Systematic Review

Graft patency after open versus endoscopic saphenous vein harvest in coronary artery bypass grafting surgery: a systematic review and meta-analysis

Karishma Kodia[1], Sinal Patel[1], Matthew P. Weber[1], Jessica G. Y. Luc[2], Jae Hwan Choi[1], Elizabeth J. Maynes[1], Syed-Saif Abbas Rizvi[1], Dylan P. Horan[1], H. Todd Massey[1], John W. Entwistle[1], Rohinton J. Morris[1], Vakhtang Tchantchaleishvili[1]

[1]Division of Cardiac Surgery, Thomas Jefferson University, Philadelphia, PA, USA; [2]Division of Cardiovascular Surgery, Department of Surgery, University of British Columbia, Vancouver, British Columbia, Canada

Correspondence to: Vakhtang Tchantchaleishvili, MD. Assistant Professor of Surgery, Division of Cardiothoracic Surgery, Thomas Jefferson University, 1025 Walnut St, Suite 607, Philadelphia, PA, USA. Email: Vakhtang.Tchantchaleishvili@jefferson.edu.

Background: Saphenous vein grafts (SVG) are a commonly used conduit for coronary artery bypass graft (CABG) surgery and can be harvested by either an open or endoscopic technique. Our goal was to evaluate long-term angiographic and clinical outcomes of open compared to endoscopic SVG harvest for CABG.

Methods: Electronic search was performed to identify all studies in the English literature that compared open and endoscopic SVG harvesting for CABG with at least one year of follow-up. The primary outcome was graft patency. Secondary outcomes included perioperative morbidity and mortality.

Results: Of 3,255 articles identified, a total of 11 studies were included for analysis. Of 18,131 patients, 10,873 (60%) patients underwent open SVG harvest and 7,258 (40%) patients underwent endoscopic SVG harvest. The mean age of patients was 65 years and 87% were male. The overall mean follow-up period was 2.6 years. During follow-up, patients who underwent open SVG harvest had superior graft patency per graft [open 82.3% *vs.* endoscopic 75.1%; OR: 0.61 (95% CI, 0.43–0.87); P=0.01], but higher rates of overall wound complications in the immediate post-operative period [open 3.3% *vs.* endoscopic 1.1%; OR: 0.02 (95% CI, 0.01–0.06); P<0.001]. Patients who underwent open SVG harvest had higher postoperative 30-day mortality [open 3.4% *vs.* endoscopic 2.1%; OR: 0.59 (95% CI, 0.37–0.94); P=0.03], but no significant difference in overall mortality [open 4.9% *vs.* endoscopic 4.9%; OR: 0.34 (95% CI, 0.50–1.27); P=0.34].

Conclusions: Patients who underwent an open SVG harvest technique had improved graft patency and comparable overall mortality to endoscopic SVG harvest at average follow-up time of 2.6 years. Patients with open SVG harvest had higher rates of early wound complications and postoperative 30-day mortality, however, there was no difference in overall mortality.

Keywords: Coronary artery bypass grafting (CABG); saphenous vein harvest; endoscopic surgery; 30-day mortality; graft patency

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Introduction

Coronary artery bypass grafting (CABG) surgery remains the most common procedure in adult cardiac surgery for coronary artery disease (1). Among arterial and venous conduits for CABG surgery, saphenous vein grafts (SVG) are the most commonly used conduit due to its superficial access site and decreased risk for bleeding compared to arterial conduits (2,3). Traditionally, the SVG is harvested under direct vision (open harvest) with linear incisions along the course of the vein for clear vein visualization,

mobilization and branch ligation (4-7). However, this approach carries an increased risk of wound complications including infection, hematomas, seromas and longer hospital length of stay (4-7).

The technique of endoscopic SVG harvesting was introduced in 1996 as a minimally invasive alternative to traditional open SVG harvesting (8). Multiple small randomized trials subsequently reported advantages of endoscopic SVG harvest as compared to open SVG harvest (4,6,7,9,10). In 2005, the International Society for Minimally Invasive Cardiothoracic Surgery published a consensus statement (11) that endorsed the use of endoscopic SVG harvest over open SVG harvest (class I, level B) to reduce wound related complications (class I, level A), improve patient satisfaction and postoperative pain (class I, level A) and reduce postoperative length of stay (class I, level A). Furthermore, the consensus statement (11) endorsed use of either endoscopic or open SVG harvest technique based on major adverse cardiac events and angiographic patency at 6 months (class IIa, level A). On the basis of these demonstrated advantages, endoscopic SVG harvest has now become the predominant mode of graft harvesting at many surgical centers (12).

In contrast to the abundant evidence demonstrating improved short-term and wound-related outcomes (6,7,13-16), observational analyses regarding the long-term patency rates of SVG harvested by endoscopic technique are conflicting and remain sparse. Endoscopic SVG harvest was reported to have similar short-term graft patency as open SVG harvest, but was concerning for a significantly reduced long-term graft patency at 12 months and beyond (12,17,18). Because of the potential implications of worse long-term outcomes in patients who undergo CABG surgery, the role of endoscopic SVG harvest, although widely considered non-inferior to open harvest, has been a subject of much debate in the literature (19-21).

