Endoscopic Vascular Harvest in Coronary Artery Bypass Grafting Surgery: A Consensus Statement of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS) 2005

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Objective: This purpose of this consensus statement was to compare endoscopic vascular graft harvesting (EVH) with conventional open vascular harvesting (OVH) in adults undergoing coronary artery bypass grafting (CABG) surgery and to determine which resulted in improved clinical and resource outcomes.

Methods: Before the consensus conference, the consensus panel reviewed the best available evidence, whereby systematic reviews, randomized trials, and nonrandomized trials were considered in descending order of importance. Evidence-based statements were created, and consensus processes were used to determine the ensuing statements. The AHA/ACC system was used to label the level of evidence and class of recommendation.

Results: The consensus panel agreed upon the following statements:

1. EVH is recommended to reduce wound related complications when compared with OVH (Class I, Level A).

2. Based on quality of conduit harvested, either endoscopic or open vein harvest technique may be used (Class IIa; Level B).

3. Based on major adverse cardiac events and angiographic patency at 6 months, either endoscopic or open vein harvest technique may be used (Class IIa; Level A).

4. EVH is recommended for vein harvesting to improve patient satisfaction and postoperative pain when compared with OVH in CABG surgery (Class I, Level A).

5. EVH is recommended for vein harvesting to reduce postoperative length of stay and outpatient wound management resources (Class I, Level A).

Conclusions: Given these evidence-based statements, the consensus panel stated that EVH should be the standard of care for patients who require saphenous vein grafts for coronary revascularization (Class I, Level B). Future research should address long-term safety, cost-effectiveness, and endoarterial harvest.

Key Words: endoscopic vascular harvest, coronary artery bypass grafting, consensus statement

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Despite recent emphasis on arterial grafting, saphenous vein grafting remains the most commonly used conduit in coronary artery bypass grafting. Harvesting the saphenous vein using a longitudinal technique increases the risk of wound complications (infection, cellulitis, drainage, dehiscence, delayed healing, lymphangitis, sepsis, and limb amputation) from 2% to 25%, creating an important clinical and economic burden.[1–4] In addition, patient dissatisfaction with traditional longitudinal saphenectomy is well documented.[3] As an alternative, endoscopic vein harvesting has been reported to reduce leg wound complications and improve patient satisfaction while decreasing resource utilization.[4] Concerns remain, however, that endoscopic manipulation of the graft could traumatize the vessel and compromise long-term patency or graft survival. An early meta-analysis of selected clinical outcomes suggested an overall benefit with endoscopic harvest compared with the traditional open technique,[5,6] and more recent trials have added further evidence of this benefit over the short and the long term.[7,8]

Although endoscopic vascular harvest has increased in popularity worldwide, its adoption rate has preceded any professional consensus on this topic. Therefore, a consensus

conference was organized to systematically develop statements on the role of endoscopic vein harvesting (EVH) relative to open vein harvesting (OVH) based on the best available current evidence.

METHODS

Purpose of the Consensus Conference

This consensus conference was held to clarify, for clinical practitioners and health care planners or administrators, the role of endoscopic vascular harvest relative to open vascular harvest in adults undergoing coronary artery bypass grafting (CABG) surgery. The recent upsurge of interest in vascular harvest through endoscopic technique has drawn attention to the need for exhaustive review of the evidence for EVH and OVH, with careful deliberation as to their relative merits, as well as the context in which they should be preferentially applied. A secondary objective of this consensus conference was to identify gaps in the evidence and suggest a future research agenda for EVH versus OVH.

Funding

Support for this consensus conference was provided by the International Society for Minimally Invasive Cardiothoracic Surgery (ISMICS), which has received unrestricted educational grants from industries that produce surgical technologies. Although ISMICS receives industry funding, no specific industry was linked with this consensus conference and did not involve direct funding from manufacturers of devices related to EVH or OVH. Editorial independence was granted to the members of the expert panel, and the expectation was that the resulting consensus statements would be clearly based on the best available evidence, with explicit methodology to allow the reader/user to determine which aspects were informed by evidence, and where evidence was lacking and opinion was required to create statements.

Selection of Panel Members

Members of the consensus panel were invited to participate by the chair (KA) and facilitator of the consensus process. Members included representation from 4 countries: 6 cardiovascular surgeons, each with experience in open and endovascular vascular harvest (1 from Japan, 1 from Germany, and 4 from the United States), 1 physician assistant (United States), 1 cardiac anesthesiologist (Canada), and 1 methodologist with expertise in health technology assessment and meta-analysis (Canada).

