

# No-touch vein grafts in coronary artery bypass surgery: a registry-based randomized clinical trial

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Received 19 August 2024; revised 2 October 2024; accepted 8 January 2025; online publish-ahead-of-print 19 February 2025

See the editorial comment for this article ‘The SWEDEGRAFT trial: when absence of evidence is not evidence of absence’, by M. Gaudino and S. Sandner, <https://doi.org/10.1093/eurheartj/ehaf043>.

## Abstract

**Background and Aims** No-touch saphenous vein harvesting may enhance graft patency and improve clinical outcomes after coronary artery bypass grafting (CABG).

**Methods** In this registry-based, randomized trial, patients undergoing CABG were randomly assigned to no-touch or conventional harvesting. The primary composite outcome was the proportion of patients with occluded/stenosed >50% vein graft on coronary computed tomography angiography, or who underwent percutaneous coronary intervention to a vein graft, or died. Secondary outcomes included clinical outcomes and leg wound complications.

**Results** A total of 902 patients were enrolled with a mean total number of distal vein anastomoses of 2.0 (SD 0.87). The primary endpoint occurred in 90/454 (19.8%) of patients randomized to no-touch and in 107/446 (24.0%) of patients randomized to the conventional technique [difference, −4.3 percentage points; 95% confidence interval (CI) −10.1–1.6;  $P = .15$ ] at a mean follow-up time of 3.5 (SD 0.1) years. The composite of death, myocardial infarction, or repeat revascularization at 4.4 (SD 1.3) years occurred in 57/454 (12.6%) and 44/446 (9.9%) in the no-touch and conventional groups, respectively (hazard ratio 1.3; 95% CI, 0.87–1.93). Leg wound complications were more common in patients assigned to no-touch harvesting at 3 months [107/433 (24.7%) vs. 59/427 (13.8%); difference, 10.9 percentage points;

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95% CI 5.7–16.1]. At 2 years, 189/381 (49.6%) vs. 91/361 (25.2%) had remaining leg symptoms (difference, 24.4 percentage points; 95% CI 17.7–31.1).

## Conclusions

No-touch vein graft harvesting for CABG was not superior to conventional open harvesting in reducing vein graft failure or clinical events after CABG but increased leg wound complications. The primary outcome requires cautious interpretation due to a lower-than-expected number of primary events.

## Structured Graphical Abstract

### Key Question

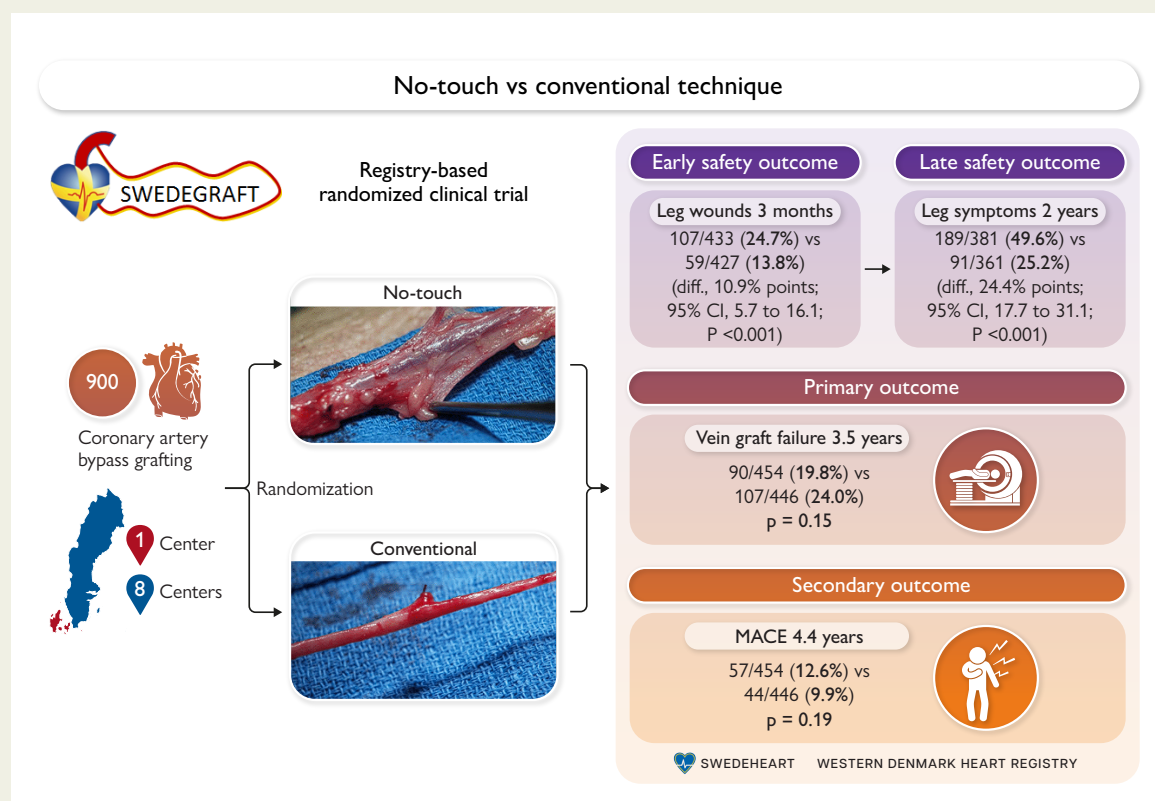
Is vein graft harvesting using a no-touch technique superior to a conventional vein graft technique for coronary artery bypass grafting (CABG) with respect to mid-term vein graft failure and major adverse cardiac events (MACE) with acceptable safety?

