



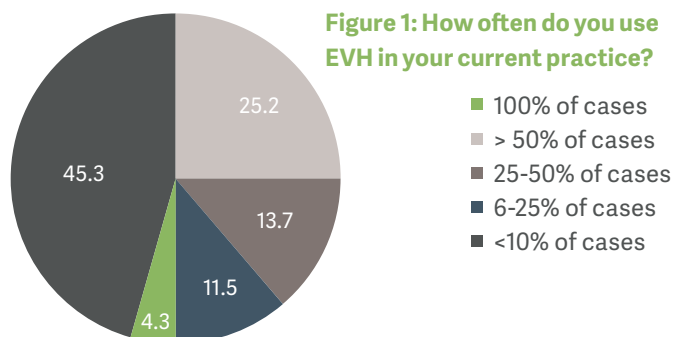
The UK EVH Survey:

Insights and best evidence for EVH utilization

Adult cardiac surgeons practicing in the UK were recently surveyed to quantify their use of endoscopic vein harvesting (EVH) during coronary artery bypass grafting (CABG) and to identify issues that might be limiting more widespread utilization.¹ A 16-question online survey was developed and emailed to 267 consultant surgeons; 139 surgeons from 48 different cardiac surgery units completed the survey, yielding a response rate of 52%.

Responses indicate that routine utilization of EVH in the UK remains quite low, with only one quarter of participating surgeons reporting use in all CABG cases and nearly half (45%) reporting use in less than 10% of cases (see Figure 1). This stands in sharp contrast to the United States, where EVH is utilized in more than 90% of CABG cases.² Despite relatively infrequent use, there was near universal (91%) agreement that EVH is associated with fewer leg wound

issues and broad support for use of EVH in patients at elevated risk for wound complications, with 62% to 75% of surgeons indicating preferential use in patients with diabetes, high body mass index, and peripheral vascular disease. Further, nearly half (47%) of respondents indicated that they felt there was sufficient evidence to warrant routine utilization of EVH, while one third (33%) disagreed, and one fifth (20%) were unsure.

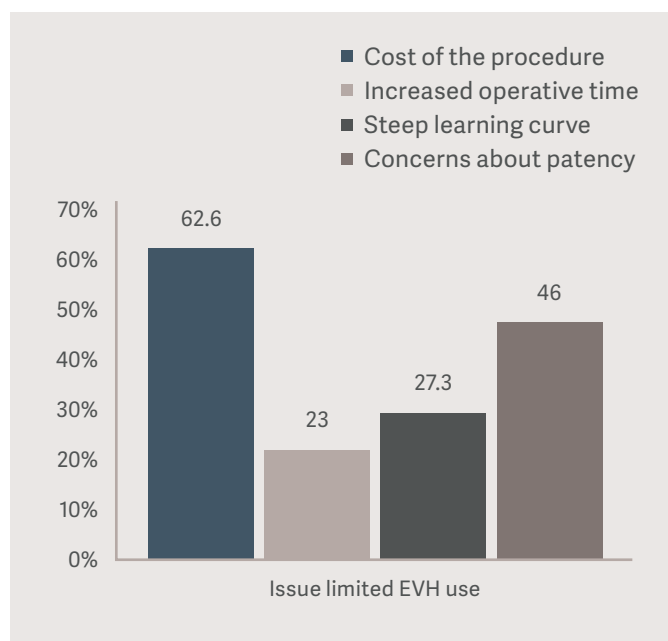


Additional questions focused on identifying the main issues limiting use of EVH technique revealed a set of persistent concerns. Subsequent sections of this manuscript will describe these concerns and examine them in context of the best available evidence.

Perceived issues limiting EVH use in current practice

Surgeons were presented with four potential issues and asked to indicate all that, in their opinions, limited use of EVH in current practice: (1) cost of the procedure, (2) increased operative time, (3) steep learning curve, and (4) concerns about patency. Surgeon responses are summarized in Figure 2.

Figure 2: In your opinion, which issue limits the use of EVH in current practice? Select all that apply



Cost of the procedure

The most commonly cited general limitation for EVH use was cost (63%). When queried about their personal opinions about cost, 48% of surgeons agreed that EVH is “expensive,” while the remaining 52% either disagreed or were unsure.

