisional cellulitis and 26 patients (8.7%) had objective dorsal thenar sensory numbness. No ischemic hand complication, perioperative myocardial infarction, reintervention in radial artery graft distribution, or numbness in the lateral forearm occurred. All patients expressed marked satisfaction with the small incision and cosmetic result.

Conclusion: In our initial experience, endoscopic radial artery harvesting can be performed safely, with minor, infrequent complications. A full-length radial artery conduit can be obtained with improved esthetics and patient satisfaction and acceptance. Late dorsal thenar paresthesias, although infrequent, continue to be a problem as with the open method.

Annals of Thoracic Surgery. 2002;74:502–505; discussion 506.

Traction injury during minimally invasive harvesting of the saphenous vein is associated with impaired endothelial function

Cook RC, Crowley CM, Hayden R, et al.

Objective: Many methods of minimally invasive surgical harvesting of the great saphenous vein have been developed because of the morbidity related to the long skin incision after traditional (open) great saphenous vein harvesting. One such method involves the use of multiple small incisions separated by 10- to 15-cm skin bridges through which the saphenous vein is harvested. Cook et al hypothesized that this method of saphenous vein harvesting might subject the saphenous vein to considerable traction forces, resulting in impaired endothelial cell function.

Methods: Four-millimeter great saphenous vein segments were obtained from patients undergoing elective coronary artery bypass graft surgery. Group A (minimally invasive surgery) consisted of 23 rings from 20 patients (age, 65.8 + 11.1 years, mean + SD). Group B (open harvesting) consisted of 33 rings from 8 patients (age, 69.8 + 8.6 years). All great saphenous vein segments were undistended and were used within 24 hours of harvesting. Isometric tension experiments were performed on each ring of the great saphenous vein by using a force-displacement transducer to measure the force of contraction in grams. Measurements included developed force after exposure to high-potassium depolarizing solution and 50 micromol/L phenylephrine and decrease in force of contraction (relaxation) after exposure to 1 and 10 micromol/L acetylcholine.

Results: There were no differences between the minimally invasive surgery and open harvesting groups in their responses to high-potassium depolarizing solution or phenylephrine: high-potassium depolarizing solution, contractions of 4.26 + 0.72 g (mean + SEM) and 3.95 + 0.38 g, respectively (p = .70); phenylephrine, contractions of 3.49 + 0.63 g and 2.73 + 0.39 g, respectively (p = .41). There was no net relaxation in segments from the minimally invasive surgery group after exposure to 1.0 or 10 micromol/L acetylcholine. In contrast, rings from the open harvesting group demonstrated relaxation of -0.41 + 0.07 g and -0.32 + 0.09 g after exposure to 1.0 and 10 micromol/L acetylcholine, respectively.

Conclusion: In undistended saphenous vein segments isolated from patients undergoing minimally invasive surgical and open techniques of harvesting, there was no acetylcholine-mediated endothelium-dependent relaxation in the minimally invasive surgery group. Therefore, harvesting of the great saphenous vein through multiple small incisions might result in endothelial dysfunction, possibly caused by traction injury.

Journal of Thoracic and Cardiovascular Surgery. 2004;127:65-70.

Open versus endoscopic saphenous vein harvesting: wound complications and vein quality

Crouch JD, O'Hair DP, Keuler JP, et al.

Background: The saphenous vein is an important conduit for coronary artery bypass grafting. Wound complications from traditional open vein harvesting occur often. Minimally invasive endoscopic saphenous vein harvesting may decrease wound complications. Vein quality may be an issue with endoscopic harvesting.

Methods: The authors reviewed 568 patients who had bypass grafting and saphenous vein harvesting either endoscopic (group A, n = 180) versus open (group B, n = 388). Both groups were demographically similar and management identical. Wound complication was defined by the need for intervention and included lymphocele, hematoma, cellulitis, edema, eschar, and infection. Multiple vein segments were obtained from 8 patients, 4 from each group, and examined histologically.

Results: Wound complications were significantly less in group A (9/180, 5%) versus group B (55/388, 14.2%), p value equal to or less than 0.001. Open harvesting (p < 0.001), diabetes (p < 0.001), and obesity (p < 0.02) were risk factors for wound complication by univariate analysis. By multiple logistic analysis, open harvesting (p < 0.0007) and diabetes (p < 0.0001) were independent risk factors for wound infection. Histologic evaluation of vein samples showed that there was no difference between the groups and vascular structural integrity was maintained.

Conclusion: Endoscopic saphenous vein harvesting was associated with fewer wound complications and infections. Vein quality was not adversely affected because of endoscopic harvesting.

Annals of Thoracic Surgery. 1999;68:1513-1516.

Long-term outcomes of endoscopic vein harvesting after coronary artery bypass grafting

Dacey LJ, Braxton JH Jr, Kramer RS, et al.

Background: Use of endoscopic saphenous vein harvesting has developed into a routine surgical approach at many cardiothoracic surgical centers. The association between this technique and long-term morbidity and mortality has recently been called into question. The present report describes the use of open versus endoscopic vein harvesting and risk of mortality and repeat revascularization in northern New England during a time period (2001 to 2004) in which both techniques were being performed.

Methods: From 2001 to 2004, 8542 patients underwent isolated coronary artery bypass grafting procedures, 52.5% with endoscopic vein harvesting. Surgical discretion dictated the vein harvest approach. The main outcomes were death and repeat revascularization (percutaneous coronary intervention or coronary artery bypass grafting) within 4 years of the index admission.

Results: The use of endoscopic vein harvesting increased from 34% in 2001 to 75% in 2004. In general, patients undergoing endoscopic vein harvesting had greater disease burden. Endoscopic vein harvesting was associated with an increased adjusted risk of bleeding requiring a return to the operating room (2.4 versus 1.7; $P = 0.03$) but a decreased risk of leg wound infections (0.2 versus 1.1; $P < 0.001$). Use of endoscopic vein harvesting was associated with a significant reduction in long-term mortality (adjusted hazard ratio, 0.74; 95% confidence interval, 0.60 to 0.92) but a nonsignificant increased risk of repeat revascularization (adjusted hazard ratio, 1.29; 95% confidence interval, 0.96 to 1.74). Similar results were obtained in propensity-stratified analysis.

Conclusion: During 2001 to 2004 in northern New England, the use of endoscopic vein harvesting was not associated with harm. There was a nonsignificant increase in repeat revascularization, and survival was not decreased.

Circulation. 2011;123:147–153.

Endoscopic vein harvesting for coronary artery bypass grafting: a systematic review with meta-analysis of 27,789 patients

Deppe AC, Liakopoulos OJ, Choi YH, et al.

Background: To determine the current strength of evidence for or against endoscopic vein harvesting (EVH) in patients undergoing coronary artery bypass grafting (CABG).

Materials and methods: A meta-analysis of randomized controlled trials (RCT) and observational trials (OT) was performed that reported the impact of EVH on adverse clinical outcomes after CABG. Analyzed postoperative outcomes included wound infection, postoperative pain, myocardial infarction (MI), vein graft failure, length of hospital stay, and mortality. Pooled treatment effects (OR or weighted mean difference (WMD), 95%CI) were assessed using a fixed or random effects model.