The aim of this systematic review was to evaluate long-term outcomes of patients who underwent CABG with open as compared to endoscopic SVG harvest techniques.

Methods

Literature search strategy

Thorough electronic searches were performed in March 2018 using Medline, Embase, Cochrane Central Register of Controlled Trials (CCTR), Cochrane Database of Systematic Reviews (CDSR), Web of Science, Scopus and CINAHL. To achieve the maximum sensitivity of the search strategy, we combined the terms: "coronary artery bypass graft (CABG)", "saphenous vein", "tissue and organ harvesting", "vein harvest", "endoscopic", and "minimally invasive" as either key words or MeSH terms. The reference lists of all retrieved articles were reviewed for further identification of potentially relevant studies and assessed using the inclusion and exclusion criteria.

Selection criteria

Eligible studies for the present systematic review and meta-analysis included double-arm studies that compared open and endoscopic SVG harvesting for CABG, with at least one year of follow-up time. Studies reporting on minimally invasive techniques other than endoscopic SVG harvesting were excluded. When institutions published duplicate studies with accumulating numbers of patients or increased lengths of follow-up, only the most complete reports with the longest follow-up were included for quantitative assessment. To ensure our results are reflective of current practice, only articles published from 1982 onwards were included. We excluded studies on patients <18 years of age, studies not published in the English language and those not involving human subjects. Furthermore, abstracts, case reports, conference presentations, editorials, reviews and expert opinions were also excluded.

Definitions

Graft patency per graft was determined using either FitzGibbon patency scale or by the exclusion of significant graft stenosis (22-24). Significant stenosis was defined as a greater than or equal to 50% stenosis as confirmed on follow-up catheterization (23).

Data extraction and critical appraisal

Data was extracted from article texts, tables and figures (S Patel, K Kodia). Discrepancies between the two reviewers were resolved by discussion and consensus.

Statistical analysis

A binary outcome meta-analysis of proportions was conducted for the available main perioperative and postoperative variables with logit transformation. Heterogeneity was evaluated using Cochran Q and I^2 test. Meta-regression was conducted

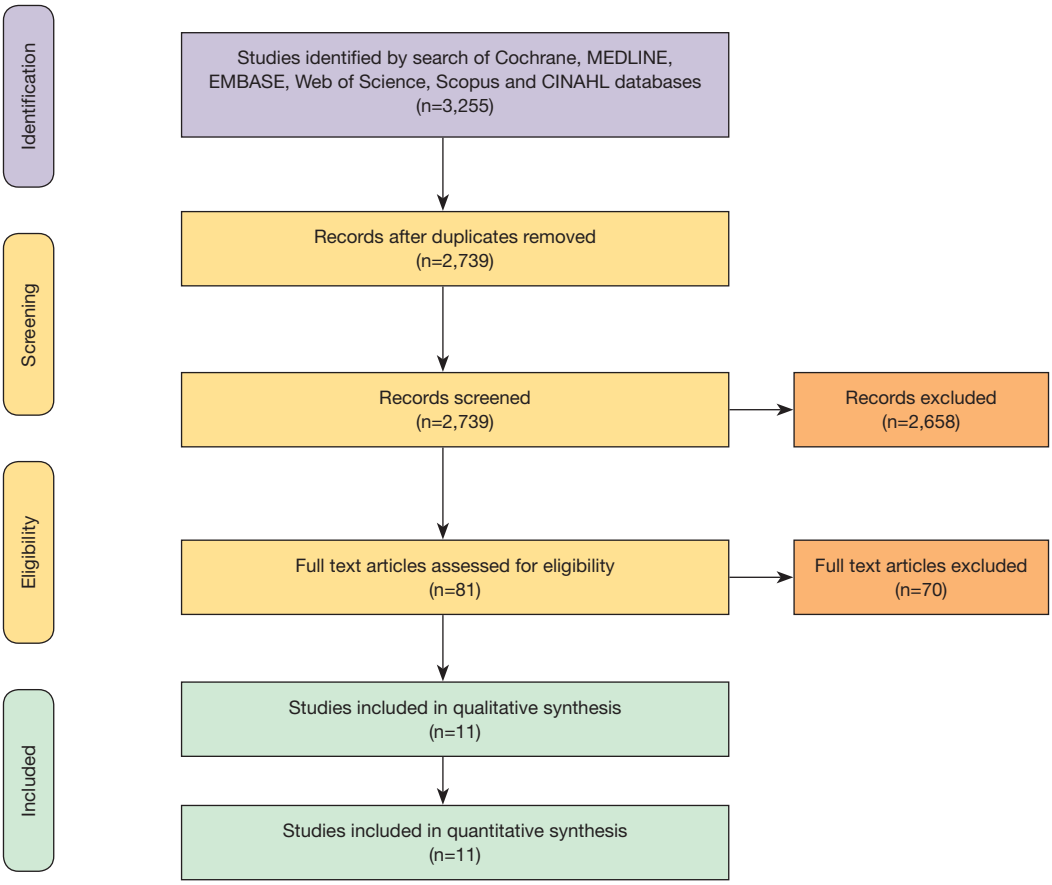


Figure 1 PRISMA schematic of search strategy. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