Cost-containment efforts have focused heavily on CABG, and excess expenses associated with the procedure are subject to particular scrutiny.³ At the same time, however, there is increasing focus on the value of healthcare treatments—the amount of benefit that is derived for the cost of treatment.³ While up-front expenditures may be higher for EVH than traditional open vein harvest due to

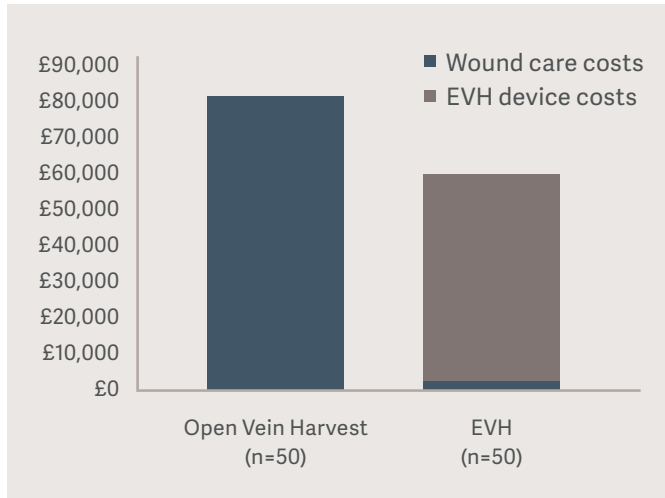
purchase of specialized devices and endoscopic equipment, the reduction in leg wound complications and associated postoperative wound care achieved with EVH confers substantial downstream savings.⁴

Wound complications following traditional, open saphenous vein graft harvest have been reported in up to 24% of CABG patients.⁵ These complications not only necessitate additional postoperative nursing care, medical supplies and medications,^{2,6} they significantly increase likelihood of hospital readmission.⁷ As shown in one large multicenter analysis of 2,174 CABG patients, hospital readmission rate was doubled among patients who developed vein harvest site infections compared with those who did not (34% vs. 17%, $p < 0.01$); median length of stay for those readmitted was 7 days.⁷ Quality and cost-containment initiatives around the globe have targeted costly, preventable complications and events like surgical site infections and readmissions, instituting mandatory reporting requirements and financial penalties to impel reduction.⁸

EVH reduces leg wound complications by approximately 70% compared with standard open vein harvest.⁹ Translation of reduced wound complications into economic benefits such as reduced lengths of stay, postoperative wound care visits, antibiotic requirements, and overall costs, has been demonstrated in several centers.^{2,4,6}

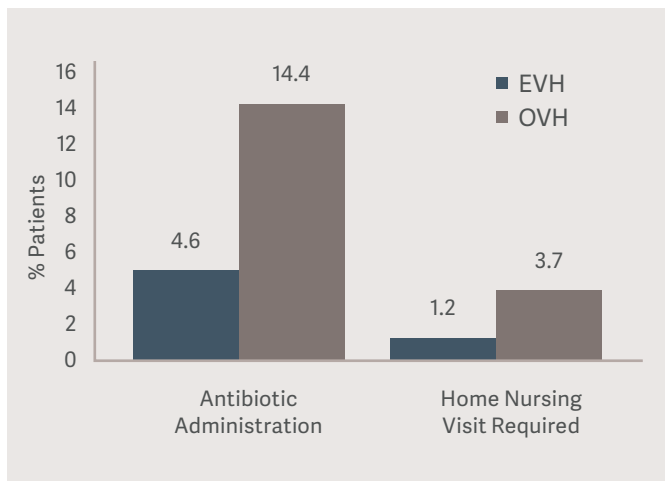
An evaluation to determine the cost effectiveness of EVH prior to routine incorporation conducted by the Cardiothoracic Surgery, Heart & Lung Centre, Wolverhampton, UK documented a 92% reduction in wound complications among patients at high risk for harvest site infections who underwent EVH compared with patients with equivalent risk factors who underwent open vein harvest (4% vs. 48%, $p < 0.01$).⁶ EVH patients also had shorter postoperative lengths of stay (4 vs. 5 days, $p = 0.01$), 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 open vein harvest. As a result of reduced postoperative wound care requirements, total wound care costs were 96% lower for EVH patients than for open vein harvest patients. After accounting for device cost, EVH was associated with a net cost savings of £856 per patient. (Figure 3)

Figure 3: Costs of care: Cardiothoracic Surgery, Heart & Lung Centre, Wolverhampton, UK