### Key Finding

No-touch vein graft harvesting was not superior to conventional open harvesting in reducing vein graft failure at 3.5 years or MACE at 4.4 years after CABG and was associated to a higher risk of early and late leg wound complications.

### Take Home Message

The trial does not support the routine use of the no-touch harvesting technique compared to the standard technique of vein handling. These findings require cautious interpretation due to a lower-than-expected number of primary events.



The SWEDEGRAFT trial design and major results. CI, confidence interval; MACE, major adverse cardiovascular events.

## Keywords

Coronary artery disease • Mortality • Myocardial infarction • Surgical complications • Long-term outcomes

## Introduction

Coronary artery bypass grafting (CABG) using the left internal thoracic artery and saphenous vein graft (SVG) is the most common surgical procedure for ischaemic heart disease.<sup>1</sup> A major limitation of SVGs in CABG is the high rate of graft failure, which is associated with recurrence of angina and repeat revascularization.<sup>2</sup> It has been shown in large clinical trials that 15–25% of vein grafts occlude within 1 year<sup>3</sup> and up to 50% of the patients have at least one occluded graft within 10 years.<sup>4</sup>

Comparisons between studies are challenging due to differences in definitions of vein graft failure, harvest technique, patient selection, and length of follow-up. Furthermore, leg wound complications, such as local infection, delayed healing, and impaired skin sensitivity are common after vein harvesting but often underreported. The reported incidence varies between 5% and 25% at ~3 months in different studies.<sup>5–7</sup>

Early and late clinical results of CABG depend partly on the sustained patency of bypass grafts.<sup>8</sup> Several randomized clinical trials have indicated that harvesting SVGs with a pedicle of surrounding tissue, known

as the no-touch technique, improves graft patency and clinical outcomes compared to the conventional open skeletonized technique, but large randomized studies are rare.<sup>9–12</sup> Based on this evidence, we hypothesized that no-touch veins are superior to conventionally harvested veins with respect to mid-term patency and long-term clinical outcomes. To test this hypothesis, we designed a Nordic, multicentre, prospective, randomized clinical trial. An important secondary aim was to assess the incidence of early and late leg wound complications.

## Methods

We designed and conducted the SWEDEGRAFT study as a multicentre, prospective, registry-based, randomized clinical trial (R-RCT)<sup>13</sup> at eight surgical sites in Sweden and one site in Denmark.<sup>14</sup> In Sweden, baseline, surgical details, postoperative complications, and clinical follow-up data were retrieved from the national population-based quality registry, the Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies (SWEDEHEART).<sup>15,16</sup> In Denmark, the corresponding data were entered in a supplemental electronic case report form. Telephone questionnaires were conducted at 3 months and 2 years after CABG, focusing on wound healing. At the 2-year follow-up, additional inquiries were made regarding physical limitations, recurrent angina, and health status using the Seattle Angina Questionnaire-7 (SAQ-7).<sup>17</sup> Coronary computed tomography angiography (CTA) was planned after at least 2 years for the collection of events for the primary and secondary outcomes. A separate protocol dictated the CTA performance (see the [Supplementary data online, Appendix](#)). Data regarding vein harvesting, patient-reported outcome measures, and CTA were registered prospectively in all centres. Long-term clinical follow-up data were collected from the SWEDEHEART<sup>15,16</sup> and the Western Denmark Heart Registry<sup>18</sup> and electronic health records.

Information on the trial leadership and investigators is provided in the [Supplementary data online, Appendix](#). Uppsala Clinical Research Center, Uppsala University, Uppsala, Sweden (<https://www.ucr.uu.se/en/>) was the academic research centre responsible for the study conduct, including data management and statistics as well as the SWEDEHEART registry infrastructure. The regulatory sponsor was the Department of Surgical Sciences, Uppsala University, Uppsala, Sweden.

## Trial patients

Patients scheduled for first-time isolated non-emergent CABG, with at least one SVG, were considered eligible. The complete set of inclusion and exclusion criteria has been published previously<sup>14</sup> and is provided in [Supplementary data online, Table S1](#). Following written informed consent, patients were randomly allocated to undergo CABG with either no-touch or conventionally harvested vein graft(s). Randomization was conducted in a 1:1 ratio stratified by site using permuted blocks via a web-based system.

The CABG procedures were performed by a cardiac surgeon experienced in using both types of SVGs according to clinical practice in accordance with current guidelines. Detailed surgical instructions were provided at site visits and were sent to the sites together with a video about both techniques. A description of the surgical procedures has been published.<sup>14</sup>

## Outcome measures

The primary composite endpoint was defined as the proportion of patients (i) with at least one vein graft occluded or stenosed by more than 50% on CTA, or (ii) who underwent percutaneous coronary intervention (PCI) to a vein graft (defined as PCI in a vein graft or in a native vessel segment proximal to the distal anastomosis of a vein graft), or (iii) died during the follow-up period after CABG. Secondary outcome measures included the incidence of major adverse cardiovascular events (MACE), defined as all-cause death, or spontaneous myocardial infarction, or repeat revascularization at the longest possible duration of the clinical follow-up period, and its

individual components. Other secondary outcomes were leg wound complications from the harvesting site 10–14 weeks and 22–26 months after surgery. The details of the primary and secondary outcomes are presented in [Supplementary data online, Table S2](#).

## Coronary computed tomography angiography—methods and evaluation

The CTA scans were uploaded on a postprocessing software with a specific coronary artery algorithm (Siemens Healthiners SyngoVia) and independently reviewed by two radiologists, blinded to the randomized assignment. Disagreements were resolved in consensus.