using open *vs*. endoscopic SVG harvest as a subgrouping variable. Egger's regression test for funnel plot asymmetry was performed to assess for publication bias. R software, version 3.01, (R Foundation for Statistical Computing, Vienna, Austria) was used for all data analysis and visualization. The meta-analysis was performed using metafor package for R. P values <0.05 were considered statistically significant.

Results

Study characteristics

Overall, 3,255 records were identified in a literature search of papers published between 1982 and present. Following application of the inclusion and exclusion criteria, 11 studies were included for analysis. Of the studies included, 5 were single-center retrospective studies, 3 were single-center prospective studies, and the remaining 3 were multicenter prospective clinical trials. Manual search of references did not yield further studies. A PRISMA flow diagram depicting the overall search strategy is shown in *Figure 1*. A detailed description of the studies used for analysis are reported in *Table 1*.

Of a total of 18,131 patients undergoing CABG, 10,873 (60%) patients underwent open SVG harvest and 7,258 (40%) patients underwent endoscopic SVG harvest. For graft patency subanalysis, 1,505 (14%) patients in the open cohort and 1,744 (24%) in the endoscopic cohort underwent angiography, follow-up evaluation for vein patency post-CABG surgery and were pooled for analysis. The overall mean follow-up period was 2.6 years. Mean angiographic follow-up time was 12.6 months [open 12.6 (95% CI, 12.21–12.99) *vs*. endoscopic 12.6 (95% CI, 12.20–12.99) months, P=0.34].

Baseline demographics

Baseline demographics of patients who underwent CABG with open and endoscopic SVG harvest techniques are

Table 1 Characteristics of studies included in the meta-analysis

Title	Authors	Year	Journal	Registry database	Study period (years)	Study institution	Study type
Decreased patency rates following endoscopic vein harvest in coronary artery bypass surgery	Andreasen *et al.*	2015	*Scandinavian Cardiovascular Journal*	Hospital administrative system and patients' records	2011–2013	Aalborg University Hospital, Denmark	Retrospective
Endoscopic vein harvest in elective off-pump coronary artery bypass grafting	Chou *et al.*	2008	*Journal of Zhejiang University*	Hospital administrative system and patients' records	2004–2005	National Taiwan University	Retrospective
Endoscopic vein harvest: advantages and limitations	Bonde *et al.*	2004	*The Annals of Thoracic Surgery*	Hospital administrative system and patients' records	2000–2001	Royal Victoria Hospital, UK	Prospective
Endoscopic versus direct vision for saphenous vein graft harvesting in coronary artery bypass surgery	Ad *et al.*	2011	*Journal of Cardiovascular Surgery (Torino)*	STS and ACC	2006–2009	Inova Heart and Vascular Institute, Falls Church, VA, US	Prospective
Endoscopic versus open vein-graft harvesting in coronary-artery bypass surgery	Lopes *et al.*	2009	*New England Journal of Medicine*	PREVENT IV trial	2002–2003	Duke Medical Center, Durham, NC	Prospective
Endoscopic *vs.* conventional vein harvesting: First results with a new, non-disposable system	Lutz *et al.*	2001	*The Thoracic and Cardiovascular Surgeon*	Hospital administrative system and patients' records	–	Albert-Ludwigs-University Freiburg, Germany	Retrospective
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 *et al.*	2011	*The Journal of Thoracic and Cardiovascular Surgery*	ROOBY Trial (18 VA centers)	2003–2007	18 Veterans Centers	Prospective
Impact of Endoscopic Versus Open Saphenous Vein Harvest Techniques on Outcomes After Coronary Artery Bypass Grafting	Ouzounian *et al.*	2010	*The Annals of Thoracic Surgery*	MHCCSR (1 Queen Elizabeth hospital, Canada)	1998–2007	Dalhousie University, Canada	Prospective
Influence of endoscopic versus traditional saphenectomy on event-free survival: five-year follow-up of a prospective randomized trial	Allen *et al.*	2003	*The Heart Surgery Forum*	Hospital administrative system and patients' records	1996–1997	St. Vincent Hospital and Health Care Center, Indiana	Prospective
Mid-term outcomes for Endoscopic versus Open Vein Harvest: a case control study	Kirmani *et al.*	2010	*Journal of Cardiovascular Surgery*	Hospital administrative system and patients' records	–	Blackpool Victoria Hospital, UK	Retrospective
What is the impact of endoscopic vein harvesting on clinical outcomes following coronary artery bypass graft surgery?	Grant *et al.*	2012	*Heart*	(Blackpool Victoria, Plymouth Derriford, and University Hospitals of South Manchester) Manchester, UK	2008–2010	University of Manchester, UK	Retrospective