Defining the Clinical Question

Before the consensus conference, the consensus panel was asked to define the clinical question, which involved defining the scope and depth of each of the following considerations: patient population of interest, intervention of interest, valid comparator group(s), and outcomes of interest.[9] The clinical question was developed collaboratively with input from all consensus panel members, and was finally stated as follows: "Does endoscopic vascular graft harvesting (EVH) compared to conventional open vascular harvesting (OVH) in adults undergoing coronary artery bypass surgery

improve clinical and resource outcomes, specifically with respect to:

1. Wound complications at the harvest site and wound infections (such as need for surgical wound reinterventions including wound debridement, skin grafts, vascular procedures, amputations, fasciotomies, free tissue transfers, fasciocutaneous flap);
2. Histologic evidence of trauma, endothelial denudation by light microscopy, and other indicators of quality of vascular integrity;
3. Major adverse cardiac events such as death, postoperative myocardial infarction (as defined by the authors), need for repeat revascularization (CABG or PCI), reexploration for bleeding, transfusions;
4. Patient satisfaction, and pain;
5. Time to harvesting, duration of surgery, ICU length of stay, total hospital length of stay, and costs."

Identifying Relevant Evidence

After the clinical questions were defined, the admissible evidence (ie, acceptable study designs) considered to be acceptable to inform this clinical question was defined by the consensus panel as any randomized or nonrandomized comparative trial comparing EVH with OVH in adults undergoing CABG. Because there was no comprehensive systematic review that included all relevant evidence to answer our clinical question, we conducted a full systematic review and meta-analysis of the evidence before the conference. The complete methodology and results of the systematic review are described in another article in this issue of the *Journal*.[10] In short, before the consensus conference, comprehensive searches of Cochrane, Medline, Embase, and other databases were conducted to identify all randomized and nonrandomized comparative trials of EVH versus OVH that reported clinical- or resource-related outcomes. Potentially relevant trials were circulated to the consensus panel for review and to determine whether any relevant trials were missed. Information related to baseline characteristics and outcomes was extracted independently by 2 authors (DC, JM) from each study that met prospectively defined inclusion criteria (comparative studies of EVH and OVH that reported at least 1 relevant clinical or economic endpoint in adults undergoing CABG). When appropriate, data were synthesized by meta-analysis to determine best aggregate estimates of clinical and resource-related outcomes. Data that were not appropriate for statistical synthesis across trials were summarized qualitatively in tables and text to ensure all relevant trials were addressed in the systematic review. The results of the systematic review and meta-analysis were used to populate evidence tables to form the basis for discussions and support the decision making of the consensus panel. Evidence for the benefit, risks, and resource considerations of EVH and OVH was sought.

Reviewing and Presenting the Evidence

Before the consensus conference, each member of the consensus panel received a copy of all identified randomized and nonrandomized clinical trials and relevant background

literature related to the clinical question. In advance of the meeting, 2 or 3 members of the consensus panel were assigned to review the evidence for EVH compared with OVH relevant to 1 of the following subquestions:

1. Does EVH compared to OVH in CABG surgery improve incidence of wound complications (composite endpoint of all complications, or individual complications including infection, cellulitis, abscess, edema, necrosis, drainage, dehiscence, debridement or surgical wound intervention)?
2. When compared to OVH in CABG surgery, does EVH compromise the quality of conduit harvested?
3. Does EVH result in an increase in major adverse cardiac events (MACE) or graft occlusion?
4. When compared to OVH in CABG surgery, does EVH improve patient satisfaction and pain?
5. When compared to OVH in CABG surgery, does EVH affect resource utilization?

Applying the Evidence to Create Recommendations

Levels of Evidence and Grade of Recommendations

The best available evidence that was used to inform each clinical subquestion was classified according to the taxonomy suggested by AHA/ACC, as outlined in Table 1. This classification categorizes the evidence based on study design and susceptibility to bias, wherein higher levels of evidence and grades are labeled to highlight their lesser likelihood for bias and increased confidence in "closeness to the truth."[11–14] Several systems of grading recommendations and labeling strength of the evidence exist. Because none of them has been found to be superior, the AHA/ACC system was chosen for consistency with other guidelines (http://www.acc.org/clinical/manual/manual_index.htm; accessed April 19, 2004) (See Tables 1 and 2). As recommended by guidelines,[15] classification of the evidence and labeling recommendations is best done by the group panel using a democratic voting process after group discussion of the strength of the evidence.

Members of the panel considered the highest possible level of evidence to inform their clinical subquestion, such that systematic reviews, meta-analyses, or randomized trials (Level A evidence, see Table 1) were to be considered preferentially to nonrandomized clinical trials. If there was insufficient Level A evidence to inform the question, members were encouraged to consult nonrandomized comparative trials (Level B evidence, see Table 1). Only when Level A and Level B evidence failed to address the clinical question were noncomparative trials consulted to inform decisions

(Level C evidence). When evidence from published or unpublished clinical trials was nonexistent, expert opinion from the consensus panel members was sought. In each case, the best available level of evidence was explicitly stated and interpreted in light of its methodologic strengths and weaknesses before a statement of recommendation was made. It was agreed that recommendations with higher levels of evidence should be interpreted with more confidence than recommendations based on lower levels of evidence, and that recommendations should be explicitly classified as per the ACC/AHA system (see Table 2). Each subgroup spent time discussing and critically evaluating the evidence they had reviewed for their preassigned subquestion(s). Subsequently, each subgroup prepared a proposed draft statement related to their assigned subquestion.