Results: A total of 27,789 patients from 43 studies (16 RCT, 27 OT) were identified who underwent saphenectomy by endoscopic (46%; $n = 12,822$) or conventional technique

(54%; $n = 14,967$). Pooled effect estimates revealed a reduced incidence ($P < 0.001$) for wound infections (OR 0.27; 95% CI 0.22 to 0.32), pain (WMD -1.26, 95% CI -2.07 to -0.44; $P = 0.0026$), and length of hospital stay (WMD -0.6 d, 95% CI -1.08 to -0.12; $P = 0.0152$). EVH was associated to an increase of the odds for vein graft failure (OR 1.38; 95% CI 1.01 to 1.88; $P = 0.0433$), a finding that lost statistical difference after pooled analysis of RCT and studies with high methodological quality. Similarly, graft-related endpoints, including mortality and MI, did not differ between the harvesting techniques.

Conclusion: The present systematic review underscores the safety of EVH in patients undergoing CABG. EVH reduces leg wound infections without increasing the midterm risk for vein graft failure, MI, or mortality.

J Surg Res. 2013 Mar;180(1):114-24.

Results of endoscopic radial artery harvesting in 1577 patients

Dimitrova KR, Dincheva GR, Hoffman DM, et al.

Objective: We reviewed 1577 consecutive patients undergoing coronary artery bypass grafting (CABG) using endoscopic harvesting of the radial artery (RA) to define our current results.

Methods: Since 2000, we have performed endoscopic RA harvest on 1577 consecutive patients; 1476 patients had isolated CABG, and 101 patients had CABG and other procedures. The mean \pm SD age was 59.4 ± 9.0 years; 80.2% were men and 40% had diabetes mellitus. All data were prospectively collected. All-cause mortality was determined using the Social Security Death Index.

Results: There were nine in-hospital or 30-day deaths, for an operative mortality of 0.57%; mortality was 0.34% in isolated CABG and 3.85% in CABG/combined procedures. The overall estimated Kaplan-Meier survival at 1, 5, and 10 years was 99%, 95%, and 88%. In 37 patients, the

RAs were not harvested or were not used for grafting because of a positive Allen test, extensive calcification or dissection, intramural hematoma, and scarring from previous arterial lines or catheterization. During postoperative follow-up, five patients (0.32%) were treated for incisional infection, and there were no ischemic hand complications. Three patients had a perioperative myocardial infarction in the RA graft distribution, and 15 patients had a coronary artery reintervention in the RA graft distribution. Two other patients had a percutaneous coronary intervention of their RAs. The overall RA patency at 10 years was 82%.

Conclusion: Endoscopic harvest of the RA is an excellent minimally invasive conduit harvesting technique with minimal morbidity.

Innovations (Phila). 2013 Nov-Dec;8(6):398-402.

Endoscopic conduit harvest in coronary artery bypass grafting surgery: an ISMICS systematic review and consensus conference statements

Ferdinand FD, MacDonald JK, Balkhy HH, et al.

Objective: The purpose of this consensus conference was to develop and update evidence-informed consensus statements and recommendations on harvesting saphenous vein and radial artery via an open as compared with endoscopic technique by systematically reviewing and performing a meta-analysis of randomized and nonrandomized clinical trials.

Methods: All randomized controlled trials and nonrandomized controlled trials included in the first International Society for Minimally Invasive Cardiothoracic Surgery Consensus Conference and Statements, in 2005 up to November 30, 2015, were included in a systematic review and meta-analysis. The resultant 76 studies (23 RCT and 53 NRT) on 281,469 patients were analyzed. From these studies consensus statements and recommendations were generated comparing the risk and benefits of endoscopic versus open conduit harvesting for patients undergoing CABG.

Results: Compared with open vein harvest, it is reasonable to perform endoscopic vein harvest of saphenous vein to reduce wound-related complications, postoperative length of stay, and outpatient wound management resources and to increase patient satisfaction (class I, level A). Based on the quality of the conduit and major adverse cardiac events as well as 6-month angiographic patency, endoscopic vein harvest was noninferior to open harvest. It is reasonable to perform endoscopic radial artery harvest to reduce wound-related complication and to increase patient satisfaction (class I, level B-R and B-NR, respectively) with reduction in major adverse cardiac events and noninferior patency rate at 1 and 3 to 5 years (class III, level B-R).

Conclusion: Based on the consensus statements, the consensus panel recommends (class I, level B) that endoscopic saphenous vein and radial artery harvesting should be the standard of care for patients who require these conduits for coronary revascularization.

Innovations (Phila). 2017 Sep/Oct;12(5):301-319.

Radial-artery or saphenous-vein grafts in coronary-artery bypass surgery

Gaudino M, Benedetto U, Fremes S, et al.

Background: The use of radial-artery grafts for coronary-artery bypass grafting (CABG) may result in better postoperative outcomes than the use of saphenous-vein grafts. However, randomized, controlled trials comparing radial-artery grafts and saphenous-vein grafts have been individually underpowered to detect differences in clinical outcomes. We performed a patient-level combined analysis of randomized, controlled trials to compare radial-artery grafts and saphenous-vein grafts for CABG.

Methods: Six trials were identified. The primary outcome was a composite of death, myocardial infarction, or repeat revascularization. The secondary outcome was graft patency on follow-up angiography. Mixed-effects Cox regression models were used to estimate the treatment effect on the outcomes.

Results: A total of 1036 patients were included in the analysis (534 patients with radial-artery grafts and 502 patients with saphenous-vein grafts). After a mean (\pm SD) follow-up time of 60 \pm 30 months, the incidence of adverse cardiac events was significantly lower in association with

radial-artery grafts than with saphenous-vein grafts (hazard ratio, 0.67; 95% confidence interval [CI], 0.49 to 0.90; $P=0.01$). At follow-up angiography (mean follow-up, 50 \pm 30 months), the use of radial-artery grafts was also associated with a significantly lower risk of occlusion (hazard ratio, 0.44; 95% CI, 0.28 to 0.70; $P<0.001$). As compared with the use of saphenous-vein grafts, the use of radial-artery grafts was associated with a nominally lower incidence of myocardial infarction (hazard ratio, 0.72; 95% CI, 0.53 to 0.99; $P=0.04$) and a lower incidence of repeat revascularization (hazard ratio, 0.50; 95% CI, 0.40 to 0.63; $P<0.001$) but not a lower incidence of death from any cause (hazard ratio, 0.90; 95% CI, 0.59 to 1.41; $P=0.68$).

Conclusion: As compared with the use of saphenous-vein grafts, the use of radial-artery grafts for CABG resulted in a lower rate of adverse cardiac events and a higher rate of patency at 5 years of follow-up. (Funded by Weill Cornell Medicine and others.)

N Engl J Med. 2018 May 31;378(22):2069-2077.

What is the impact of endoscopic vein harvesting on clinical outcomes following coronary artery bypass graft surgery?

Grant SW, Grayson AD, Zacharias J, et al.

Objective: Endoscopic vein harvesting (EVH) is increasingly used as an alternative to open vein harvesting (OVH) for coronary artery bypass graft (CABG) surgery. Concerns about the safety of EVH with regard to midterm clinical outcomes following CABG have been raised. The objective of this study was to assess the impact of EVH on short-term and midterm clinical outcomes following CABG.