ACC, American College of Cardiology; MHCCSR, Maritime Heart Center Cardiac Surgery Registry; PREVENT, Project of Ex-Vivo Vein Graft Engineering via Transfection IV; ROOBY, Randomized On/Off Bypass; STS, Society of Thoracic Surgeons.

shown in *Table 2*. The mean age of patients in the open SVG harvest group was 65.3 years and in the endoscopic SVG harvest group was 64.4 years (P=0.64), with >80% being male. Between patients undergoing CABG who underwent open or endoscopic SVG harvest, there were no significant differences in body mass index, smoking status, urgency of surgery, severity of coronary artery disease and comorbidities, including diabetes, hypertension, dyslipidemia, peripheral or cerebrovascular vascular disease, respiratory disease and renal failure.

Operative details

There were no significant differences in intraoperative variables between open and endoscopic SVG harvest, including concomitant valvular procedures, number of bypass grafts, SVG harvest time, vein graft length, graft injury, cardiopulmonary bypass and aortic cross clamp time, total operative time and hospital length of stay (*Table 3*).

Postoperative morbidity

Overall episodes of wound complication were significantly higher in patients who underwent CABG via open SVG harvest as compared to endoscopic SVG harvest [open 3.3% *vs.* endoscopic 1.1%; OR: 0.02 (95% CI, 0.01–0.06), P<0.001] (*Table 4*). Of wound complications, these were further subcategorized by leg infection [open 3.5% *vs.* endoscopic 1.0%; OR: 0.28 (95% CI, 0.18–0.45), P<0.001 requiring postoperative treatment with antibiotics [open 10.5% *vs.* endoscopic 0.0%; OR: 0.08 (95% CI, 0.01–0.58), P=0.01], wound drainage [open 3.8% *vs.* endoscopic 0.2%; OR: 0.14 (95% CI, 0.03–0.76), P=0.02] and altered sensation [open 13.5% *vs.* endoscopic 2.0%; OR: 0.23 (95% CI, 0.08–0.65), P=0.01]. There were no significant differences amongst the groups in terms of hematoma formation [open 13.9% *vs.* endoscopic 3.0%; OR: 0.31 (95% CI, 0.08–1.25), P=0.10] and wound dehiscence [open 5.9% *vs.* endoscopic 0.6%; OR: 0.22 (95% CI, 0.02–2.16), P=0.19]. Revision secondary to bleeding [open 2.5% *vs.* endoscopic 2.5%; OR: 0.97 (95% CI, 0.58–1.63), P=0.91] and hospital readmission for various reasons [open 9.3% *vs.* endoscopic 9.0%; OR: 0.83 (95% CI, 0.54–1.26), P=0.37] was also comparable between the two groups.

Graft patency, myocardial infarction, and mortality

The primary endpoint, graft patency per graft beyond one year, significantly favored open SVG harvest as compared to endoscopic SVG harvest for patients undergoing CABG surgery [open 82.3% *vs.* endoscopic 75.1%; OR: 0.61 (95% CI, 0.43–0.87), P=0.01] (*Table 4*) (*Figure 2*).

Myocardial infarction in the 30-day postoperative period [open 1.0% *vs.* endoscopic 0.5%; OR: 0.77 (95% CI, 0.44–1.34), P=0.35] and on long-term follow-up [open 1.7% *vs.* endoscopic 1.5%; OR: 1.04 (95% CI, 0.68–1.60), P=0.85] was similar between the two groups.

The 30-day postoperative mortality was significantly higher in patients who underwent CABG via open SVG harvest [open 3.4% *vs.* endoscopic 2.1%; OR: 0.59 (95% CI, 0.37–0.94), P=0.03] (*Figure 3*), with no significant differences in overall mortality [open 4.9% *vs.* endoscopic 4.9%; OR: 0.80 (95% CI, 0.50–1.27), P=0.34] (*Table 4*).

Discussion

In this systematic review and meta-analysis of 18,131 patients undergoing CABG surgery, we demonstrate that the open SVG harvest technique appears to confer improved intermediate-term graft patency per graft as compared to endoscopic SVG harvest. However, patients with open SVG harvest had higher rates of early wound complications (infection, neuralgia) and postoperative 30-day mortality that importantly, did not translate to differences in overall mortality. Reasons for the higher postoperative 30-day mortality are unclear but may reflect variances in patient selection, severity of premorbid disease, urgency, hemodynamic stability, and timing of surgery.

Although a few studies comparing endoscopic and open SVG harvest have been published (7,10,25,26), they are limited by low patient volume, lack of randomization, lack of angiographic assessment and short follow-up time during which clinically significant outcomes such as vein graft failure rates or major adverse cardiac outcomes may not yet become apparent. Maintaining long-term graft patency is the desired outcome as it is associated with long-term patient survival and reduces the need for re-intervention (27).