Consensus Process and the Role of Evidence Versus Opinion

After each subgroup presented a proposed draft statement for their assigned subquestions to the entire consensus panel, further discussion of the strength, consistency, clinical significance, and relevance of the evidence occurred before final revisions and final agreement was made to the consensus statement (along with its appropriate level of evidence and class of recommendation) for each of the subquestions.

When limited evidence was found to inform a clinical subquestion, it was explicitly recognized that scientific information would need to be supplemented by the interpretations and opinions of the experts. Legitimate conflicts over values and interpretations were resolved by discussion and majority vote.

After each subquestion had been addressed, the entire consensus panel reviewed all of the recommendations and their assigned grades and proposed levels of evidence to answer the overarching summary clinical question: Does EVH compared to OVH in adults undergoing CABG improve clinical and resource outcomes?

In summary, this consensus process sought to be primarily evidence-based, while allowing for opinions to enlighten when information was incomplete, and requiring that the basis for the statement be labeled by a declarative level of evidence. Bringing selected experts together in a consensus process allowed for breadth of perspectives and representations of interpretations for a multidimensional and carefully

TABLE 1.   Levels of Evidence

Level of Evidence A	Data derived from multiple randomized clinical trials
Level of Evidence B	Data derived from a single randomized trial, or nonrandomized studies
Level of Evidence C	Consensus opinion of experts

TABLE 2.   Classes of Recommendations

Class I	Conditions for which there is evidence and/or general agreement that a given procedure or treatment is useful and effective
Class II	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment
IIa	Weight of evidence/opinion is in favor of usefulness/efficacy
IIb	Usefulness/efficacy is less well established by evidence/opinion
Class III	Conditions for which there is evidence and/or general agreement that the procedure/treatment is NOT useful/effective, and in some cases may be harmful

considered judgment of the evidence along with its certainties and uncertainties.

RESULTS

The systematic review and meta-analysis of the evidence performed by the consensus panel was used as the basis for the discussion of the evidence and formation of the recommendations, because all available randomized and nonrandomized comparative trials were included in the systematic review.[10] In only 1 instance, evidence from comparative trials (Level A or B) was not available to inform the clinical question (see long-term patency, Question 3), requiring that evidence from noncomparative studies (Level C) be sought.

The systematic review with meta-analysis identified 13 randomized trials (1,319 patients) and 23 nonrandomized trials (8,313 patients) for a total of 36 trials involving 9,632 patients comparing EVH and OVH. Most trials identified were published in English (except for 1 trial each in French and Italian), and most were conducted in the United States between the 1996 and 2002. Average age of patients at baseline was 64.6 years; approximately 27% were female, 30% were diabetic patients, and 20% were obese patients, and over 17% had peripheral vascular disease. On average, 4.3% of patients required conversion from EVH to OVH.

When heterogeneity was identified across studies for endpoints, much of the heterogeneity was found to be due to nonrandomized studies.[10] Nevertheless, much of the heterogeneity was less concerning since it was driven by uncertainty about the size of effect and not the direction of effect, and therefore did not put into question the presence of significant benefit (when detected).

The summary discussion and resulting statements with assignment of levels of evidence and class of recommendation are given below for each clinical subquestion, and for the overarching clinical question. The aggregate results for randomized trials (RCTs, Level A) from the meta-analysis are preferentially reported here; however, when randomized trials were unavailable, aggregate results from nonrandomized evidence (nRCTs, Level B) are reported. Readers may consult the original publication for comprehensive reporting of both randomized and nonrandomized trials for all endpoints.[10] For discrete outcomes, odds ratios and their 95% confidence intervals (OR, 95% CI) are reported. For continuous outcomes, the weighted mean difference (WMD, 95% CI) is reported.

Question #1: Does EVH reduce wound complications (composite endpoint of all complications, or individual complications including infection, cellulitis, abscess, edema, necrosis, drainage, dehiscence, debridement) when compared to OVH in CABG surgery?

For the composite endpoint of wound complications, a total of 22 relevant studies were identified (3 RCTs, 19 nRCTs). Definitions varied for the subcomponents of wound complications included in the overall composite definition, and the results were significantly heterogeneous across the trials.[10] Overall, the odds of wound complications were

reduced by 73% (OR, 0.27, 95% CI 0.13–0.55, $P < 0.0001$; 3 RCTs, Level A) by EVH. Nonrandomized trials suggested similar results.

Many subcomponents of wound complications were individually significantly reduced in aggregate analysis of randomized trials, including risk of wound infection or cellulitis (OR 0.23, 95% CI 0.11–0.46, $P < 0.0001$; 10 RCTs, Level A), necrosis (OR 0.08, 95% CI 0.02-0.39, $P = 0.001$; 3 RCTs, Level A), drainage (OR 0.26, 95% CI 0.11–0.62, $P = 0.002$; 3 RCTs, Level A), and edema (OR 0.004, 95% CI 0.00–0.031, $P < 0.0001$; 2 RCTs, Level A). Subcomponents of wound complications that were not significantly reduced in aggregate analysis of randomized trials alone, but which were significantly reduced in aggregate analysis of randomized and nonrandomized trials, included: dehiscence (OR 0.22, 95% CI 0.13–0.38; 11 trials, Level A and Level B combined), seroma/lymphocele (OR 0.35, 95% CI 0.18–0.65; 9 trials, Level A and Level B combined), and surgical intervention for wound complications (OR 0.16, 95% CI 0.08–0.29; 14 trials, Level A and Level B combined).