To assess the graft patency, the contrast filling and degree of stenosis were analysed. Where possible, the maximal stenosis degree in a single graft or each segment of a sequential graft was graded as 0, 1–24, 25–49, 50–69, 70–99%, or occluded. Stenoses in the proximal and distal anastomosis were separately graded as 0, <50, 50–99, or 100%. If a stenosis degree was not assessable due to suboptimal image quality, then contrast opacification, proximal and distal anastomosis patency, and/or graft occlusion were assessed.

## Statistical analysis

Based on a vein graft failure rate of 20–50% in previous trials,<sup>4,3</sup> defined as diameter stenosis of at least 75% at 1-year follow-up, we anticipated an approximate 50% rate of vein graft failure using a stricter definition of a diameter stenosis of 50%<sup>19</sup> after at least 2 years of follow-up. We considered a 25% relative risk reduction in graft occlusion using the no-touch technique to be clinically important. This difference in risk reduction is consistent with other interventions to improve graft patency such as antiplatelet therapy and radial artery vs. SVG.<sup>20</sup> We estimated that a sample size of 450 patients per group, including compensation for an assumed loss to follow-up of ~15% for the CTA investigation,<sup>21</sup> would provide 90% power for a two-sided alpha of .05.

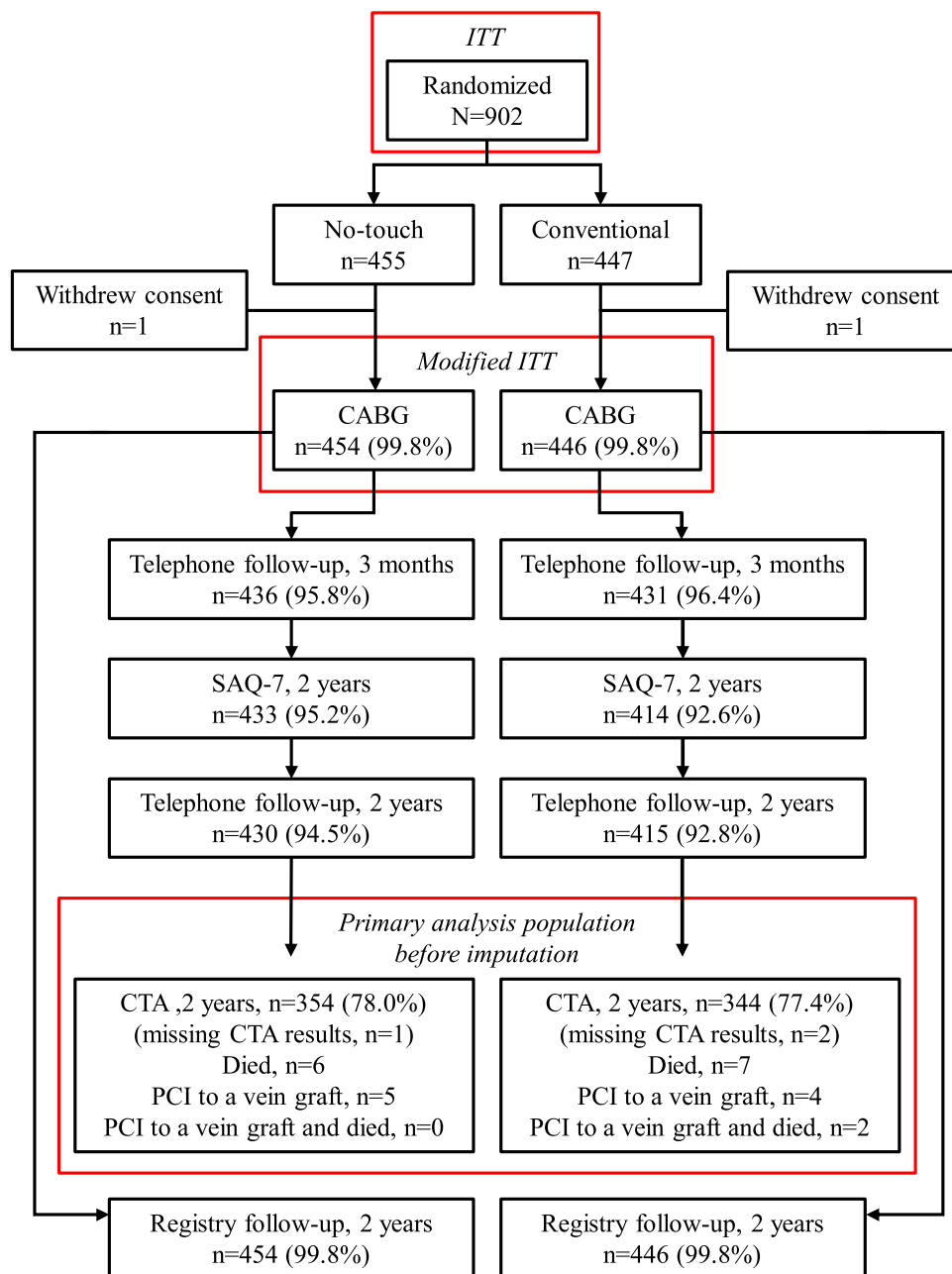
All randomized patients who underwent surgery were included in the primary modified intention-to-treat (mITT) analyses. Due to missing values on the primary outcome variable in 178/900 (19.8%), caused by patients not attending the CTA visit after 2 years, we used multiple imputation with chained equation to impute missing data for the primary analysis and the subgroup analyses of the primary outcome to address the risk of reduced power and biased results. A complete case analysis was done for the primary outcome variable and its component SVG occluded/stenosed on CTA to present observed data. For the subgroup analyses, imputation was performed separately by randomized treatment. A per-protocol population defined as all patients who adhered to their assigned treatment with no major protocol deviations and had data available for assessing the primary endpoint (PCI to a vein graft, deceased, or underwent CTA) was used for the sensitivity analysis.