Methods: This was a retrospective analysis of prospectively collected multi-centre data. A propensity score was developed for EVH and used to match patients who underwent EVH to those who underwent OVH. Setting Blackpool Victoria Hospital, Plymouth Derriford Hospital and the University Hospital of South Manchester were the main study settings.

Patients: There were 4709 consecutive patients who underwent isolated CABG using EVH or OVH between January 2008 and July 2010. Main outcome measures The main outcome measure was a

combined end point of death, repeat revascularisation or myocardial infarction. Secondary outcome measures included in-hospital morbidity, in-hospital mortality and midterm mortality.

Results: Compared to OVH, EVH was not associated with an increased risk of the main outcome measure at a median follow-up of 22 months (HR 1.15; 95% CI 0.76 to 1.74). EVH was also not associated with an increased risk of in-hospital morbidity, in-hospital mortality (0.9% versus 1.1%, $p=0.71$) or midterm mortality (HR 1.04; 95% CI 0.65 to 1.66).

Conclusion: This multi-centre study demonstrates that at a median follow-up of 22 months, EVH was not associated with adverse short-term or midterm clinical outcomes. However, before the safety of EVH can be clearly determined, further analyses of long-term clinical outcomes are required.

Heart. 2012;98:60–64.

Secondary surgical-site infection after coronary artery bypass grafting: a multi-institutional prospective cohort study

Gulack BC, Kirkwood KA, Shi W, et al.

Objective: To analyze patient risk factors and processes of care associated with secondary surgical-site infection (SSI) after coronary artery bypass grafting (CABG).

Methods: Data were collected prospectively between February and October 2010 for consenting adult patients undergoing CABG with saphenous vein graft (SVG) conduits. Patients who developed a deep or superficial SSI of the leg or groin within 65 days of CABG were compared with those who did not develop a secondary SSI.

Results: Among 2174 patients identified, 65 (3.0%) developed a secondary SSI. Median time to diagnosis was 16 days (interquartile range 11-29) with the majority (86%) diagnosed after discharge. Gram-positive bacteria were most common. Readmission was more common in patients with a secondary SSI (34% vs 17%, $P < .01$). After adjustment, an open

SVG harvest approach was associated with an increased risk of secondary SSI (adjusted hazard ratio [HR], 2.12; 95% confidence interval [CI], 1.28-3.48). Increased body mass index (adjusted HR, 1.08, 95% CI, 1.04-1.12) and packed red blood cell transfusions (adjusted HR, 1.13; 95% CI, 1.05-1.22) were associated with a greater risk of secondary SSI. Antibiotic type, antibiotic duration, and postoperative hyperglycemia were not associated with risk of secondary SSI.

Conclusion: Secondary SSI after CABG continues to be an important source of morbidity. This serious complication often occurs after discharge and is associated with open SVG harvesting, larger body mass, and blood transfusions. Patients with a secondary SSI have longer lengths of stay and are readmitted more frequently.

J Thorac Cardiovasc Surg. 2018 Apr;155(4):1555-1562.

Current practice of state-of-the-art surgical coronary revascularization

Head SJ, Milojevic M, Taggart DP, et al.

Coronary artery bypass grafting remains one of the most commonly performed major surgeries, with well-established symptomatic and prognostic benefits in patients with multivessel and left main coronary artery disease. This review summarizes current indications, contemporary practice, and outcomes of coronary artery bypass grafting. Despite an increasingly higher-risk profile of patients, outcomes have significantly improved over time, with significant reductions in operative mortality and perioperative complications. Five- and 10-year survival rates are ~85% to 95% and 75%,

respectively. A number of technical advances could further improve short- and long-term outcomes after coronary artery bypass grafting. Developments in off-pump and no-touch procedures; epiaortic scanning; conduit selection, including bilateral internal mammary artery and radial artery use; intraoperative graft assessment; minimally invasive procedures, including robotic-assisted surgery; and hybrid coronary revascularization are discussed.

Circulation. 2017 Oct 3;136(14):1331-1345.

Current perspectives in endoscopic vessel harvesting for coronary artery bypass grafting

Kempfert J, Rastan A, Leontyev S, et al.

Background: Coronary artery bypass grafting is still the most commonly performed procedure in cardiac surgery. Minimally invasive or endoscopic vessel harvesting was developed a decade ago. It has been shown that these less traumatic techniques significantly reduce wound healing problems and improve patient satisfaction. However, there are some concerns regarding bypass patency and

long-term outcomes. The aim of this article is to describe the historic development of endoscopic vessel harvesting, different harvesting techniques and to give an update of the scientific evidence and the current debate regarding outcome and safety of these minimally invasive techniques.

Expert Review of Cardiovascular Therapy. 2011;9:1481–1488.

High-pressure distention of the saphenous vein during preparation results in increased markers of inflammation: a potential mechanism for graft failure

Khaleel MS, Dorheim TA, Duryee MJ, et al.

Background: Coronary artery disease is the single leading cause of death in the United States. Commonly it is treated with coronary bypass grafting using the saphenous vein (SV) or internal mammary artery (IMA) as a conduit. Unfortunately, the SV has much lower patency rates compared with the IMA. Several hypotheses exist as to why occlusion occurs more commonly in SV grafts than in IMA grafts. However detailed studies in this area have been limited. This study investigates the effects of pressure distention on inflammation in SV conduit used in coronary artery bypass grafting (CABG).

Methods: Saphenous vein distention pressure was measured intraoperatively during 48 CABG procedures. A segment of SV was excised from the conduit before distention. Because the vein was used for coronary artery grafting, sequential pieces were archived for evaluation. Real-time polymerase chain reaction (RT-PCR) and immunohistochemical analyses were performed to investigate a change in the expression of biomarkers.

Results: Upregulation of various biomarkers occurred. These biomarkers included scavenger receptors A and B (SR-A, SR-B), toll-like receptors 2 and 4 (TLR2, TLR4), platelet endothelial cell adhesion molecule (PECAM), vascular cell adhesion molecule (VCAM), and intercellular cell adhesion molecule (ICAM) in segments of SV that were subjected to distention. Immunohistochemical results mirrored RT-PCR findings. A significant correlation was observed between biomarkers and pressure values.

Conclusion: These studies demonstrate that markers of inflammation are upregulated in response to SV distention. The data suggest that the pressure used in graft preparation procedures should be regulated to avoid inflammation and its potential to induce graft failure.

Annals of Thoracic Surgery. 2012;93:552–558.

A prospective randomized study of endoscopic versus conventional harvesting of the radial artery

Kiaii BB, Swinamer SA, Fox SA, et al.

Objectives: The aims of the study were to determine whether endoscopic harvesting of the radial artery (RA) reduces morbidity due to pain, infection, and disability with improvement in satisfaction and cosmesis compared to the conventional technique and (2) to compare the 6-month angiographic patency of the RA harvested conventionally and endoscopically.

Methods: In a prospective randomized study, 119 patients undergoing coronary artery bypass grafting using the RA were randomized to have RA harvested either conventionally (n = 59) or endoscopically (n = 60).