Wound complications that were not significantly reduced when Level A and/or Level B evidence was considered included only abscess (OR 0.26, 95% CI 0.05–1.30; 4 trials, Level A and Level B combined) and hematoma (OR 0.80, 95% CI 0.44–1.44, $P = 0.5$; 23 trials, Level A and Level B combined).

Statement

1) Endoscopic vein harvesting significantly reduces wound complications compared to OVH (Level A).
2) Specific wound complications reduced by EVH include: (a) Infection or cellulitis, necrosis, wound drainage, need for antibiotic and leg edema (Level A) (b) Seroma/lymphocele, dehiscence, and surgical debridement (Level B).
3) Wound hematoma and abscess formation is similar between the two techniques (Level A).

Recommendation

Endoscopic vascular graft harvesting is recommended to reduce wound related complications when compared to OVH (Class I, Level A).

Question 2: When compared to OVH in CABG surgery, does EVH compromise the quality of conduit harvested?

Reported outcomes that were considered relevant to this question included number of patients requiring harvest vein repairs, mean number of venous repair stitches, endothelial damage scores (typically ranging from 1 to 5), medial continuity score, and potential markers of endothelial injury including interleukin (IL)-1, IL-2, IL-10, vascular cell adhesion molecule, and intracellular adhesion molecule. The odds of requiring harvest vein repair during the harvest procedure was not significantly different for EVH and OVH (OR 2.16, 95% CI 0.71–6.54, $P = 0.2$; 6 RCTs, Level A). However, the mean number of venous repair stitches was significantly increased, on average by 1.1 stitches, in EVH compared with OVH (WMD 1.12, 95% CI 0.24–2.00), $P = 0.01$; 3 RCTs,

Level A). Endothelial damage scores were reported in 3 studies (1 RCT, 2 nRCTs), and were not significantly different when Level A and/or Level B evidence was considered separately and in aggregate (SMD −0.09, 95% CI −0.27, 0.09, $P = 0.3$; 3 trials, 3 trials, Level A and B combined). Medial continuity score was reported in 1 nRCT only, and was not significantly different (WMD 0.00, 95% CI −0.22, 0.22, $P = 1.0$; Level B). The biochemical markers (IL-1, IL-2, IL-10, vascular cell adhesion molecule, and intracellular adhesion molecule) were reported in 1 nRCT only, and were not significantly different between EVH and OVH (Level B).

Although endothelial damage scores and markers or endothelial injury were considered to inform the question of quality of conduit harvested, no guidelines and no agreement exists in the literature regarding the validity of these indices of quality of conduit harvested. In particular, there are no guidelines for appropriate preparation and valid measurement of markers of injury in vein segments. No consensus is available regarding which biochemical markers represent a valid marker of injury, and no empirical information is available to inform whether these markers (and, at what threshold) represent clinically meaningful associations with clinical outcomes such as graft patency and MACE. Similar limitations exist for other indicators of endothelial injury, such as visual inspection of endothelial intimal integrity through electron microscopy. Therefore, these preliminary indicators of graft quality should be interpreted with caution. Rather, greater emphasis should be placed on the more clinically relevant outcomes of myocardial infarction, need for reintervention, heart failure, and survival over the longer term.

Statement

1) The number of patients who required vein repair is similar between EVH and OVH; however, the number of repair sites per vein is increased with EVH (Level A).
2) Histological appearance of conduit harvested by EVH and OVH is similar (Level B).

Recommendation

Based on quality of conduit harvested, either endoscopic or open vein harvest technique may be used (Class IIa; Level B).

Question 3: Does EVH result in an increase in major adverse cardiac events or graft occlusion?

Relevant reported outcomes included graft patency, postoperative myocardial infarction, and stroke, rethoracotomy for bleeding, reintervention for ischemia or angina recurrence, and all-cause mortality. None of these outcomes was significantly different for EVH versus OVH when Level A and/or Level B evidence was considered for outcomes reported at 30 days or up to 5 years.[10] Clinical outcomes at 30 days were as follows: all-cause mortality (OR 0.71, 95% CI 0.34–1.48, $P = 0.4$; 8 trials, Level A and B studies combined), postoperative myocardial infarction (OR 1.02, 95% CI 0.58–1.78; 11 trials, Level A and B studies combined),

angina recurrence or reintervention for ischemia (OR 1.06, 95% CI 0.38–2.96; 5 trials, Level A and B combined), rethoracotomy for bleeding (OR 0.91, 95% CI 0.09–8.89; 3 trials, Level A and B combined).