A two-sided Z test for proportion was used to analyse the primary endpoint and the secondary endpoint of leg wound complication. Prespecified subgroup analyses for age at CABG, sex, diabetes, hypertension, any sequential graft, estimated glomerular filtration rate, enrolment period, centre, and whether no-touch was a standard technique before the trial were performed with logistic regression models testing for interaction with surgical intervention treatment.

A time-to-event analysis was conducted with Cox proportional-hazards models with prespecified covariates of age at CABG, sex, diabetes, kidney function, indication, centre, and emergency surgery for the secondary outcome of MACE. Data from patients who withdrew consent for medical record follow-up were censored at the time of withdrawal of consent.

All statistical testing has been performed at the two-sided alpha = .05 significance level.

Details on multiple imputation and secondary, and sensitivity analyses, are provided in the [Supplementary data online, Appendix](#). All statistics were performed on SAS 9.4 and R version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria).



**Figure 1** Trial flow chart

## Results

Between 20 April 2018 and 3 June 2020, 902 patients were randomly assigned to undergo CABG with no-touch vein or conventional vein harvesting technique (Figure 1). Two patients withdrew consent before CABG and were excluded from the primary mITT analysis. The two groups did not differ in baseline or procedural characteristics with 88% men, a mean age of 67 years, and a mean body mass index of 28 kg/m<sup>2</sup> (Table 1 and Supplementary data online, Table S3). In most cases, the operation was performed on indication of chronic coronary syndromes (53.4%). The extracorporeal circulation time was 90 [standard deviation (SD) 32] and 83 (SD 32) minutes in the no-touch

compared to the conventional groups, respectively. No patients underwent off-pump surgery. A left internal thoracic artery was used in 887/900 (98.6%) patients. Sequential vein grafts were used in 556/900 (61.8%) of patients, similarly in both randomized groups. The mean total number of distal vein anastomoses was 2.0 (SD 0.87).

There was a cross-over from no-touch to conventional technique in 9/455 patients (2.0%) and no patient cross-over from conventional to no-touch technique. Seven patients randomized to the no-touch and three patients randomized to the conventional group did not receive any vein graft due to insufficient vein quality.

Among all randomized patients, 701/902 (78%) underwent CTA with a mean duration from randomization of 34 (SD) 4.5 months.

**Table 1 Patient characteristics**

Variables	No-touch (n = 454)	Conventional (n = 446)	All (n = 900)
Age, years	66.9 (7.8)	67.1 (7.4)	67.0 (7.6)
Male, n (%)	400/454 (88.1)	392/446 (87.9)	792/900 (88.0)
BMI, kg/m <sup>2</sup>	28.0 (3.9)	28.0 (4.0)	28.0 (4.0)
eGFR (mL/min/1.73 m <sup>2</sup> )	86.8 (15.1)	86.2 (15.0)	86.5 (15.0)
Diabetes mellitus, n (%)	129/453 (28.5)	115/446 (25.8)	244/899 (27.1)
Prior PCI, n (%)	92/454 (20.3)	86/446 (19.3)	178/900 (19.8)
Previous stroke, n (%)	28/454 (6.2)	19/446 (4.3)	47/900 (5.2)
Extracardiac arteriopathy, n (%)	21/454 (4.6)	16/446 (3.6)	37/900 (4.1)
Systolic left ventricular function, n (%)			
Good (>50%)	353/454 (77.8)	356/446 (79.8)	709/900 (78.8)
Moderate (31–50%)	88/454 (19.4)	79/446 (17.7)	167/900 (18.6)
Poor (≤30%)	13/454 (2.9)	11/446 (2.5)	24/900 (2.7)
Chronic pulmonary disease, n (%)	37/454 (8.1)	39/446 (8.7)	76/900 (8.4)
Left main stenosis, n (%)	158/454 (34.8)	165/446 (37.0)	323/900 (35.9)
EuroSCORE II	1.6 (1.3)	1.6 (1.5)	1.6 (1.4)
Urgency, n (%)			
Elective	233/454 (51.3)	248/446 (55.6)	481/900 (53.4)
Urgent	221/454 (48.7)	198/446 (44.4)	419/900 (46.6)
Left interior mammary artery (%)	448/454 (98.7)	439/446 (98.4)	887/900 (98.6)
Any sequential vein graft (%)	273/454 (60.1)	283/446 (63.5)	556/900 (61.8)
Mean of total distal vein anastomoses (%)	1.9 (0.9)	2.1 (0.8)	2.0 (0.9)
Aspirin treatment at discharge (%)	427/454 (94.1)	422/444 (95.0)	849/898 (94.5)
Oral anticoagulation at discharge (%)	57/454 (12.6)	86/446 (19.3)	143/900 (15.9)
Oral P2Y <sub>12</sub> receptor inhibition at discharge (%)	177/454 (39.0)	147/446 (33.0)	324/900 (36.0)

All continuous values are presented as mean with standard deviation in brackets.

PCI, percutaneous coronary intervention; eGFR, estimated glomerular filtration rate defined by the CKD-EPI Creatinine Equation (2021).

There was no difference between the groups regarding loss to follow-up for CTA, time to CTA, or time between SAQ-7 and CTA. The mean duration of clinical follow-up was 52 (SD 16) months, and no patients were lost to clinical follow-up.