Results: Radial artery harvest time (open wound time) was significantly reduced in the endoscopic group (36.5 ± 9.4 vs 57.7 ± 9.4 minutes, P < 0.001). Only one patient developed wound infection (1.6%) in the endoscopic group compared with six patients (10.2%), P = 0.061, in the conventional group. Although this was not statistically significant, clinically this was relevant in terms of reduction in postoperative morbidity. Postoperative pain in the arm incision was significantly lower in the endoscopic group at

postoperative day 2 (P < 0.001) and at discharge (P < 0.001) and similar to the conventional open group at 6 weeks' follow-up (P = 0.103). Overall patient satisfaction and cosmesis were significantly better in the endoscopic group at postoperative day 2 (P < 0.001), at discharge (P < 0.001), and at 6 weeks' follow-up (P < 0.001). There was no difference in the arm disability postoperatively (P = 0.505) between the two groups. Six-month angiographic assessment of 23 patients (12 endoscopic and 11 open) revealed no difference in the patency rate (10/12 in endoscopic and 9/11 in open group).

Conclusion: Endoscopic RA harvesting reduced the incidence of postoperative wound infection and wound pain and improved patient satisfaction and cosmesis compared with conventional harvesting technique. There was no difference in the 6-month angiographic patency of the RA harvested conventionally and endoscopically.

Innovations (Phila). 2017 Jul/Aug;12(4):231-238.

A prospective randomized trial of endoscopic versus conventional harvesting of the saphenous vein in coronary artery bypass surgery

Kiaii B, Moon BC, Massel D, et al.

Objectives: Our objectives were (1) to determine whether minimally invasive endoscopic harvesting of the saphenous vein reduces morbidity due to postoperative wound infection and pain with improved cosmetic results and mobilization as compared with the conventional technique and (2) to compare the histologic properties of the saphenous veins harvested conventionally and endoscopically.

Methods: One hundred forty-four patients undergoing coronary artery bypass grafting were randomized to have vein harvesting performed by either the conventional (n = 72) or an endoscopic (n = 72) minimally invasive technique.

Results: Vein harvest time (open leg wound time) was significantly reduced in the endoscopic group (27.6 versus 64.4 minutes; P < .0001). The rate of leg wound infection was significantly reduced in the endoscopic group (4.3%) as compared with the conventional group (24.6%), a relative

risk reduction of 83% (95% confidence interval: 36%-129%; P = .0006). The majority of infections (84.2%) occurred after hospital discharge. Postoperative leg pain, mobilization, and overall patient satisfaction were also significantly improved in the endoscopic group. Double blinded histologic assessment of harvested vein (n = 28) showed no evidence of any clinically important significant damage to the specimens in either group.

Conclusion: In this prospective randomized trial, endoscopic harvesting of the saphenous vein significantly reduced postoperative leg wound complications, including infection, and improved patient satisfaction as compared with the conventional harvesting technique. There were no significant histologic differences between the conventional and endoscopically harvested saphenous veins.

Erratum in Journal of Thoracic Cardiovascular Surgery. 2002;123:204-212.

A comprehensive review on learning curve associated problems in endoscopic vein harvesting and the requirement for a standardised training programme

Krishnamoorthy B, Critchley WR, Venkateswaran RV, et al.

Endoscopic vein harvesting is becoming one of the most favourable vein harvesting techniques in multiple bypass coronary surgery, due to its short term post-operative benefits with high patient satisfaction. However, long-term graft patency has been both supported and questioned in the literature. Graft failure can be affected by harvesting methods and operator's experience. Endoscopic vein harvesting is associated with a learning curve period, during which the incidence of vein trauma is high due to unfamiliarity with the surgical technique. There is a paucity of structured learning tools for novice practitioners, meaning that training

differs significantly between hospital centres. Inconsistent training methods can lead to poor surgical technique, which can have a significant impact on vein quality and stress level of the practitioner. In turn, this can lead to increased postoperative complications and longer surgical duration. The main aim of this literature review is to understand the impact of the learning curve on the vein conduit and whether there is a requirement for a standardised training programme for the novice practitioners.

J Cardiothorac Surg. 2016 Apr 8;11:45.

Endoscopic versus open vein-graft harvesting in coronary-artery bypass surgery

Lopes RD, Hafley GE, Allen KB, et al.

Background: Vein-graft harvesting with the use of endoscopy (endoscopic harvesting) is a technique that is widely used to reduce postoperative wound complications after coronary-artery bypass grafting (CABG), but the long-term effects on the rate of vein-graft failure and on clinical outcomes are unknown.

Methods: We studied the outcomes in patients who underwent endoscopic harvesting (1753 patients) as compared with those who underwent graft harvesting under direct vision, termed open harvesting (1247 patients), in a secondary analysis of 3000 patients undergoing CABG. The method of graft harvesting was determined by the surgeon. Vein-graft failure was defined as stenosis of at least 75% of the diameter of the graft on angiography 12 to 18 months after surgery (data were available in an angiographic subgroup of 1817 patients and 4290 grafts). Clinical outcomes included death, myocardial infarction, and repeat revascularization. Generalized estimating equations were used to adjust for baseline covariates associated with vein-graft failure and to account for the potential correlation between grafts within a patient. Cox proportional-hazards modeling was used to assess long-term clinical outcomes.

Results: The baseline characteristics were similar between patients who underwent endoscopic harvesting and those who underwent open harvesting. Patients who underwent endoscopic harvesting had higher rates of vein-graft failure at 12 to 18 months than patients who underwent open harvesting (46.7% versus 38.0%, $P < 0.001$). At 3 years, endoscopic harvesting was also associated with higher rates of death, myocardial infarction, or repeat revascularization (20.2% versus 17.4%; adjusted hazard ratio, 1.22; 95% confidence interval [CI], 1.01 to 1.47; $P = 0.04$), death or myocardial infarction (9.3% versus 7.6%; adjusted hazard ratio, 1.38; 95% CI, 1.07 to 1.77; $P = 0.01$), and death (7.4% versus 5.8%; adjusted hazard ratio, 1.52; 95% CI, 1.13 to 2.04; $P = 0.005$).

Conclusion: Endoscopic vein-graft harvesting is independently associated with vein-graft failure and adverse clinical outcomes. Randomized clinical trials are needed to further evaluate the safety and effectiveness of this harvesting technique.

New England Journal of Medicine. 2009;361:235–244.

Endoscopic vein harvest in patients at high risk for leg wound complications: a cost-benefit analysis of an initial experience

Luckraz H, Kaur P, Bhabra M, et al.

Background: A cost-benefit analysis of endoscopic vein harvesting (EVH) versus open vein harvest (OVH) was performed in patients at high risk for wound complications.

Methods: Risk factors for leg wound infection were identified as age older than 75 years, being a woman, body mass index > 28, having diabetes, being a smoker, and diagnosis of peripheral vascular disease. Patients who had at least 2 of these risk factors were selected for a pilot use of EVH and were matched to patients undergoing OVH (n = 50 patients/group). Costs incurred included costs of dressings, additional hospital stay, and costs for attending our outpatient wound clinic (OWC), amongst others. For the EVH group, there was the additional cost of the kit (£650 per patient). Data were prospectively collected.