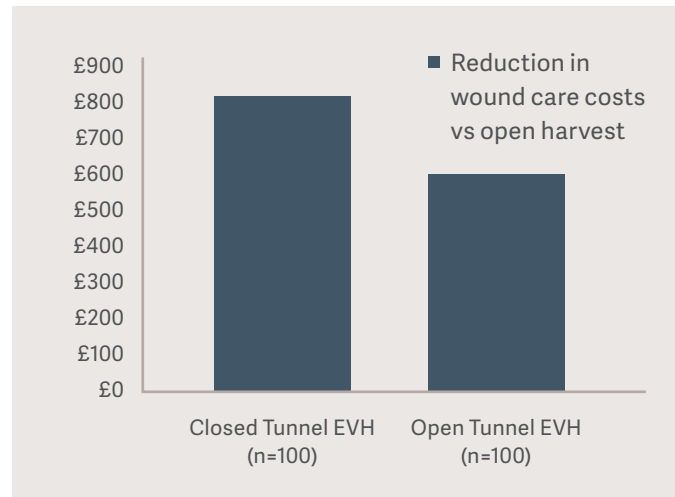
Similar reductions in postoperative wound care for EVH were demonstrated in the REGROUP trial, a randomized comparison of EVH vs. open vein harvest conducted at 16 US Veterans Affairs centers.² Patients whose CABG procedures were performed using EVH had 55% fewer leg wound complications (1.4% vs. 3.1%, $p < 0.05$) and a 68% reduction in both antibiotic requirements (4.6% vs. 14.4%, $p < 0.05$) and home nursing visits for wound care (1.2% vs. 3.7%, $p < 0.05$) compared with those who underwent open vein harvest. (Figure 4)

Figure 4: Postoperative wound care requirements: REGROUP Trial



Additional evidence of healthcare cost savings attributable to EVH was documented in the VICO randomized clinical trial, which was conducted by the University Hospital of South Manchester NHS Foundation Trust.⁴ Three hundred CABG patients were randomized to three vein harvesting methods: open vein harvest, closed-tunnel EVH, and open-tunnel EVH. Vein-harvesting costs for the two EVH approaches were higher than those for traditional open vein harvest. However, both EVH approaches led to lower downstream costs associated with follow-up care, including costs for general practitioner visits, district nurse visits, hospital stays, postoperative antibiotics, hospital readmission, additional surgical treatment, and vacuum-assisted closure. Closed-tunnel EVH led to a mean reduction in costs of £814 per person ($p=0.002$) versus open vein harvest, whereas open-tunnel OT-EVH led to a mean reduction of £598 ($p=0.03$). When vein harvesting cost and downstream costs of care were combined, both EVH methods led to slight net cost increases over open procedures (£274 for closed-tunnel EVG and £436 for open-tunnel EVH per patient), primarily reflecting the one-time expense associated with the endoscopic tower purchase. (Figure 5)

Figure 5: EVH Reduction in wound care costs: VICO Study



Concerns about graft patency

Nearly half (46%) of UK EVH survey respondents indicated that “concerns about patency” were an issue limiting the widespread clinical use of EVH, though follow-up questioning revealed that just over half (54%) of respondents felt those concerns were “not genuine,” while 25% felt they were, and 21% were unsure.

Despite reassuring data from several large analyses and results from a recent randomized trial designed specifically to assess EVH outcomes, qualms about EVH graft quality and clinical outcomes appear to linger in the UK. Graft patency concerns stem largely from secondary analyses of two landmark trials: PREVENT IV and ROOBY.^{10,11} Shortcomings of these trials have been widely noted and will be mentioned only briefly here. Though frequently referred to as “randomized” studies of EVH, patients were randomized with respect to the treatments of original interest (edifoligide vs. placebo in PREVENT IV, off- vs. on-pump CABG in ROOBY) not EVH vs. open vein harvest. Vein harvest method was determined by surgeon preference, leaving open the possibility that selection bias and unequal distribution of relevant patient risk factors confounded results.¹²

The safety of EVH has been consistently reinforced by the results of large (sample sizes greater than 1,000 patients) studies conducted since publication of the PREVENT IV secondary analysis in 2009.^{2,13-17} In total, more than 265,000 patients have been followed an average 1.8–4 years without any observed increase in adverse cardiac events among patients treated with EVH. An overview of these studies is provided in Table 1.

The largest of these studies, mandated by the US Food and Drug Administration, compared 3-year revascularization outcomes for 235,394 propensity-matched patients in the STS Adult Cardiac Surgery Database.¹⁷ EVH was associated with a significant reduction in wound complications with no increase in mortality (HR = 1.0, $p > 0.99$) or the composite of death, myocardial infarction or repeat revascularization (HR = 1.0, $p = 0.34$).