Although follow-up periods of more than 6 to 12 months are rare in comparative trials of EVH versus OVH, 1 randomized trial reported survival free of major adverse coronary events (death, myocardial infarction, heart failure, or angina recurrence) at up to 5 years, and found no significant difference (75% vs. 74%, $P = 0.85$).[16]

Angiographic outcomes were as follows: graft occlusion at 3 to 6 months (OR 1.30, 95% CI 0.79–2.15, $P = 0.3$; 2 RCTs, Level A), stenosis greater than 50% after 3 months (OR 0.79, 95% CI 0.44–1.45, $P = 0.5$; 3 RCTs, Level A). In a noncomparative study (Level C) of patients undergoing EVH, angiography showed patency rates at 6 months follow-up that were comparable to those historically reported for OVH techniques.[17]

None of the clinically relevant cardiovascular outcomes and overall survival differed significantly for EVH compared with OVH; however, the confidence intervals remain wide because the power to rule out significant differences was relatively low even with aggregate analysis of all trials through meta-analysis. Inadequate power also hindered the precision of outcome estimates for graft patency, because few studies reported angiographic outcomes, and of those that did, a significant proportion of patients did not undergo angiography during long-term follow-up. Therefore, the angiographic results should be interpreted conservatively at this time, until further studies with adequate follow-up become available.

Statement

1) No difference in myocardial infarction and reintervention for ischemia or angina recurrence was found at 30 days (Level A) and up to 5 years (Level B).
2) Mortality is not different at 30 days (Level A), 6 months (Level A), and 5 years (Level B).
3) No difference was found for angiographic patency at 3 to 6 months (Level A). Follow-up for 3 years showed comparable patency rates (Level C).

Recommendation

Based on major adverse cardiac events and angiographic patency at 6 months, either endoscopic or open vein harvest technique may be used (Class IIa; Level A).

Question 4: When compared with OVH in CABG surgery, does EVH improve patient satisfaction and pain?

Pain scores were reported in 2 randomized trials. Visual analogue scale score was significantly reduced while in hospital (WMD −2.18 points, 95% −3.56, −0.79, $P = 0.002$; 4 trials, Level A and B combined) and at 6 weeks (WMD 0.35; 95% CI −0.58, −0.12; $P = 0.003$; 2 trials, Level A and Level B combined). Morphine equivalents given to patients undergoing EVH were significantly reduced compared with patients undergoing OVH (WMD −0.14 mg/kg; 95% CI −0.20, −0.08 mg/kg; $P < 0.0001$; 1 nRCT, Level B), and duration of

analgesia was significantly reduced with EVH compared with OVH (WMD −13.8 days; 95% CI −21.2, −6.4 days; *P* = 0.0003; 1 nRCT, Level B). The proportion of patients reporting moderate to severe postoperative pain was significantly reduced in hospital (OR 0.26; 95% CI 0.12–0.55; *P* < 0.0001, 5 trials, Level A and B combined) and at 3 to 6 months (OR 0.17, 95% CI 0.05–0.60, *P* = 0.006; 2 RCTs, Level A). Similarly, the proportion of patients reporting sensory disturbances was significantly reduced with EVH compared with OVH at 4 to 6 weeks follow-up (OR 0.19, 95% CI 0.08–0.48, *P* < 0.0001; 2 RCTs, Level A), and at 3 to 6 months follow-up (OR 0.22, 95% CI 0.09–0.50, *P* < 0.0001; 2 RCTs, Level A). Mobility disturbances were significantly reduced at postoperative day 2 to 4 (OR 0.31, 95% CI 0.15–0.65 *P* = 0.002; 2 trials, Level A and B combined) and at 30 days (OR 0.06, 95% CI 0.008–0.49, *P* = 0.009; 1 nRCT, Level B).

Different indicators of patient satisfaction were reported in 4 trials (3 RCTs, 1 nRCT).[18–21] Patients undergoing EVH reported significantly higher satisfaction scores for pain experienced while in hospital (WMD 1.88 points, 95% CI 1.49–2.28 points, *P* < 0.0001; 1 RCT, Level B), but no significant difference was found at 4 to 6 weeks of follow-up (WMD 0.24 points; 95% CI −0.09, 0.57 points; *P* = 0.2; 1 RCT, Level B). The risk of dissatisfaction with surgical results was significantly reduced in patients undergoing EVH compared with those undergoing OVH (OR 0.06, 95% CI 0.008–0.49, *P* = 0.009; 2 trials, Level A and B combined). The risk of dissatisfaction with cosmetic result was also reduced in those undergoing EVH (OR 0.24, 95% CI 0.08–0.71, *P* = 0.009; 2 RCTs, Level A). Patients undergoing EVH reported significantly higher scores for subjective evaluation of mobility at discharge (WMD 2.40 points, 95% 2.05–2.75 points, *P* < 0.0001; 1 RCT, Level B), and for cosmetic result in hospital (WMD 2.33 points, 95% CI 1.90–2.75, *P* < 0.0001; 1 RCT, Level B) and at 6 weeks (WMD 0.93 points, 95% CI 0.58–1.27, *P* < 0.0001; 1 RCT, Level B).

Despite the recognized importance of patient satisfaction in EVH compared with OVH, few studies reported this outcome. Furthermore, no studies reported on quality of life. This remains a significant gap in the literature.