Results: There were no significant differences in the preoperative characteristics between the 2 groups. During in-hospital stay, 18% (9 out of 50) versus 32% (16 out of 50) (P = .08) of patients (EVH vs OVH, respectively) had minor leg-wound suppurations. Patients in the OVH group had longer hospital stay (P = .01). Attendance at the OWC for leg-wound issues was 4% (2 out of 50) versus 48% (24 out of 50), respectively (P < .01), costing a total of £2,758 for the EVH group compared with £78,036 for the OVH group (P < .01). This amounted to cost savings of £42,778 (including EVH kit costs) favoring EVH.

Conclusion: In patients at high-risk of leg wound complications, EVH was associated with significant cost-savings and less leg wound complications.

Am J Infect Control. 2016 Dec 1;44(12):1606-1610.

Histologic evidence of the safety of endoscopic saphenous vein graft preparation

Meyer DM, Rogers TE, Jessen ME, et al.

Background: Endoscopic methods of saphenous vein procurement have recently been introduced. These techniques have been successful in limiting pain and wound complications, but less information on assessing potential trauma to the harvested vein segment is available.

Methods: Fourteen male patients undergoing coronary artery bypass grafting were included in the study. Nine patients underwent endoscopic procurement of saphenous vein whereas 5 patients underwent procurement using standard open techniques. Histologic appearance and immunohistochemical studies (factor VIII:vWF [von Willebrand factor protein] and CD34) of the vein segments were reviewed in a blinded fashion.

Results: On histologic analysis, no differences in the intima, media, or adventitia were found between endoscopically and conventionally obtained vein segments. Immuno-histochemical staining for factor VIII:vWF and CD34 showed no differences between veins harvested by the two techniques.

Conclusion: Endoscopic saphenous vein harvesting does not appear to traumatize the vessel wall any more than open techniques. Longitudinal assessment is necessary to evaluate long-term patency in vein grafts procured using this method.

Annals of Thoracic Surgery. 2000;70:487-491.

Minimally invasive saphenous vein harvesting

Morris RJ, Butler MT, Samuels LE

Background: Minimally invasive techniques to harvest the saphenous vein for coronary artery bypass grafting continue to improve and evolve. Smaller cutaneous incisions have been shown to decrease postoperative discomfort and improve healing. We describe a technique involving carbon dioxide insufflation and endoscopic dissection to allow easier and atraumatic dissection.

Methods: The VasoView endoscope system (Origin Medsystems, Inc) was used to harvest the saphenous vein for coronary artery bypass grafting in 27 patients. This group was compared with 24 patients having traditional saphenous vein harvesting. Wounds were examined for complications daily. Pain and postoperative mobility were quantified independently by physical therapists.

Results: Comparison of patients in the two groups revealed greater edema in the legs with traditional harvesting. Patients with endoscopic removal also had less pain and increased mobility postoperatively. On average, minimally invasive harvesting allowed patients to ambulate to a pre-discharge goal of 300 ft. 2 days earlier.

Conclusion: Minimally invasive harvesting of the saphenous vein by insufflation techniques is safe, effective, and atraumatic to the conduit. Discomfort is minimized, promoting earlier and improved ambulation.

Annals of Thoracic Surgery. 1998;66:1026–1028.

Endoscopic radial artery harvesting procedure for coronary artery bypass grafting

Navia JL, Olivares G, Ehasz P, et al.

Development and adoption of endoscopic minimally invasive saphenous vein harvesting prompted its application to the radial artery in an effort to minimize surgical trauma. Recently, we reported that endoscopic radial artery harvesting was associated with better wound appearance and it proved to be safe and effective, with less pain and fewer wound complications

than the open surgical technique. Based on this positive experience, our institution adopted endoscopic radial artery harvesting, hence the aim of this manuscript is to describe the minimally invasive endoscopic radial artery harvesting for coronary artery bypass grafting.

Ann Cardiothorac Surg. 2013 Jul;2(4):557-64.

Risk factors for leg harvest surgical site infections after coronary artery bypass graft surgery

Olsen MA, Sundt TM, Lawton JS, et al.

Objective: Harvest site infections are more common than chest surgical infections after coronary artery bypass surgery, yet few studies detail risk factors for these infections. We sought to determine independent risk factors for leg surgical site infections using our institutional Society of Thoracic Surgeons database.

Methods: We retrospectively analyzed data collected from 1980 coronary artery bypass patients undergoing surgery at our institution from January 1, 1996, through June 30, 1999, using The Society of Thoracic Surgeons database. Independent risk factors for leg harvest site infection were identified by multivariate logistic regression.

Results: Seventy-six patients (4.5%) were coded as having had a leg harvest site infection, of which 67 were confirmed by infection control. The length of hospital stay after surgery was significantly longer in patients with leg harvest site infection (mean 10.1 days) compared with that of

patients without infection (mean 7.1 days, $P < .001$), and infected patients were more likely to be readmitted to the hospital within 30 days of surgery. Independent risk factors for leg harvest site infection included previous cerebrovascular accident (odds ratio, 2.9), postoperative transfusion of 5 units or more of red blood cells (odds ratio, 2.8), obesity (odds ratio, 2.5), age 75 years or older (odds ratio, 1.9), and female gender (odds ratio, 1.8).

Conclusion: Consistent with previous studies, female gender and obesity were identified as independent risk factors for leg harvest site infection, while previous cerebrovascular accident, postoperative transfusion, and older age are newly described risk factors. The Society of Thoracic Surgeons database is a useful tool for identification of predictors of leg harvest site infections.

J Thorac Cardiovasc Surg. 2003 Oct;126(4):992-9.

Impact of endoscopic versus open saphenous vein harvest techniques on outcomes after coronary artery bypass grafting

Ouzounian M, Hassan A, Buth KJ, et al.

Background: Endoscopic saphenous vein harvest (EVH) decreases leg wound infections and improves cosmesis after coronary artery bypass grafting (CABG). Recent data, however, suggest that EVH may be associated with reduced graft patency rates. The objective of this study is to assess the effect of EVH on short-term and midterm outcomes after CABG.

Methods: Data were prospectively collected on all first-time isolated CABG and combined valve/CABG with saphenous vein graft between 1998 and 2007 at a single center. Patients having traditional "open" vein harvest (OVH) were compared with patients having EVH. Multivariate models were used to examine the risk-adjusted impact of EVH on postoperative leg infection, composite in-hospital adverse events, and individual and composite midterm adverse events.

Results: The study included 5,825 patients, of whom 2,004 (34.4%) had EVH. Patients having EVH were more likely to have ejection fraction less than 50% (32.0%

versus 29.3%, $p = 0.04$), recent myocardial infarction (24.2% versus 18.3%, $p < 0.0001$), and left main disease (26.0% versus 22.1%, $p = 0.0009$). Median follow-up was 2.6 years. After risk adjustment, EVH was associated with reduced rates of leg infection (odds ratio 0.48, $p = 0.003$) but had no association with either in-hospital (odds ratio 0.93, $p = 0.56$) or midterm adverse outcomes (hazard ratio 0.93, $p = 0.22$). Endoscopic saphenous vein harvest was associated with reduced readmission to hospital for unstable angina (odds ratio 0.74, $p = 0.01$).