The REGROUP trial randomized 1,188 CABG patients to EVH or open saphenous vein harvest.² Treatment groups were well matched for baseline characteristics and coronary complexity, and EVH was performed by experienced harvesters with a minimum of 100 procedures prior experience and low rates of conversion to open harvest. Patients who underwent EVH had 55% fewer wound complications than those who underwent open vein harvest ($p < 0.05$). At median follow up of 2.78 years, vein harvest groups did not differ on the composite endpoint of all-cause mortality, nonfatal myocardial infarction and repeat revascularization (HR = 1.12, $p = 0.47$).

Longest clinical follow up to date is provided by a retrospective comparison of 7,527 consecutive patients (1,029 EVH, 6,498 open harvest) undergoing isolated coronary artery bypass grafting at Blackpool Victoria Hospital between 2007 and 2017.¹⁸ No significant difference in survival at a median of five years was observed for patients who had undergone EVH vs. open vein harvest ($p = 0.23$).

Table 1: Large (N > 1,000) studies evaluating EVH clinical outcomes post-2009

Study location	N	Follow up	MACCE	HR [†]	P
Halifax, Nova Scotia (16)	5,825	2.6 years	All-cause mortality, readmission for cardiac catheterization, repeat revascularization, unstable angina, MI, heart failure	0.93 (0.83-1.05)	0.22
Virginia, USA (13)	1,988	1.8 years	Death, MI, repeat revascularization	1.04 (0.61-1.77)	0.90
New England, USA (14)	8,542	4 years	Death	0.74 (0.60-0.92)	0.007
			Repeat revascularization	1.24 (0.90-1.71)	0.092
Manchester, UK (15)	4,709	1.8 years	Death, MI, repeat revascularization	1.15 (0.76-1.74)	0.51
STS ACS Database (17)	235,394	3 years	Death, MI, repeat revascularization	1.00 (0.98-1.05)	0.34
REGROUP Trial, USA (2)	1,188	2.8 years	Death, MI, repeat revascularization	1.12 (0.83-1.51)	0.47
Blackpool, UK (18)	7,527	5 years	Survival [†]	EVH 85.5% (82.8–88.2) vs. Open 86.1% (85.3–87.0)	0.23

[†] Kaplan-Meier survival for EVH vs. open harvest is presented for the Blackpool, UK analysis.

Contemporary EVH practice has incorporated several evidence-based procedural improvements to optimize conduit quality and patient outcomes. Pre-harvest administration of low dose heparin¹⁸, strict avoidance of distension^{19,20}, protection against thermal injury²¹, and avoidance of excessive traction²² have all been demonstrated to improve conduit quality and graft patency.

Steep learning curve

The third most frequently identified contributor to low EVH utilization was the steep learning curve associated with the procedure, which was indicated by 27% of respondents. When individual opinion about the learning curve was probed, more than half of surgeons (57%) indicated that they did not personally regard it as a serious issue, while 36% did see it as significant, and 7% expressed being unsure.

The EVH learning curve has come under increased scrutiny as harvester inexperience has been linked to histopathological and intraluminal imaging signs of vein trauma.^{23,24} In light of these findings, efforts to improve the training of novice harvesters and implement safeguards to minimize conduit injury during the learning curve have intensified.^{24,25}

Structured training protocols that stress gradual introduction of increasingly complex patient anatomies under skilled supervision have shown superior skill acquisition and reduced vessel trauma.^{24,25} Patient selection during the learning curve is important in minimizing conduit damage and increasing harvester confidence. Patients with diabetes, peripheral vascular disease, and abnormal or diseased veins should be avoided early in the learning experience due to increased complexity and the potential for exacerbating risk of accelerated vein graft stenosis.²⁴

Mastery of leg anatomy and prior handling of endoscopic equipment in low-risk settings such as animal/cadaver labs or inanimate leg models are essential, as is detailed instruction on how to address difficult anatomy and potential problems.²⁴ Some trainers have found it beneficial to limit the length of vein harvested by trainees initially, gradually increasing it as proficiency is demonstrated.²⁴ Finally, use of adjunct technology can be helpful during the learning curve and with complicated patient anatomy. Intraoperative ultrasound imaging has been shown to be beneficial in identifying venous abnormalities and planning incision sites.^{26,27} Allen and Shar²⁶ reported that use of ultrasonography was associated with a 46% decrease in time required to locate and dissect out the saphenous vein ($p = 0.002$). General principles for safely and effectively training novice EVH harvesters are outlined in Table 2.