In the post hoc sub-analysis of the PREVENT-IV trial (Project of Ex-Vivo Vein Graft Engineering via Transfection IV), endoscopic SVG harvest was associated with a higher rate of vein graft occlusion at 12 to 18 months and higher long-term mortality (12). A post hoc sub-analysis of the ROOBY trial (Randomized On/Off Bypass) (28) reported similar outcomes with lower vein graft patency and higher 1-year revascularization rates among patients who

Table 2 Baseline demographics

Variable	Open saphenous vein graft harvest				Endoscopic saphenous vein graft harvest				Overall				P
	No. of studies	n/N	Pooled value (95% CI)	I^2 (%)	No. of studies	n/N	Pooled value (95% CI)	I^2 (%)	No. of studies	n/N	Pooled value (95% CI)	I^2 (%)	
Age (year)	11	–	65.3 (62.52, 68.12)	0.0	11	–	64.4 (61.59, 67.19)	0.0	11	–	64.9 (62.87, 66.83)	0.0	0.64
Male (%)	11	9,400/10,873	87.4 (80.00, 92.30)	98.0	11	5,933/7,258	86.0 (82.10, 89.20)	93.0	11	15,333/18,131	87.0 (83.60, 89.80)	97.0	0.71
White race (%)	2	1,311/1,501	83.3 (58.90, 94.60)	98.0	2	2,877/3,407	84.5 (59.10, 95.30)	99.0	2	4,188/4,988	83.9 (70.40, 91.90)	99.0	0.93
Body mass index (kg/m^2)	6	–	28.0 (26.49, 29.41)	0.0	6	–	27.8 (26.49, 29.13)	0.0	6	–	27.9 (26.89, 28.85)	0.0	0.88
Obesity (%)	3	430/3,941	17.9 (8.70, 33.20)	91.0	3	278/2,122	17.0 (10.80, 25.60)	74.0	3	708/6,063	16.4 (12.70, 20.90)	86.0	0.90
Smoking (%)	6	6261/9,569	55.1 (48.30, 61.80)	96.0	6	3,664/6,204	57.9 (40.90, 73.20)	99.0	6	9,925/15,773	55.6 (47.40, 63.40)	99.0	0.77
Urgent CABG (%)	3	1,864/8,851	18.0 (11.90, 26.40)	99.0	3	594/3,154	18.9 (14.00, 25.10)	92.0	3	2,452/12,005	18.5 (14.40, 23.30)	97.0	0.85
Hypertension (%)	11	3,395/10,871	29.5 (23.50, 36.40)	97.0	11	2,666/7,249	31.5 (27.10, 36.20)	92.0	11	6,061/18,120	30.3 (26.50, 34.40)	96.0	0.63
Diabetes Mellitus (%)	6	7,488/10,534	75.7 (70.50, 80.30)	97.0	6	5,122/6,730	77.3 (72.90, 81.10)	93.0	6	12,610/17,264	76.5 (73.00, 79.70)	96.0	0.63
Dyslipidemia (%)	6	5,416/6,473	83.5 (77.80, 87.90)	95.0	6	5,235/6,208	83.0 (76.20, 88.20)	97.0	6	10,651/12,681	83.3 (79.50, 86.50)	96.0	0.95
Respiratory disease (%)	5	1,371/9,287	14.1 (11.30, 17.90)	92.0	5	792/4,977	14.1 (10.30, 18.90)	94.0	5	2,163/14,264	14.2 (12.10, 16.70)	92.0	0.99
Renal failure (%)	5	416/10,280	3.3 (1.60, 6.70)	97.0	555	226/4,996	3.9 (2.30, 6.70)	91.0	5	642/15,276	3.7 (2.40, 5.50)	95.0	0.70
Peripheral vascular disease (%)	9	1,650/10,552	15.9 (13.50, 18.60)	85.0	9	788/5,451	13.3 (10.10, 17.20)	90.0	9	2,438/16,003	14.8 (12.90, 16.90)	87.0	0.25
Cerebrovascular disease (%)	3	658/4,257	13.2 (9.70, 17.70)	73.0	3	552/3,827	12.9 (9.10, 18.10)	92.0	3	1,210/8,084	13.5 (11.30, 16.00)	84.0	0.93
History of stroke/TIA (%)	3	136/2,408	5.6 (4.40, 7.20)	48.0	3	244/4,051	6.4 (4.90, 8.20)	76.0	3	380/6,459	6.0 (5.10, 7.10)	60.0	0.50
Previous surgery (%)	3	118/4,439	3.7 (0.40, 2.61)	99.0	3	395/2,384	2.7 (0.10, 37.70)	97.0	3	631/6,823	3.4 (0.80, 13.10)	99.0	0.87
Prior myocardial infarction (%)	5	3,439/9,627	38.5 (23.50, 56.00)	100.0	5	2,273/6,166	39.6 (30.60, 49.40)	98.0	5	5,712/15,793	39.1 (30.50, 48.40)	99.0	0.91
Unstable angina (%)	2	65/134	45.0 (14.70, 79.40)	94.0	2	150/322	42.0 (27.00, 58.60)	79.0	2	215/456	43.5 (29.70, 58.40)	86.0	0.89
Triple vessel disease (%)	2	3,603/5,030	71.4 (69.40, 73.20)	39.0	2	817/1,150	71.1 (64.70, 76.70)	81.0	2	4,420/6,180	71.1 (68.90, 73.20)	58.0	0.92
Left main stem disease (%)	2	1,928/7,944	24.1 (20.30, 28.50)	95.0	2	665/2,590	25.7 (24.00, 27.40)	0.0	2	2,593/10,534	24.7 (22.40, 27.20)	86.0	0.50
NHYA class III or IV (%)	3	1,369/5,610	22.0 (16.80, 28.30)	94.0	3	771/4,056	19.2 (11.60, 30.10)	98.0	3	2,140/9,666	20.4 (15.90, 25.70)	97.0	0.63
Left ventricular ejection fraction (%)	2	–	55.3 (39.16, 71.53)	0.0	2	–	57.1 (42.86, 71.41)	0.0	2	–	56.4 (45.65, 67.06)	0.0	0.87
Impaired ejection fraction (%)	4	2,216/8,907	23.1 (18.20, 28.80)	96.0	4	861/3,206	22.3 (14.60, 32.50)	96.0	4	3,077/12,113	22.7 (19.00, 27.00)	96.0	0.89