Conclusion: Endoscopic saphenous vein harvest is associated with a lower rate of leg infection and is not an independent predictor of in-hospital or midterm adverse outcomes. Endoscopic saphenous vein harvest is a safe alternative to OVH for patients undergoing CABG with saphenous vein.

Annals of Thoracic Surgery. 2010;89:403-408.

Endoscopic radial artery harvesting is better than the open technique

Patel AN, Henry AC, Hunnicutt C, et al.

Background: Radial arteries are being used more often for coronary artery bypass grafting. A minimally invasive technique was devised for harvesting vessels and compared with the traditional harvesting technique.

Methods: In a prospective study of 200 consecutive patients undergoing coronary artery bypass grafting, 100 patients had traditional open radial artery harvesting and 100 underwent endoscopic radial artery harvesting. All patients had a preoperative modified Allen's test with Doppler imaging. The traditional technique involved a longitudinal incision over the radial aspect of the arm from the wrist to the antecubital fossa. The radial artery was dissected subfascially and removed. The endoscopic technique involved a 3-cm incision over the radial aspect of the arm. A vessel loop was placed around the artery and carbon dioxide was insufflated into the wound. The radial artery was dissected to the brachial artery and ligated with an Endo-loop ligature. The branches were divided with bipolar electrocautery and ligated with clips. Patients were evaluated for postoperative pain, bleeding, neuralgias,

infection, and any adverse events. A p value of less than 0.05 was considered significant.

Results: All 200 radial arteries were successfully harvested and used as grafts. Patients who had undergone endoscopic radial artery harvesting had significantly fewer major complications than patients who underwent the open technique: hematomas (five versus no complications) or wound infections requiring antibiotics (seven versus one complication). The occurrence of major neuralgias that restricted function were also significantly lower postoperatively and 1, 3, and 6 months later (ten versus one, eight versus one, five versus zero, and one versus zero, respectively).

Conclusion: Endoscopic radial artery harvesting results in good cosmetic results, useable grafts, and minimal neuralgias. Endoscopic radial artery harvesting is better than traditional open radial artery harvesting.

Annals of Thoracic Surgery. 2004;78:149–153.

Prospective analysis of endoscopic vein harvesting

Patel AN, Hebeler RF, Hamman BL, et al.

Background: Utilization of bridging vein harvesting (BVH) of saphenous vein grafts (SVG) for coronary artery bypass grafting results in large wounds with great potential for pain and infection. Endoscopic vein harvesting (EVH) may significantly reduce the morbidity associated with SVG harvesting.

Methods: A prospective database of 200 matched patients receiving EVH and BVH was compared. The patients all underwent CABG done over a period of 4 months (April to August 2000). Patients were excluded if they had prior vein harvesting.

Results: The EVH and BVH group included 100 patients each with similar demographics. The patients in the EVH group had significantly fewer wound complications, mean days to ambulation, and total length of stay ($p < 0.05$). There was no difference in harvest time or vein injuries.

Conclusion: Endoscopic vein harvesting results in significantly fewer wound complications, decrease in days to ambulation, and the total length of stay. EVH is superior to BVH in patients undergoing CABG.

American Journal of Surgery. 2001;182:716–719.

A prospective randomized angiographic study of open versus endoscopic saphenectomy for CABG

Perrault LP, Bilodeau L, Jeanmart H, et al.

Objective: Although endoscopic saphenectomy for coronary artery bypass grafting surgery (CABG) is associated with a decreased incidence of wound complications and has shown no increased incidence of histological trauma or endothelial dysfunction, a concern remains about the angiographic results of saphenous vein grafts (SVG) harvested with this technique in regard to the development of intimal hyperplasia in the body of the graft due to bipolar cauterisation of side branches. The purpose of this study was to compare the angiographic appearance of SVG harvested with the open versus endoscopic technique after CABG.

Methods: Forty patients undergoing primary CABG surgery with at least one internal mammary artery (IMA) and one SVG were randomized preoperatively to open versus endoscopic saphenectomy using the Guidant Vasoview system with bipolar cauterisation of side branches. Quantitative coronary angiography was performed (mean 3 months) after CABG.

Results: There were no significant differences between preoperative variables between both groups. There was no statistically significant difference in the patency rates of IMA grafts and in the patency rate of SVG (85.2% versus 84.4 % respectively) ($P < 0.05$) between the two groups and no difference in graft stenosis in the body of the SVG between both groups ($P < 0.05$).

Conclusion: The angiographic appearance and patency rate of SVG harvested for CABG by the endoscopic technique with bipolar cauterization are similar to those harvested with the open technique. These results support use of endoscopic saphenectomy for CABG because of the lower incidence of wound and infectious complications and superior functional results.

Heart Surgery Forum. 2003;6(suppl 1):S48.

Heparin administration prior to endoscopic vein harvest limits clot retention and improves graft patency

Poston R, Desai P

Objective: Residual clot strands within the saphenous vein (SV) is an increasingly recognized sequela of endoscopic vein harvest (EVH). CO₂ insufflation, used to facilitate visualization, causes stagnation of blood within the SV yet anticoagulation is not usually given until after harvest. We hypothesized that heparinization prior to CO₂ insufflation would reduce the severity of this residual clot and improve graft patency.

Methods: We prospectively studied acute graft patency in 460 patients that underwent OPCAB using IMA and SV procured endoscopically using CT angiography on POD 5. Patients receiving no heparin prior to EVH ($n = 306$) were compared to those receiving a heparin bolus of 2500U ($n = 55$), 5000U ($n = 60$), or 200U/kg ($n = 31$) prior to the onset of EVH. In a subset of the most recent 110 patients, the full tract of harvested SV was imaged using catheter-based infrared imaging (OCT) in order to measure residual clot within the conduit, quantified as clot volume (mm³) and %SV length that contained clot (%clot). Baseline and intraoperative characteristics were compared between the groups receiving heparin versus no heparin.

Results: Graft patency was significantly greater in those patients that received any heparin bolus ($n = 146$) versus no heparin ($n = 306$) prior to EVH (98.9 versus 95.2% patency, $p < 0.05$). Compared to no heparin control group that underwent OCT imaging, those receiving heparin prior to EVH showed significantly reduced the incidence (85 versus 42%, $p < 0.05$) and volume of clot (1.2 ± 1.3 versus 0.18 ± 0.37 mm³, $p < 0.05$) and %clot (72 ± 39 versus 19 ± 18 %, $p < 0.001$). All analyzed perioperative risk factors were similar between the pre-heparinized and control groups.

Conclusion: Giving a heparin bolus as low as 2500U prior to EVH was found to be associated with a reduced quantity of retained clot and improved SV graft patency compared to SV procured without preheparinization. The inconsistent use of this strategy in centers participating in the PREVENT IV trial may help explain the disappointing SV graft patency rates seen in conduits procured using EVH.

Paper presented at the 2009 annual meeting of the International Society of Minimally Invasive Cardiothoracic Surgery; June 3–6, 2009; San Francisco, CA.

The influence of endoscopic vein harvesting on outcomes after coronary bypass grafting: a meta-analysis of 267,525 patients

Sastry P, Rivinius R, Harvey R, et al.