Statement

1) Endoscopic vascular graft harvesting improves patient satisfaction regarding cosmetic result (Level A).
2) Endoscopic vascular graft harvesting reduces the incidence (Level A) and severity (Level B) of acute postoperative leg pain (Level A).
3) Endoscopic vascular graft harvesting reduces the incidence of sensory disturbance at 6 months follow-up (Level A).

Recommendation

Endoscopic vascular graft harvesting is recommended for vein harvesting to improve patient satisfaction and postoperative pain when compared with OVH in CABG surgery (Class I, Level A).

Question 5: When compared with OVH in CABG surgery, does EVH affect resource utilization?

Outcomes that were relevant to this subquestion included time required to harvest the graft, rate of graft harvest, overall surgery duration, time to ambulation, hospital length of stay, readmission for wound complications, need for outpatient wound management resources, costs, and cost-effectiveness.

Average time required to harvest the graft was increased (WMD 7.64 minutes, 95% CI 0.82–14.46, *P* = 0.03; 9 RCTs, Level A) and mean closure time was significantly reduced (WMD −17.73 minutes; 95% CI −25.65, −9.80; *P* < 0.0001; 2 RCTs, Level A) with EVH compared with OVH technique. Although total operative time was not significantly increased when only randomized trials were considered (WMD 14.40 minutes; 95% CI −28.34, 57.14; 3 RCTs, Level A), it was significantly increased when randomized and nonrandomized data were combined (WMD 15.26 minutes, 95% CI 0.01–30.51, *P* = 0.05; 9 trials, Level A and B combined). The rate of vascular harvest was not significantly different with EVH and OVH (WMD −0.10 minutes; 95% CI −0.34, 0.14; *P* = 0.3; 4 trials, Level A and B combined).

Readmissions for wound complications for EVH compared with OVH were not significantly reduced when randomized trials were considered alone (OR 0.49, 95% CI 0.13–1.89, *P* = 0.3; 6 RCTs, Level A); however, when randomized and nonrandomized trials were combined, readmissions were significantly reduced (OR 0.53, 95% CI 0.29–0.98, *P* = 0.04; 15 trials, Level A and B combined).

Time to ambulation was not significantly different with EVH and OVH (−0.38 days; 95% CI −1.17, 0.41; *P* = 0.7; 4 nRCTs, Level B). Total hospital length of stay was reduced significantly when both randomized and nonrandomized data were combined (WMD −0.85 days; 95% CI −1.55, −0.15; *P* = 0.02; 12 trials, Level A and B combined), but intensive care unit length of stay was not reduced (WMD 0.07; 95% CI −0.20, 0.34; *P* = 0.6; 4 trials, Level A and B combined).

Physician visits and emergency room visits were reduced (OR 0.14, 95% CI 0.05–0.38, *P* < 0.0001, 3 RCTs, Level A), and need for nursing or home care services was significantly reduced (OR 0.05, 95% CI 0.01–0.17, *P* < 0.0001; 2 RCTs, Level A) with EVH compared with OVH.

Of the two studies that addressed costs from the perspective of the hospital in the United States, the estimates suggested US $68 (1 nRCT, Level B)[22] to US $1,500 savings per patient undergoing EVH instead of OVH (1 RCT, Level B);[23] however, these cost estimates included varying categories of direct costs while in hospital and for limited outpatient follow-up, and the incremental cost-effectiveness was not estimable from the limited information provided. Formal cost-effectiveness studies were not found.

Judgments about whether the costs of EVH are reasonable and feasible depend on the definition of cost-effectiveness and on the perspective taken (ie, the different perspectives of patients, physicians, hospitals, health care systems, and society would result in differing definitions of relevant

costs and outcomes). Because cost analyses and formal cost-effectiveness analyses were rarely conducted for studies of EVH and OVH, there is limited data to base recommendations on the resource implications of the two techniques.

Statement

1) Time to harvest is increased in EVH (Level B); however, overall surgery duration is no different (Level A).
2) Endoscopic vascular graft harvesting reduces postoperative length of stay (Level B).
3) Incidence of readmission for wound complications is similar in EVH and OVH; however, EVH is associated with a reduced need for outpatient wound-management resources (Level A).
4) There is inadequate cost data to allow comparison between EVH and OVH.

Recommendation

Endoscopic vascular graft harvesting is recommended for vein harvesting to reduce postoperative length of stay and outpatient wound management resources (Class I, Level A).

Consensus Summary for the Overarching Question

After discussion of each of the substatements for the 5 subquestions, the consensus panel discussed what should be the overall role of EVH compared with OVH in clinical practice, in order to address the overarching question: Does EVH compared to OVH in adults undergoing CABG improve clinical and resource outcomes? Because there are no studies that examine a policy of EVH versus OVH as standard of care, the maximal level of evidence for this recommendation is Level B. But, because there was consistency of opinion across the consensus panel, the recommendation was designated as Class I.

Recommendation

Endoscopic vascular graft harvesting should be standard of care for patients who require saphenous vein grafts for coronary revascularization (Class I, Level B).