## Efficacy

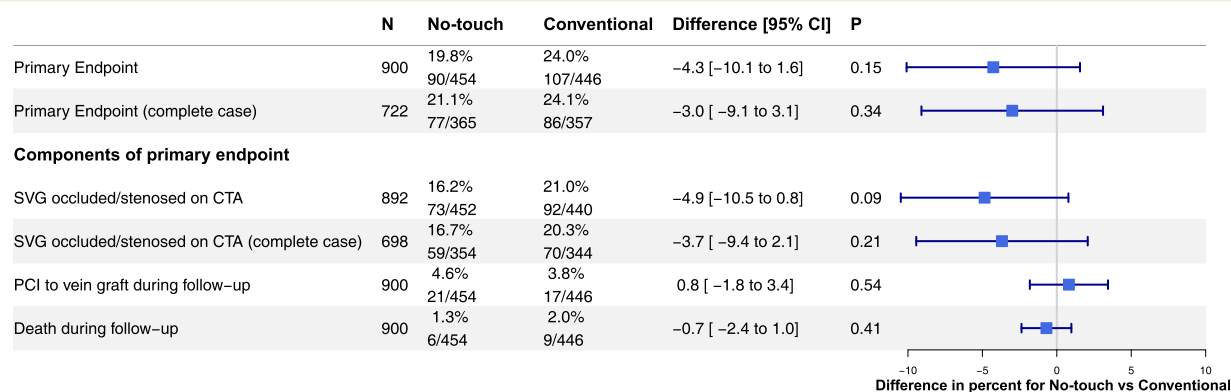
The primary endpoint was available in 722/900 (80.2%) patients from the mITT population who had a CTA, or had undergone PCI to a vein graft, or died. A total of 168 patients (89 in the no-touch group and 89 in the conventional group) had their primary outcome imputed by multiple imputation due to the missing data. The primary endpoint occurred in 90/454 (19.8%) of patients randomized to no-touch and in 107/446 (24.0%) of patients randomized to the conventional technique [difference, −4.3 percentage points; 95% confidence interval (CI), −10.1–1.6;  $P = .15$ ] (Figure 2) after a mean follow-up time of 3.5 (SD 0.1) years. An analysis based on complete cases ( $n = 722$ ) showed consistent results with the imputed analyses. The individual components of the primary endpoint

including the proportions of patients with at least one stenosed/occluded vein graft, or who underwent PCI to a vein graft, or died, were not different between the groups (Figure 2).

The primary outcome was consistent across important subgroups but with a significant statistical interaction for diabetes (Figure 3 and Supplementary data online, Figure S1 for complete case analysis). In patients without diabetes, the proportion of the primary endpoint was significantly lower in patients randomized to no-touch grafts [54/325 (16.7%)] vs. the conventional technique [82/331 (24.9%)] (odds ratio 0.61; 95% CI, 0.40–0.92), and significantly higher in patients with diabetes [40/129 (31.3%) vs. 21/115 (18.2%); odds ratio 2.05; 95% CI, 1.08–3.88]. There was no interaction for site of enrolment ( $P = .34$ ) (data not shown).

The primary outcome and its components were not different between the groups in the per-protocol analysis (see Supplementary data online, Table S4)

In a *post hoc* tipping point sensitivity analysis shown in a contour plot, we single imputed missing primary endpoint events across all possible



**Figure 2** Primary outcome in patients randomized to no-touch or conventional vein harvesting

values and found very low likelihood of achieving different results if all patients had undergone a CTA investigation (see [Supplementary data online, Figures S2 and S3](#)). Descriptive statistics for patients with and without missing values on the primary endpoint by treatment group and for all are shown in [Supplementary data online, Table S5](#).

The composite of MACE (death, myocardial infarction, or repeat revascularization) occurred in 57/454 (12.6%) and 44/446 (9.9%) in the no-touch and conventional vein graft groups, respectively, (hazard ratio 1.3; 95% CI, 0.87–1.93) ([Table 2](#)) at a mean of 4.4 (SD 1.3) years.

In an SAQ-7 questionnaire completed at the CTA visit, there was no difference in physical performance or chest pain (see [Supplementary data online, Table S6](#)).

## Leg wound complications

### Early

Patients randomized to the no-touch technique experienced more leg wound complications at 3 months [107/433 (24.7%) vs. 59/427 (13.8%); difference, 10.9 percentage points; 95% CI, 5.7–16.1]. Leg wound complications were significantly more prevalent in the no-touch group, including a higher incidence of surgical revisions and antibiotic therapy ([Figure 4](#)). The increased incidence of complications was consistent across subgroups based on sex, diabetes, hypertension, enrolment period (early or late), and surgical centre, without significant statistical interactions (data not shown).

### Late

At 2 years, patients randomized to the no-touch technique experienced more late leg wound complications [189/381 (49.6%) vs. 91/361 (25.2%); difference, 24.4 percentage points; 95% CI, 17.7–31.1] ([Figure 5](#)). The predominant symptoms were increased sensitivity disturbance and residual pain. These symptoms were consistently reported across all subgroups (data not shown).