In recent times, practice in cardiac surgery has shifted towards using endoscopic techniques to harvest the saphenous vein from the leg for use as a bypass graft. A paper published in the *New England Journal of Medicine (NEJM)* in 2009 raised concerns over increased graft occlusion rates in veins harvested endoscopically. This *NEJM* paper has been criticized, but has nonetheless been influential in guiding practice. We have undertaken this meta-analysis to provide evidence on the clinical outcomes of endoscopic vein harvesting (EVH), so that clinicians can make an informed judgement about whether this technique, popular as it is with patients, should still be offered. We systematically reviewed the global literature and performed a meta-analysis of clinical outcomes after endoscopic and

open vein harvesting. In all outcomes, endoscopic harvesting appears to be equal, if not superior, to open harvesting. The suspicion of higher rates of vein graft occlusion was not borne out by randomized studies. When considering evidence from only randomized studies, there is no statistical difference in vein graft stenosis or occlusion between open and endoscopically harvested veins. In conclusion, EVH reduces pain and leg wound complications. At a median follow-up of 2.6 years, we found no significant difference in mortality, myocardial infarction, repeat revascularization, angina recurrence, vein graft stenosis or occlusion. Therefore, the authors support the ongoing use of endoscopic harvesting techniques.

Eur J Cardiothorac Surg. 2013 Dec;44(6):980-9.

The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 1—coronary artery bypass grafting surgery

Shahian DM, O'Brien SM, Filardo G, et al.

Background: The first version of The Society of Thoracic Surgeons National Adult Cardiac Surgery Database (STS NCD) was developed nearly 2 decades ago. Since its inception, the number of participants has grown dramatically, patient acuity has increased, and overall outcomes have consistently improved. To adjust for these and other changes, all STS risk models have undergone periodic revisions. This report provides a detailed description of the 2008 STS risk model for coronary artery bypass grafting surgery (CABG).

Methods: The study population consisted of 774,881 isolated CABG procedures performed on adult patients aged 20 to 100 years between January 1, 2002, and December 31, 2006, at 819 STS NCD participating centers. This cohort was randomly divided into a 60% training (development) sample and a 40% test (validation) sample. The development sample was used to identify predictor variables and estimate model coefficients. The validation sample was used to assess model calibration and discrimination. Model outcomes included operative mortality, renal failure, stroke, reoperation for any cause, prolonged ventilation, deep sternal wound infection, composite major morbidity or mortality, prolonged length of stay (> 14 days), and short length of stay (< 6 days and alive). Candidate predictor variables were selected based on their availability in versions 2.35, 2.41, and 2.52.1 of the STS NCD and their presence in (or ability to be mapped to) version 2.61. Potential predictor variables were screened

for overall prevalence in the study population, missing data frequency, coding concerns, bivariate relationships with outcomes, and their presence in previous STS or other CABG risk models. Supervised backwards selection was then performed with input from an expert panel of cardiac surgeons and biostatisticians. After successfully validating the fit of the models, the development and validation samples were subsequently combined, and the final regression coefficients were estimated using the overall combined (development plus validation) sample.

Results: The c-index for the mortality model was 0.812, and the c-indices for other endpoints ranged from 0.653 for reoperation to 0.793 for renal failure in the validation sample. Plots of observed versus predicted event rates revealed acceptable calibration in the overall population and in numerous subgroups. When patients were grouped into categories of predicted risk, the absolute difference between the observed and expected event rates was less than 1.5% for each endpoint. The final model intercept and coefficients are provided.

Conclusion: New STS risk models have been developed for CABG mortality and eight other endpoints. Detailed descriptions of model development and testing are provided, together with the final algorithm. Overall model performance is excellent.

Annals of Thoracic Surgery. 2009;88(1 suppl):S2-22

Risk factors for radial artery harvest site infection following coronary artery bypass graft surgery

Trick WE, Scheckler WE, Tokars JI, et al.

Radial arteries increasingly are used during coronary artery bypass graft (CABG) surgery. Although risk factors for saphenous vein harvest site infection (HSI) have been reported, rates of and risk factors for radial artery HSI are not well established. We compared rates of radial artery HSI that were detected by 2 surveillance methods, regular and heightened. Risk factors were determined by a case-control study. We identified 35 radial artery HSIs ("case sites") in 26 case patients. The radial artery HSI rate was significantly higher during heightened surveillance than during routine surveillance (12.3% vs. 3.1%,

respectively; $P=0.002$). Multivariate analysis showed that diabetes mellitus with a preoperative glucose level ≥ 200 mg/dL (odds ratio [OR], 4.4; $P=0.01$) and duration of surgery ≥ 5 h (OR, 3.1; $P=0.02$) were independent risk factors for radial artery HSI. Infection is a common complication of radial artery harvesting for CABG surgery, and infection rates are dependent on the intensity of surveillance. We identified preoperative hyperglycemia and surgery duration as independent risk factors for radial artery HSI.

Clin Infect Dis. 2000 Feb;30(2):270-5.

Preoperative correlates of impaired wound healing after saphenous vein excision

Utley JR, Thomason ME, Wallace DJ, et al.

Although major wound complications after saphenous vein excision are infrequent, we have found broadly defined impairment in leg wound healing to be relatively common. Wound healing impairment is defined in this study as inflammation, separation, cellulitis, lymphangitis, drainage, necrosis, or abscess necessitating dressing, antibiotics, or débridement before wound healing with complete epithelialization without eschar. Healing was impaired in 245 of 1047 patients (24.3%). Significant

correlations were found between impaired wound healing and female sex (p less than 0.005), body mass index (obesity) (p less than 0.005), diabetes mellitus (p less than 0.005), left ventricular end-diastolic pressure greater than 15 mm Hg ($p = 0.0074$), arterial occlusive disease of the legs ($p = 0.0124$), and preoperative hematocrit value ($p = 0.0491$).

J Thorac Cardiovasc Surg. 1989 Jul;98(1):147-9.

Association between endoscopic versus open vein-graft harvesting and mortality, wound complications, and cardiovascular events in patients undergoing CABG surgery

Williams JB, Peterson ED, Brennan JM, et al.

Context: The safety and durability of endoscopic vein graft harvest in coronary artery bypass graft (CABG) surgery has recently been called into question.

Objective: To compare the long-term outcomes of endoscopic versus open vein-graft harvesting for Medicare patients undergoing CABG surgery in the United States.

Design, Setting, and Patients: An observational study of 235,394 Medicare patients undergoing isolated CABG surgery between 2003 and 2008 at 934 surgical centers participating in the Society of Thoracic Surgeons (STS) national database. The STS records were linked to Medicare files to allow longitudinal assessment (median 3-year follow-up) through December 31, 2008.

Main Outcome Measures: All-cause mortality. Secondary outcome measures included wound complications and the composite of death, myocardial infarction, and revascularization.

Results: Based on Medicare Part B coding, 52% of patients received endoscopic vein-graft harvesting during CABG surgery.