Statement on Future Research

A number of gaps in the evidence were identified throughout the consensus process. Based on discussion of the limitations of the evidence base, the following areas were suggested by the consensus panel as priority areas for future research.

Trial Design

Future trials should be designed to maximize validity, with incorporation of valid randomization processes and primary analysis by intention-to-treat, with subsequent subanalysis of patients who crossover.

Definitions

Efforts should be made to standardize definitions of wound complications, wound infections, surgical intervention and debridement, as well as applicable costs.

Outcomes

Although the evidence for benefits related to wound complications is sufficiently replete and does not require additional study for patients undergoing EVH for the saphenous vein, there are additional outcomes that have been inadequately studied. In particular, outcomes that should be addressed are long-term patency, MACE, and resource utilization. In addition, studies are urgently needed to address all relevant clinical and resource outcomes for patients undergoing endoradial harvest.

DISCUSSION

To the authors' knowledge, this is the first consensus statement for EVH. The systematic approach to defining the research question, identifying all relevant published and unpublished evidence, and labeling that evidence based on its quality suggests that these statements represent the best available guideline for evidence-based clinical practice and resource decisions. These statements should be interpreted and applied with full acknowledgment of the level of evidence that informs that statement, whereby statements based on Level A evidence are given more confidence than those of Level B or less.[24] Every effort was made throughout the consensus process and peer review process to ensure that the recommendations are clearly stated, and their basis clearly documented.

Overall, the recommendations suggest that EVH has advantages with respect to reduced wound complications, when considered as a composite endpoint or individually for most of the subparts of the broader composite definition (eg, wound infections, dehiscence, necrosis). Resource-related endpoints also favored EVH. For other endpoints, no difference was found for either technique. For none of the reported clinical endpoints was EVH found to be less favorable or more risky than OVH. Although certain resource-related outcomes such as time to harvest the graft were significantly increased, the overall surgery time did not differ significantly. Preliminary evidence suggests that the balance of costs may favor EVH (i.e., increases in harvest time are offset by reduced cost of treating downstream wound complications); however, valid economic analyses are required before more definitive conclusions of relative cost-effectiveness can be given.

Strengths and Limitations

This consensus statement is based on a current and comprehensive systematic review of the evidence with formal consensus processes that limited the role of opinion secondary to that of the evidence base. Care was taken to explicitly label the recommendations with the evidence available to inform it, and when evidence was unavailable, to apply considered expert judgment to provide perspective for potential users of the statement. With this explicit evidence based consensus process, it is clear to the user how the recommendations were derived. The statements have also been exposed to the rigors of secondary panel review and subsequent external peer review before publication.

A notable strength of this consensus statement is its reliance on the evidence base, with comprehensive consideration of benefits, risks, and resource-related issues. The methodology undertaken and recommendations provided by this consensus conference are in agreement with current recommendations for developing consensus statements[15] and guidelines.[25] In order to self-appraise our consensus statement against current standards for valid guidelines, we subjected our consensus process and recommendations to quality assessment checklists and found that most indicators of high quality were met or exceeded.[25,26] This is in contrast to the majority of existing guidelines, which rarely meet all of these recommended criteria.[26]

Although a wide range of health care professionals and methodologic expertise was represented on the consensus panel, some stakeholders were not represented. In particular, patients were not invited to participate; however, patient-related outcomes including satisfaction and quality of life were sought from published trials in order to address this perspective. It is unfortunate that patient satisfaction was infrequently reported in the studies. In addition, stakeholders from the manufacturing sector (ie, producers of technologies related to endoscopic and open vascular grafting) were not included in the consensus and review process to reduce the risk of bias that may result from direct manufacturer involvement.

Clinicians tend to overestimate the effectiveness of new interventions, especially if the intervention in question rests within the realm of their expertise.[27] In addition, there is a tendency for group decision-making processes to experience "regression to the mean" or a groupthink or "herd effect," whereby compromises are made in recommendations to come closest to pleasing all members of the panel, even for issues that start off greatly polarized. To mitigate these risks, experts in evidence-based methodology and health technology assessment from within and outside of the surgical field were invited to facilitate the discussion and to ensure the best available evidence was the focus for discussion rather than opinions or political charges.

The paucity of trials with longer-term follow-up also remains a limitation of the evidence. Although there is at least 1 trial with 5 years follow-up for EVH versus OVH,[7] the evidence is not mature enough to definitively rule out the possibility of clinically important differences in major cardiac events over the longer term. However, early indications suggest that there may be little cause for increased suspicion of differences in outcomes over time.[7]

The lack of long-term follow-up also precludes conclusions on angiographic outcomes and the more clinically relevant outcomes of MACE and need for reintervention. Most trials followed patients until hospital discharge or first patient follow-up visit at 4 to 6 weeks after CABG; however, longer-term follow-up of angiographic patency, and more importantly, MACE and need for reintervention will be required before definitive conclusions can be made for the comparative graft quality over time. Nevertheless, the evidence available to date does not suggest that there is cause for concern in this regard up to 5 years.[7]

A further limitation of the evidence base on which these recommendations were made is the inconsistent management of patients who crossed over from EVH to OVH (most commonly due to small veins or difficult morphology). Although in some trials these patients were analyzed by intention-to-treat, in many trials patients who were crossed over were either analyzed in the OVH group or excluded from the study. Studies that analyzed crossover patients may provide over-estimations of benefit because the risk of crossover to OVH is not included in the EVH group. Therefore, these results represent those related to patients who undergo OVH without requiring crossover to EVH, and should be interpreted as such.