## Discussion

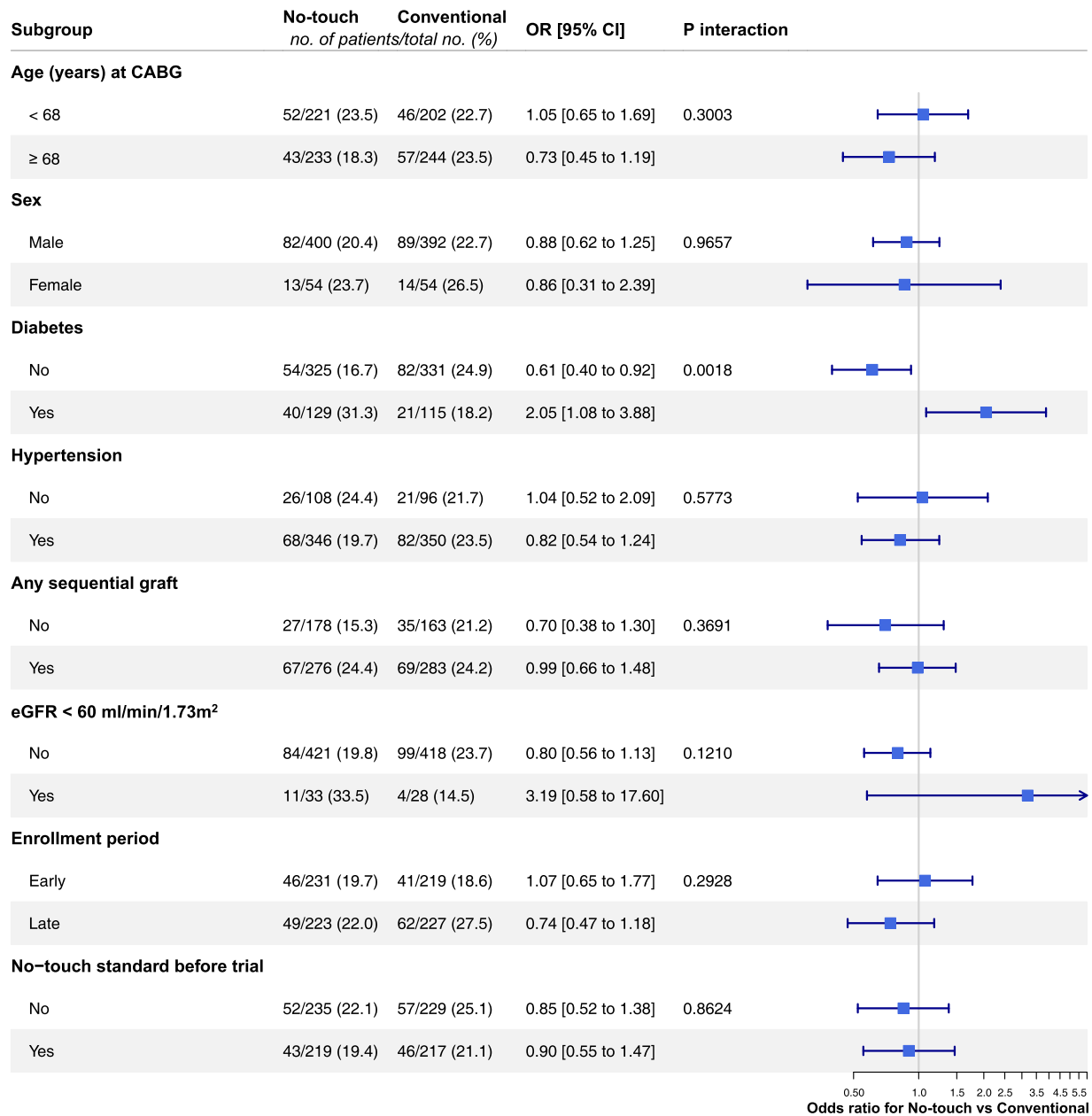
In this bi-national, multicentre, R-RCT of patients undergoing non-emergent CABG, the no-touch vein technique was not superior to the conventional technique regarding vein graft failure or long-term clinical outcomes. No-touch vein harvest increased the proportion of early leg wound complications and residual wound symptoms ([Structured Graphical Abstract](#)).

Several experimental studies have supported the superiority of no-touch vein grafts, indicating that perivascular tissue, including vasa vasorum, possesses mechanical and functional properties that preserve endothelial and vasomotor integrity and prevent degeneration.<sup>22–26</sup> It has been demonstrated that no-touch vein grafts exhibit a slower progression of intimal hyperplasia<sup>27</sup> and atherosclerosis<sup>28</sup> compared to the conventional vein grafts.

Our findings are partly in contrast with previous trials. The first pivotal, open-label, single-centre trial showed 95% patency of no-touch veins as compared to 89% patency of conventional veins by invasive angiography at a mean follow-up of 17 months.<sup>10</sup> Still, at 16 years of follow-up, the patency was very high; 83% in the no-touch vein graft group compared to 64% in the conventional group.<sup>9</sup> This trial had a very small sample size, was open label and included selected patients. Based on this and other small studies, the current 2018 European myocardial revascularization guidelines are recommending no-touch harvesting when an open surgical technique is used (IIa B).<sup>29</sup> Also, the more recent joint American College of Cardiology, American Heart Association, Society for Cardiovascular Angiography and Interventions guidelines from 2021 labelled the use of a no-touch harvesting bypass conduit as best practice in patients at low risk of wound complications.<sup>30</sup>

More recently, a large multicentre randomized trial in China, including 2655 patients, showed lower vein graft occlusion rates at 3 months [2.8% vs. 4.8%; odds ratio 0.57 (95% CI, 0.41–0.80);  $P < .001$ ] and at 12 months of follow-up [3.7% vs. 6.5%; odds ratio 0.56 (95% CI, 0.41–0.76);  $P < .001$ ] and less reported angina, but there was no difference in clinical outcomes and more postoperative leg wound complications, consistent with our trial.<sup>11</sup>

Our trial cannot refute the reported biological effects by no-touch vein grafts, or a moderate effect on vein graft failure based on CTA. However, we found no evidence that any of these results are translated into a significant reduction of mid-term vein graft failure or a long-term clinical benefit. Our trial had a longer duration of follow-up of 3.5 years for the primary endpoint using a more liberal cut-off for the definition of vein graft failure, blinded CTA analyses, and more than 4 years of follow-up for the clinical outcomes, in contrast to many previous trials and importantly is the largest European trial performed in centres with very high surgical quality and high secondary prevention standards.<sup>31</sup> The statistical interaction with a statistically significant benefit of the no-touch technique for patients without diabetes and harm for patients with diabetes cannot be explained by our data and further analyses and studies are warranted.