CABG, coronary artery bypass grafting; TIA, transient ischemic attack.

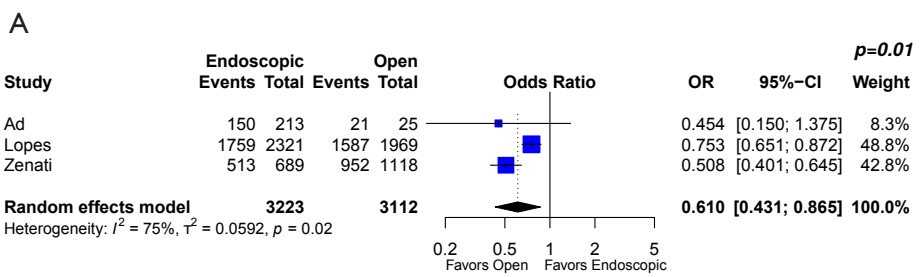
Table 3 Perioperative details and study characteristics

Variable	Open saphenous vein graft harvest				Endoscopic saphenous vein graft harvest				Overall				P
	No. of studies	n/N	Pooled value (95% CI)	I^2 (%)	No. of studies	n/N	Pooled value (95% CI)	I^2 (%)	No. of studies	n/N	Pooled value (95% CI)	I^2 (%)	
Procedural variables													
CABG + valve repair	2	74/312	7.1 (0.20, 76.00)	86.0	2	323/1,788	5.9 (0.30, 58.00)	80.0	2	397/2,100	17.3 (9.60, 29.20)	88.0	0.94
CABG off pump	2	536/985	91.2 (7.00, 100.00)	92.0	2	549/834	95.2 (3.90, 100.00)	95.0	2	1,085/1,819	60.3 (46.60, 72.60)	91.0	0.87
Number of bypass grafts	5	–	2.6 (1.94, 3.32)	38.0	5	–	2.57 (1.50, 3.65)	45.0	5	–	2.57 (2.05, 3.15)	36.0	0.93
Cardiopulmonary bypass time (minutes)	2	–	94.2 (79.11, 109.36)	0.0	2	–	96.23 (79.92, 112.54)	0.0	2	–	95.2 (84.07, 106.25)	0.0	0.86
Crossclamp time (minutes)	3	–	58.4 (41.24, 75.62)	0.0	3	–	61.45 (42.91, 79.99)	0.0	3	–	59.8 (47.22, 72.43)	0.0	0.81
Operative time (minutes)	2	–	255.9 (200.81, 311.00)	0.0	2	–	259.34 (194.93, 323.79)	0.0	2	–	257.4 (215.49, 299.24)	0.0	0.94
Harvest time (minutes)	2	–	29.8 (14.05, 45.52)	0.0	2	–	43.25 (21.77, 64.73)	0.0	2	–	34.5 (21.80, 47.18)	0.0	0.32
Vein graft length (cm)	2	–	39.9 (24.27, 55.59)	0.0	2	–	41.76 (34.76, 48.75)	0.0	2	–	41.5 (35.07, 47.84)	0.0	0.84
Unrepairable graft injury (%)	2	8/134	6.3 (2.70, 13.80)	30.0	2	12/322	0.4 (0.10, 69.00)	94.0	2	20/456	5.3 (5.30, 18.50)	86.0	0.77
Internal mammary artery use (%)	2	128/134	96.1 (76.00, 99.50)	56.0	2	299/322	95.6 (73.40, 99.40)	60.0	2	427/456	93.6 (87.80, 96.80)	41.0	0.94
Hospital stay (days)	3	–	9.1 (4.37, 13.91)	23.0	3	–	8.22 (2.96, 13.49)	52.0	3	–	8.4 (5.33, 11.55)	31.0	0.80
Study characteristics													
Follow-up time (years)	5	–	2.5 (1.62, 3.46)	45.0	5	–	2.6 (1.64, 3.47)	43.0	5	–	2.6 (2.06, 3.13)	37.0	0.98
Angiography follow-up time (months)	2	–	12.6 (12.21, 12.99)	0.0	2	–	12.6 (12.20, 12.99)	0.0	2	–	12.6 (12.32, 12.88)	0.0	0.34

CABG, coronary artery bypass grafting.