The heterogeneity of definitions for wound complications and wound infections is also a limitation in the evidence base. However, this heterogeneity is less concerning when examination of the effect for each study shows heterogeneity only in the magnitude of effect, but homogeneity in the direction of effect. Thus, the variation in definitions results in some uncertainty around how large the benefit is, but does not question whether the effect exists.

A further limitation relates to the lack of studies evaluating the applicability of results of EVH of saphenous vein to arterial grafts. Studies are needed before explicit recommendations can be made for EVH of arterial grafts.

Finally, the lack of randomized trials to inform every aspect of this consensus statement is a limitation that deserves discussion here. Although this limitation is ubiquitous in medicine and is true of most, if not all, other consensus statements,[15,28] it does not provide reason to abandon the consensus statement or afford it less credence. Rather, the purpose of consensus statements that are evidence-based is to explicitly define the best available evidence to inform each statement, in order that clinical and resource-related decision making can be optimally evidence-based. Even without availability of an ideal evidence base, decisions must be made. Examination of the statements and their supporting levels of evidence outlines when greater assurance (Level A) or lesser certainty (Level B, and especially Level C) can be given to the statement. The meta-analysis of EVH versus OVH, on which most of these recommendations were based, performed detailed analysis of the distribution of baseline characteristics between groups. When studies were considered in aggregate, patients in the OVH group were significantly older but less likely to be obese, than in the EVH group. Although there were more females in the OVH group compared with EVH, the difference did not quite reach statistical significance ($P = 0.06$). It is unknown whether these imbalances in baseline characteristics, when considered together, would unfavorably bias the results in favor of EVH (more obesity) or OVH (older, more females). This potential bias needs to be incorporated into the interpretation of the statements and underscores the need to put greater emphasis and confidence in statements that are based on Level A evidence. However, this need not invalidate the statements that are based on Level B evidence, because the magnitude of imbalance between the EVH and OVH groups was small (ie, on average, patients in the OVH group were 1.2 years older than those in the EVH

group, and there were 3% more females but 4% fewer obese patients in the OVH group than in the EVH group), and insufficient to explain the difference in clinical events that was found between EVH and OVH. Nevertheless, readers should bear in mind that the evidence base for statements labeled with Level B may be an overestimation of the overall magnitude of benefit. The consensus panel incorporated this uncertainty into their discussions and assigned the Class of Recommendation to reflect this uncertainty. It is hoped that future trials will be conducted to address these areas where only lower levels of evidence are available.

Feasibility and Training

Judgments about whether the costs of EVH are feasible depend on the local context and setting. Feasibility issues worth considering include time, skills, staff, training and equipment necessary to carry out the recommendations, and the ability of systems of care to implement them. Administrative barriers to implementing these recommendations were not explicitly discussed during the consensus conference, due to the broad range of global contexts represented by the consensus panel. Issues to consider when localizing these recommendations to specific settings include: training available to develop EVH skills, availability of endoscopic devices, and supporting technologies.

Future Directions

These consensus statements will need to be revisited and updated if there are changes in the available technologies or if significant evidence on the benefits and harms and resource implications change. Research efforts should be encouraged to address the gaps in the evidence as outlined in the statement for further research given above.

Summary and Conclusions

After review and discussion of the best available evidence, the following summary consensus recommendations were delineated (Table 3):

TABLE 3. Summary of Consensus Recommendations

Class of Recommendation and Level of Evidence	ISMICS Consensus Recommendations
Class I; Level A	EVH is recommended to reduce wound-related complications, improve patient satisfaction, and decrease postoperative pain, hospital length of stay, and outpatient wound-management resources when compared with OVH.
Class IIa; Level A	Based on major adverse cardiac events and angiographic patency at 6 months, either endoscopic or open vein harvest technique may be used.
Class IIa; Level B	Based on quality of conduit harvested, either endoscopic or open vein harvest technique may be used.

- Endoscopic vascular graft harvesting is recommended to reduce wound-related complications, improve patient satisfaction, and decrease postoperative pain, hospital length of stay, and outpatient wound-management resources when compared with OVH (Class I; Level A).
- Based on quality of conduit harvested, either endoscopic or open vein harvest technique may be used (Class IIa; Level B).
- Based on major adverse cardiac events and angiographic patency at 6 months, either endoscopic or open vein harvest technique may be used (Class IIa; Level A).

Given these statements, it was the prevailing opinion of the consensus panel members that EVH should be standard of care for patients who require saphenous vein grafts for coronary revascularization (Class I, Level B).

Future research efforts should address long-term angiographic patency, MACE, and cost-effectiveness. In addition, trials should address clinical and resource outcomes in patients undergoing endoarterial harvest.

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