After propensity score adjustment for clinical characteristics, there were no significant differences between long-term mortality rates (13.2% [12,429 events] versus 13.4% [13,096 events]) and the composite of death, myocardial infarction, and revascularization (19.5% [18,419 events] versus 19.7% [19,232 events]). Time-to-event analysis for those patients receiving endoscopic versus open vein-graft harvesting revealed adjusted hazard ratios [HRs] of 1.00 (95% CI, 0.97–1.04) for mortality and 1.00 (95% CI, 0.98–1.05) for the composite outcome. Endoscopic vein-graft harvesting was associated with lower harvest site wound complications relative to open vein-graft harvesting (3.0% [3654/122,899 events] versus 3.6% [4047/112,495 events]; adjusted HR, 0.83; 95% CI, 0.77–0.89; $P < .001$).

Conclusion: Among patients undergoing CABG surgery, the use of endoscopic vein-graft harvesting compared with open vein-graft harvesting was not associated with increased mortality.

Journal of the American Medical Association. 2012;308:475–484.

Randomized trial of endoscopic versus open vein harvest for coronary artery bypass grafting: six-month patency rates

Yun KL, Wu Y, Aharonian V, et al.

Objective: We sought to compare the 6-month angiographic patency rates of greater saphenous veins removed during coronary artery bypass grafting with the endoscopic vein harvest or open vein harvest techniques.

Methods: Two hundred patients undergoing nonemergency on-pump coronary artery bypass grafting were prospectively randomized to either endoscopic vein harvest or open vein harvest. Follow-up angiography of all vein grafts was scheduled at 6 months. Graft patency and disease grades were assigned independently by 2 interventional cardiologists. Leg wound healing was evaluated at discharge, 1 month, and 6 months for evidence of complications.

Results: There were 3 conversions from endoscopic vein harvest to open vein harvest because of vein factors. Leg wound complications were significantly lower in the endoscopic vein harvest group (7.4% versus 19.4%, $P = .014$). On multivariable analysis, endoscopic vein harvest emerged as the only factor affecting wound complications (odds ratio, 0.33). Three deaths (2 perioperative and 1 late) occurred in the endoscopic vein harvest group that were unrelated to vein graft closure. Twenty-four and 29 patients in the endoscopic vein harvest and open vein harvest cohorts, respectively, refused the follow-up 6-month angiography. Therefore

a total of 144 angiograms (73 endoscopic vein harvests and 71 open vein harvests) and 336 vein grafts (166 endoscopic vein harvests and 170 open vein harvests) were available for analysis. The overall occlusion rates at 6 months were 21.7% for endoscopic vein harvest and 17.6% for open vein harvest. Additionally, there was evidence of significant disease (> 50% stenosis) in 10.2% and 12.4% of endoscopic vein harvest and open vein harvest grafts, respectively. By means of ordinal hierarchic logistic regression, endoscopic vein harvest was not found to be a risk factor for vein graft occlusion or disease (odds ratio, 1.15). Significant predictors were congestive heart failure (odds ratio, 2.87), graft to the diagonal artery territory (odds ratio, 1.76), larger vein conduit size (odds ratio, 1.32), and graft flow (odds ratio, 0.90).

Conclusion: Endoscopic vein harvest reduces leg wound complications compared with open vein harvest without compromising the 6-month patency rate. The overall patency rate depends on target and vein-related variables and patient characteristics rather than the method of vein harvesting.

Journal of Thoracic and Cardiovascular Surgery. 2005;129:496–503.

Comment in:
Journal of Thoracic and Cardiovascular Surgery. 2005;129:488–490.

Randomized trial of endoscopic or open vein-graft harvesting for coronary-artery bypass

Zenati MA, Bhatt DL, Bakaeen FG, et al.

Background: The saphenous-vein graft is the most common conduit for coronary-artery bypass grafting (CABG). The influence of the vein-graft harvesting technique on long-term clinical outcomes has not been well characterized.

Methods: We randomly assigned patients undergoing CABG at 16 Veterans Affairs cardiac surgery centers to either open or endoscopic vein-graft harvesting. The primary outcome was a composite of major adverse cardiac events, including death from any cause, nonfatal myocardial infarction, and repeat revascularization. Leg-wound complications were also evaluated.

Results: A total of 1150 patients underwent randomization. Over a median follow-up of 2.78 years, the primary outcome occurred in 89 patients (15.5%) in the open-harvest group and 80 patients (13.9%) in the endoscopic-harvest group (hazard ratio, 1.12; 95% confidence interval [CI], 0.83 to 1.51; $P=0.47$). A total of 46 patients (8.0%) in the open-harvest group and 37 patients (6.4%) in the endoscopic-harvest group

died (hazard ratio, 1.25; 95% CI, 0.81 to 1.92); myocardial infarctions occurred in 34 patients (5.9%) in the open-harvest group and 27 patients (4.7%) in the endoscopic-harvest group (hazard ratio, 1.27; 95% CI, 0.77 to 2.11), and revascularization occurred in 35 patients (6.1%) in the open-harvest group and 31 patients (5.4%) in the endoscopic-harvest group (hazard ratio, 1.14; 95% CI, 0.70 to 1.85). Leg-wound infections occurred in 18 patients (3.1%) in the open-harvest group and in 8 patients (1.4%) in the endoscopic-harvest group (relative risk, 2.26; 95% CI, 0.99 to 5.15).

Conclusion: Among patients undergoing CABG, we did not find a significant difference between open vein-graft harvesting and endoscopic vein-graft harvesting in the risk of major adverse cardiac events. (Funded by the Cooperative Studies Program, Office of Research and Development, Department of Veterans Affairs; REGROUP ClinicalTrials.gov number, NCT01850082 .).

N Engl J Med. 2019 Jan 10;380(2):132-141.

Impact of endoscopic versus open saphenous vein harvest technique on late coronary artery bypass grafting patient outcomes in the ROOBY (Randomized On/Off Bypass) Trial

Zenati MA, Shroyer AL, Collins JF, et al.

Objective: In the Randomized On/Off Bypass (ROOBY) Trial, the efficacy of on-pump versus off-pump coronary artery bypass grafting was evaluated. This ROOBY Trial planned subanalysis compared the effects on postbypass patient clinical outcomes and graft patency of endoscopic vein harvesting and open vein harvesting.

Methods: From April 2003 to April 2007, the technique used for saphenous vein graft harvesting was recorded in 1471 cases. Of these, 894 patients (341 endoscopic harvest and 553 open harvest) also underwent coronary angiography 1 year after coronary artery bypass grafting. Univariate and multivariable analyses were used to compare patient outcomes in the endoscopic and open groups.

Results: Preoperative patient characteristics were statistically similar between the endoscopic and open groups. Endoscopic vein harvest was used in 38%

of the cases. There were no significant differences in both short-term and 1-year composite outcomes between the endoscopic and open groups. For patients with 1-year catheterization follow-up ($n=894$), the saphenous vein graft patency rate for the endoscopic group was lower than that in the open harvest group (74.5% vs 85.2%, $P<.0001$), and the repeat revascularization rate was significantly higher (6.7% vs 3.4%, $P<.05$). Multivariable regression documented no interaction effect between endoscopic approach and off-pump treatment.

Conclusion: In the ROOBY Trial, endoscopic vein harvest was associated with lower 1-year saphenous vein graft patency and higher 1-year revascularization rates, independent of the use of off-pump or on-pump cardiac surgical approach.

J Thorac Cardiovasc Surg. 2011 Feb;141(2):338-44.

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