Table 4 Early and late outcomes of open as compared to endoscopic saphenous vein grafting (SVG) post coronary artery bypass grafting surgery

Variable	Open SVG harvest, n/N (%)	Endoscopic SVG harvest, n/N (%)	Odds ratio	95% CI	P
Early outcomes					
Revision for bleeding (%)	29/1,161 (2.5)	57/2,298 (2.5)	0.97	(0.58, 1.63)	0.91
Readmission (%)	29/312 (9.3)	161/1,785 (9.0)	0.83	(0.54, 1.26)	0.37
Wound complications					
Total episodes (%)	315/9,417 (3.3)	94/8,341 (1.1)	0.02	(0.01, 0.06)	<0.001
Leg	154/4,457 (3.5)	42/4,268 (1.0)	0.28	(0.18, 0.45)	<0.001
Sternal	38/3,940 (1.0)	21/2,117 (1.0)	0.75	(0.19, 2.89)	0.68
Hematoma	29/209 (13.9)	12/394 (3.0)	0.31	(0.08, 1.25)	0.10
Wound drainage	10/260 (3.8)	1/443 (0.2)	0.14	(0.03, 0.76)	0.02
Edema	48/207 (23.2)	8/398 (2.0)	0.11	(0.04, 0.32)	0.23
Leg wound dehiscence	8/136 (5.9)	2/324 (0.6)	0.22	(0.02, 2.16)	0.19
Altered sensation	28/208 (13.5)	8/397 (2.0)	0.23	(0.08, 0.65)	0.01
Infection treated with antibiotics (%)	12/114 (10.5)	0/106 (0.0)	0.08	(0.01, 0.58)	0.01
Late outcomes					
Recurrent angina (%)	12/114 (10.5)	10/104 (9.6)	0.91	(0.37, 2.26)	0.84
Myocardial infarction (%)					
Within 30 days	43/4,133 (1.0)	20/3,789 (0.5)	0.77	(0.44, 1.34)	0.35
Overall	43/2,357 (1.8)	63/4,220 (1.5)	1.04	(0.68, 1.60)	0.85
Mortality (%)					
Within 30 days	178/5,222 (3.4)	93/4,442 (2.1)	0.59	(0.37, 0.94)	0.03
Overall	136/2,790 (4.9)	222/4,558 (4.9)	0.80	(0.50, 1.27)	0.34
Graft patency per graft (%)	2,560/3,112 (82.3)	2,422/3,223 (75.1)	0.61	(0.43, 0.87)	0.01



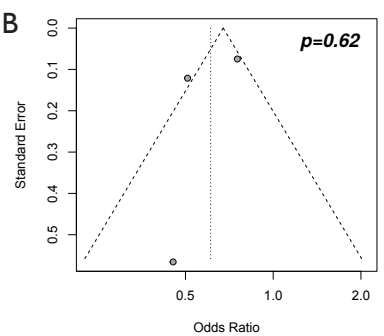


Figure 2 Graft patency per graft of open as compared to endoscopic saphenous vein grafting post coronary artery bypass grafting surgery (A) forest plot and (B) funnel plot.

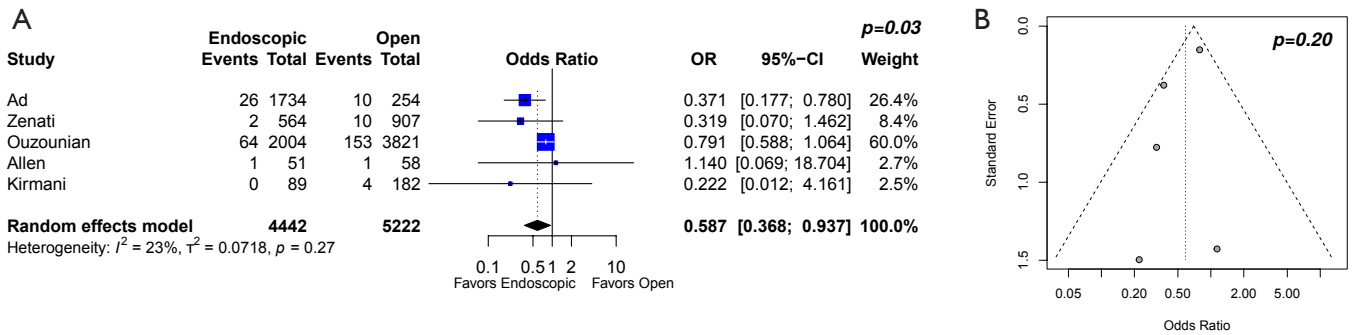


Figure 3 30-day post coronary artery bypass grafting mortality with open as compared to endoscopic saphenous vein grafting (A) forest plot and (B) funnel plot.