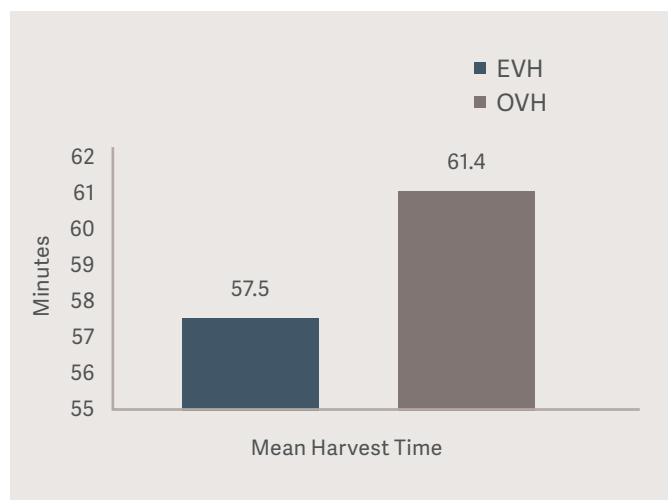
Table 2: Principles for safely and effectively negotiating the EVH learning curve

- Thorough understanding of leg anatomy
- Hands-on practice in animal, cadaver or inanimate leg models
- Careful patient selection, initial avoidance of complex anatomies
- Supervised, staged progress; gradual increase in complexity with demonstrated proficiency
- Use of enabling technology (e.g., ultrasound vein mapping)

Increased operative time

Approximately one quarter (23%) of responding surgeons identified increased operative time attributable to the procedure as a limiting factor for EVH utilization. In general, published comparisons of various operative time parameters for EVH and open vein harvest have not documented significant increases in overall operating time for EVH.⁹ Instead, the slight increase in harvest time appears to be compensated by a large reduction in wound closure time. Meta-analysis of published vein harvest times (22 studies), closure times (6 studies), and total operating time (16 studies) documented a mean increase of 7 minutes in harvest time ($p = 0.03$) and a mean decrease of 21 minutes in wound closure time ($p < 0.00001$) for EVH compared with open vein harvest, with no significant difference in total operating time for the two procedures.⁹ Furthermore, EVH harvest time improves with experience. In the REGROUP trial, EVH harvest time for experienced harvesters averaged 4 minutes less than open vein harvest time (57.5 vs. 61.4 minutes, $p = 0.01$).² (Figure 6)

Figure 6: Vein harvest times: REGROUP Trial



Conclusions

The recent UK EVH survey provides a window into beliefs about EVH held by a substantial subset of practicing UK cardiac surgeons. Responses indicate that nearly all responding surgeons believe that EVH is highly advantageous for leg wound healing and that almost half believe the available evidence is sufficient to justify its routine utilization. Nonetheless, consistent EVH use was reported by only one quarter of survey respondents, and almost half of surgeons reported using EVH in less than 10%

of CABG cases. This low rate of utilization stands in contrast to other industrialized countries in which EVH has become the preferred method of saphenous vein graft harvest.²⁹ EVH is utilized in more than 90% of CABG cases in the United States⁶ and has become the predominant harvesting technique in the Netherlands, with adoption more than doubling since 2010 to account for an estimated 53% of CABG cases in 2018.^{31,32}

The most frequently cited barrier to consistent use of EVH in this survey was the cost of the procedure. However, focus on up-front costs alone ignores the significant downstream healthcare savings that accrue from reduced leg wound complications and associated costs of care. Concerns about graft patency was identified next most frequently as limiting broad application of EVH, though more than half of responding surgeons felt these concerns are unwarranted. Favorable revascularization outcomes for EVH have been uniformly documented in a series of large recent studies with extended follow up, including an FDA-mandated analysis of over a quarter of a million patients, a rigorously designed randomized controlled trial, and a UK cohort with five-year outcomes. These results, together with reduced leg wound morbidity, reduced hospital readmissions, and reduced wound care costs, constitute compelling evidence for routine use of EVH. Accordingly, current UK National Institute for Health and Care Excellence (NICE) guidance³³ and ESC/EACT guidelines³⁴ both support use of EVH during myocardial revascularization.

While EVH requires a different skill set than that required for open vein harvest, the learning curve can be managed safely and with minimal disruption if progressive training employing proficiency-based milestones and careful initial patient selection are implemented. Investment in careful training will be rewarded with improved conduit quality, better patient outcomes and reduced harvest times.

In conclusion, pressure to contain costs while maintaining CABG quality and prioritizing patient experience have increased emphasis on reduced morbidity, economic outcomes, and patient satisfaction among cardiac surgery societies and healthcare payers worldwide.^{30,35} Accumulating evidence of equivalent revascularization outcomes, overall cost effectiveness, and patient preference for less invasive options affording quicker recovery underscore the need to develop strategies to enhance EVH adoption in the UK and other regions where it is underutilized.

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