**Figure 3** Subgroup analyses for the primary outcome

The harvesting technique for no-touch veins requires more extensive dissection resulting in larger wounds that may increase the risk of wound complications and saphenous nerve damage.<sup>32</sup> We found an increased incidence of early and late leg wound complications and residual wound symptoms. Our results raise caution that the no-touch vein harvest increases the need of wound care, surgical revisions, and antibiotic therapy, along with more symptoms of poor skin sensitivity. This issue has been reported in previous small multicentre trials.<sup>11,21</sup>

Similar to our trial, large observational studies have not suggested reduction of repeat revascularization or mortality,<sup>33,34</sup> and a prematurely stopped medium sized randomized trial enrolling 250 patients with 1-year follow-up<sup>21</sup> did not show that the no-touch technique was associated with improved patency of SVGs.

We conducted a pragmatic, registry-based randomized trial to reflect routine clinical practice, using existing electronic infrastructure. By comparing baseline characteristics of the first 203 patients included in SWEDEGRAFT and 1535 other patients in the Cardiac Surgery Registry who underwent CABG during the same time period,<sup>14</sup> we confirmed the representativeness of our study population to the Swedish CABG population.

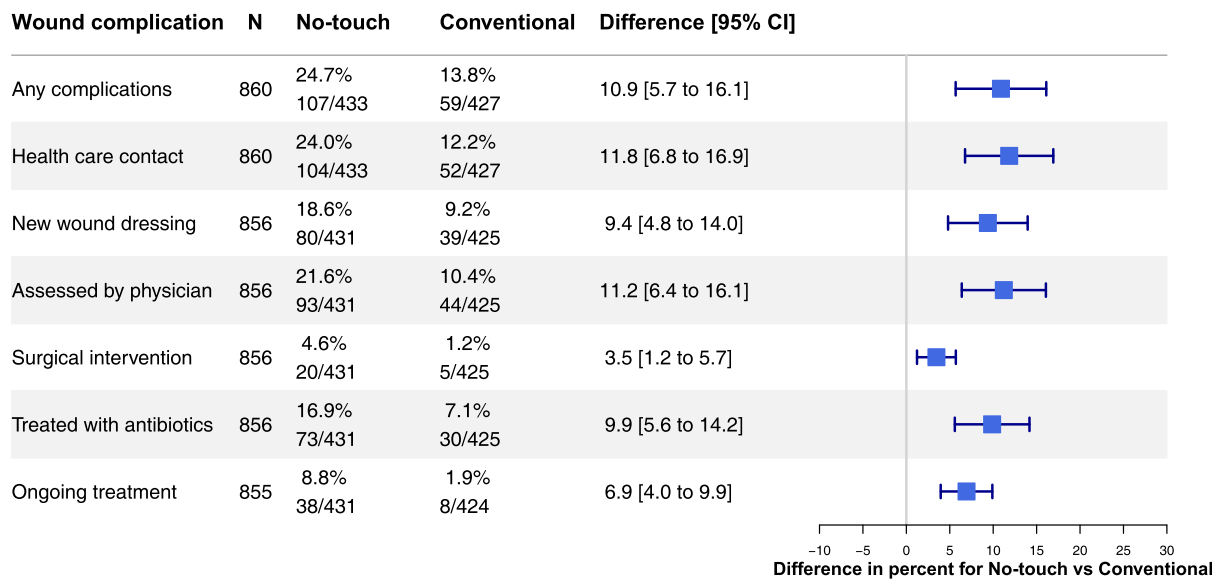
## Limitations

The trial was open-label, which may affect the interpretation of symptoms and side effects. However, CTA evaluation was performed in a blinded fashion. The primary endpoint was based on objective criteria not affected by any potential ascertainment bias.

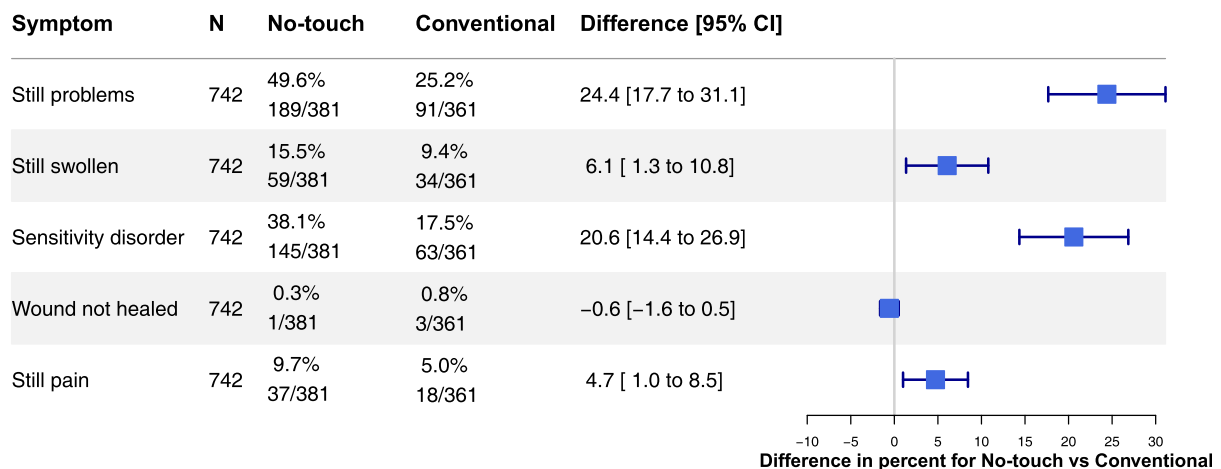
**Table 2 Major adverse cardiac events**