underwent endoscopic SVG harvest as compared to open SVG harvest. In the EPIC trial (Evaluation of the PAS-Port in Coronary Surgery) (29), worse SVG angiographic patency at 9 months was seen with endoscopic as compared to open SVG harvest. A propensity score adjusted analysis of the Society of Thoracic Surgeons National Database on Medicare patients (30), with a median follow-up of 3 years, reports no relationship between endoscopic SVG harvest and long-term mortality, or the composite endpoint of death, myocardial infarction and revascularization. In contrast, the Northern New England Cardiovascular Disease Study reports that endoscopic SVG harvest was associated with lower long-term mortality within 4 years of the index admission (31).

Endoscopic SVG harvest is not one homogenous procedure, although, due to the lack of granularity in the included studies, for the purposes of the present analysis they were pooled as one. Differences observed in prior studies may be due to differences in surgical technique (28), operator experience (32) and devices used (28,33), which may influence vessel-harvesting-related injuries. More importantly, for post hoc sub-analyses of trials, it is vital to recognize that vein harvest technique was not the basis for randomization. As such, unrecognized confounding variables may be unaccounted for, such as on-pump *vs.* off-pump CABG (28), with or without CO_2 insufflation (34), as well as endoscopic SVG harvest devices used (29,33), pre *vs.* post SVG harvest use of heparin (35), quality of distal target run-off (9,36) which have all been shown to independently affect graft patency. Reduced graft patency with endoscopic SVG harvest could be related to intraoperative trauma with endoscopic manipulation of the graft leading to compromised functional integrity, poor vein quality and early occlusion (37). As well, thermal injury to the vessel wall can result from use of the bipolar cautery in endoscopic SVG harvest (3,14,38).

At a histologic level, studies have shown that endoscopic manipulation of an SVG is associated with increased endothelial injury. A prospective, small study using multiphoton imaging, immunofluorescence and biochemical techniques has demonstrated increased endothelial damage and reduced viability in endoscopic SVG vein grafts (39). Furthermore, others have shown that endoscopically harvested SVG may undergo residual clotting and stranding, resulting in endothelial damage, infiltration of smooth muscle cells into the lamina and ultimately, graft thrombosis and failure (35), though these findings are not supported by all histologic studies (6,40). Caution should be exercised when interpreting these histologic studies as they only reflect acute histologic features and not long-term histologic findings (12).

Limitations

This meta-analysis has several key limitations and must be interpreted with care. Heterogeneity was likely contributed to by differences among reports, between study populations, study design, definitions of adverse events, patient selection, site of vein graft harvest (thigh *vs.* calf), pre *vs.* post SVG harvest use of heparin, conduct of CABG with on-pump *vs.* off-pump technique, choice of distal target runoff, medical management of coronary artery disease and antithrombotic regime post CABG, as well as postoperative angiographic follow-up to document graft patency. We acknowledge that this heterogeneity in study population is a fundamental limitation that cannot be addressed due to inability to extract sufficient detail from the pooled data. Moreover, the heterogeneity in results precludes broad generalization into

prognostic terms.

Due to the lack of granularity in studies, we were unable to differentiate between different endoscopic SVG harvest techniques (open tunnel *vs.* closed tunnel with carbon dioxide insufflation), although it has previously been shown that there were no device-specific differences in clinical outcomes (33). Pooled results of CABG outcomes spanning 1982 to present may not correctly reflect the changes over the last 4 decades. Furthermore, although our goal was to evaluate long-term patency, limited follow-up from available studies only allowed for intermediate-outcome analysis. Despite these limitations, this systematic study aimed to assess the intermediate-term clinical and angiographic outcomes of SVG harvest for CABG via open as compared to endoscopic technique and in doing so, forms the basis for future studies.

Conclusions

The results of this systematic review and meta-analysis of 18,131 patients demonstrates superior SVG patency in patients who underwent CABG via open SVG harvest as compared to endoscopic SVG harvest at average follow-up time of 2.6 years. Patients with open SVG harvest had higher rates of early wound complications and postoperative 30-day mortality that importantly, did not translate to differences in overall mortality. Reasons for the higher postoperative 30-day mortality are unclear but may reflect variances in patient selection, urgency and severity of premorbid disease. Further studies to find and support methods to prevent graft failure are needed to evaluate the safety of endoscopic SVG harvest as compared to open SVG harvest in long-term angiographic and clinical outcomes. These studies should include large prospective randomized clinical trials that are adequately powered and take into account device-specific considerations.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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