Variable	No-touch (n = 454)		Conventional (n = 446)		Hazard ratio	95% CI
	Patients with events (%)	KM (%)	Patients with events (%)	KM (%)		
MACE	57 (12.6)	7.27	44 (9.9)	4.93	1.30	(0.87–1.93)
MI	20 (4.4)	2.21	19 (4.3)	2.02	1.03	(0.55–1.93)
Revascularization	43 (9.5)	6.62	34 (7.6)	4.27	1.25	(0.80–1.97)
Death	9 (2.0)	0.44	10 (2.2)	0.67	0.87	(0.35–2.16)

Kaplan–Meier (KM) percentages is calculated at 360 days. Hazard ratio for no-touch vs. conventional from Cox proportional-hazards model. MI, myocardial infarction.



**Figure 4** Leg wound complications at 3 months



**Figure 5** Leg wound complications at 2 years

A varying surgical experience in handling no-touch vein grafts may have introduced a potential bias. However, we gave detailed instructions to investigators, at a site visit and with an instructive video how both of the techniques were going to be systematically used with avoidance of excessive dilation of the vein in both groups. Moreover, before the trial started, we performed a feasibility study in all centres. All surgeons had experience in handling both types of vein grafts and such a bias was refuted by the lack of interaction for centre and whether patients were enrolled early or late in the trial.

The proportion of vein graft failure was lower than expected which reduced the trial's power and weakens the conclusion regarding the primary outcome. The overall proportion of vein graft occlusion in our trial at 3.5 years was 18.5% similar to the overall proportion of 18% vein graft occlusion in a recent patient level meta-analysis of 871 patients from four trials using CTA at ~1 year.<sup>35</sup> Due to low power, we cannot exclude a type II error with a false negative primary outcome. The extended follow-up due to the pandemic, from 2 to 3.5 years after CABG for the CTA endpoint and to 4.4 years for the clinical outcomes, increased the event rate for evaluation of the long-term MACE outcomes. The low proportion of vein occlusion and low clinical event rate proves the high quality of cardiac surgery in the Nordic countries. Considering the totality of the results, including the long-term clinical outcomes and safety outcomes, the overall clinical conclusion of the trial would not change. The proportion of patients that underwent CTA at 3.5 years was 78%, which is lower than the 92% reported by Tian *et al.*<sup>11</sup> at 1 year, as well as the expected 85% planned in our protocol at 2 years. The delay of follow-up and subsequently lower proportion of follow-up was caused by the pandemic but in a *post hoc* tipping point sensitivity analysis, we found very low likelihood of achieving different results if all patients had undergone a CTA investigation. All-cause mortality remained relatively low and not apparently affected by the pandemic.<sup>36</sup> Patients were very well treated pharmacologically at discharge in accordance with Nordic standards and international guidelines.<sup>31</sup>

We used a liberal definition of vein graft failure with a 50% diameter stenosis, but as total vein graft occlusion dominated, the disease findings a different cut-off would likely not change the results.

## Conclusions

No-touch vein grafts were found non-superior to conventional vein grafts with respect to the incidence of vein graft failure or clinical events up to 4 years after non-emergent CABG. No-touch veins increased leg wound complications. Our trial does not support the routine use of the no-touch harvesting technique compared to the standard technique of vein handling. The primary outcome requires cautious interpretation due to a lower-than-expected number of primary events.

## Acknowledgements

We thank the staff at all participating sites, the staff at Uppsala Clinical Research Center; Susanne Heller (Senior Project Leader), Stefano Caramuta, (Lead Data Manager), Ida Björkgren (Publications Manager), and Maria Eriksson-Svensson (Executive director).

## Supplementary data

Supplementary data are available at European Heart Journal online.

## Declarations

### Disclosure of Interest

I.S.M. has received an unrestricted grant from the Novo Nordisk Foundation (NNF 0083480). Ö.F. reports personal fees for consultancy services from Abbvie. A.J. reports personal fees for advisory boards and/or lectures from AstraZeneca, LFB Biotechnologies, Bayer, Boehringer-Ingelheim, Novo Nordisk, and Werfen, outside the present work. S.J. reports institutional research grants/support from AstraZeneca, Novartis, and Amgen and personal fees from Medtronic for valve proctoring. The other authors have nothing to disclose.

### Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

### Funding

The SWEDEGRAFT trial was funded by grants from the Swedish Research Council (grant number VR 2017-00214) and the Swedish Heart Lung Foundation (grant number Hj-Lu 20170428).

### Ethical Approval

The study was approved by the regional Human Research Ethics Committee in Uppsala, Sweden, the Central Denmark Regional Committee on Health Research Ethics, Denmark, and the Swedish Radiation Safety Authority. The trial was carried out in accordance with Good Clinical Practice and the Declaration of Helsinki.

### Pre-registered Clinical Trial Number

The pre-registered clinical trial number is NCT03501303.

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