


REVIEW

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# Effect of preoperative ultrasound mapping of the saphenous vein on leg wound complications after coronary artery bypass surgery: a systematic review

Ara Shwan Media<sup>1</sup>, Rathini Rajendran<sup>1</sup>, Hans Henrik Kimose<sup>1,2</sup> and Ali Imad El-Akkawi<sup>1\*</sup> 

## Abstract

**Background:** The long saphenous vein is one of the most used conduits for coronary artery bypass graft surgery. The aim of this study was to assess the existing evidence regarding the effects of preoperative ultrasound mapping of the long saphenous vein with special attention to leg wound complications in patients undergoing elective coronary artery bypass graft surgery.

**Main text:** A systematic literature search was conducted in PubMed, Cochrane, and Embase databases. Extraction of relevant data was performed including study characteristics, patient characteristics, and all reported outcomes. The Cochrane Risk of Bias tool was used to evaluate the risk of bias of the included studies. The primary outcome measure was leg wound infections.

Of 4514 papers screened in this systematic review, 36 papers underwent full-text assessment with final inclusion of 5 studies; 3 observational studies, and 2 randomized trials. The two randomized controlled trials showed no effects of preoperative ultrasound. Data from the three non-randomized studies was pooled in a meta-analysis, which suggested a significant reduction in the risk of harvest wound complications by ultrasound mapping prior to surgery (RR 0.32; 95%CI = [0.19–0.55]).

**Conclusions:** The main findings of this systematic review showed, that (1) the evidence in this field is limited and of low quality, i.e., low power or methodology and (2) despite limitations of the included studies, preoperative ultrasound mapping of the saphenous vein seems to be beneficial in terms of reducing the risk of postoperative leg wound complications.

**Keywords:** Ultrasound mapping, Coronary artery bypass grafting, Long saphenous vein, Harvest wound complications

## Background

Cardiovascular disease is the leading cause of deaths world-wide according to the World Health Organization, causing 17.9 million deaths annually [1]. Coronary

artery disease (CAD) is the most prominent cause of morbidity and mortality [2]. Due to advances in both surgical techniques and percutaneous coronary intervention, an increasing percentage of patients with CAD are eligible for myocardial revascularization [3]. Coronary artery bypass grafting (CABG) remains the standard of care for patients with three-vessel or left main CAD and improves myocardial ischemia, cardiac function, and cardiac-related mortality rates [2, 4, 5].

\*Correspondence: aliakkawi@hotmail.com

<sup>1</sup> Department of Cardiothoracic and Vascular Surgery, Aarhus University Hospital, Palle Juul-Jensens Blvd 99, 8200 Aarhus N, Denmark  
Full list of author information is available at the end of the article

CABG requires autologous conduits; one of the most frequently used is the long saphenous vein (LSV) [6, 7].

The reported incidences of wound related complications after LSV harvest ranges from 2 to 20% [8, 9]. Commonly reported leg wound complications related to saphenous vein harvesting include surgical site infection, pain, swelling, and impaired mobility [6]. Such complications are a major cause of patient morbidity, resulting in prolonged hospital stay and delayed recovery with the need for additional interventions such as debridement, antibiotic therapy, and dressing changes [6, 10, 11].

Ultrasonography (US) for preoperative vein mapping has been used to assess and determine the anatomical course of the LSV, thereby facilitating rapid and accurate location of the vein during surgery [12, 13]. Furthermore, preoperative vein mapping has been suggested to be of value in patients whose veins are not evident by physical examination due to edema, multiple varicosities, or complex saphenous vein anatomy [14]. Thus, unnecessary incisions can be avoided reducing complications at incision sites and wound healing disturbances [12].

A previous Best Bet study from 2013 supports the use of preoperative ultrasound assessment of the saphenous vein [15, 16]. However, only one of the included studies was comparing ultrasound mapping with conventional vein harvest [16]. Therefore, the aim of this present systematic review was to determine whether preoperative ultrasound mapping of the LSV reduces leg wound complications compared to conventional vein harvest.

## Main text

### Search strategy

The data search was performed on May 10th, 2022. This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [17]. No ethics approval was required for this review.

Publications were identified through a search of online databases: Cochrane Central Register of Controlled Trials, PubMed, and EMBASE. The search was not limited by language or publication status, and no date restriction was implemented. Following search terms were used to search the PubMed and adapted appropriately for EMBASE and Cochrane: (((“Coronary Artery Bypass”[Mesh]) OR (coronary bypass)) OR (cabg)) AND (((“Ultrasonography”[Mesh]) OR (ultrasound)) OR (ultrasonics)) OR (mapping))) AND (((“Veins”[Mesh]) OR (saphenous)) OR (vein)). The bibliographies of all included studies were hand-searched

for any relevant references that may have been missed by the literature searches.

### Eligibility criteria

Citations retrieved from all literature sources were collated into an EndNote™ 20 library. Eligible studies were included if they met the following inclusion criteria: participants were adults (18 years or older); participants were undergoing elective isolated CABG surgery with LSV as conduit; studies evaluating ultrasound mapping of the LSV prior CABG surgery compared to conventional harvesting; study designs included were randomized controlled trials (RCTs) and prospective and retrospective cohort studies, respectively.

Reviews and case reports were excluded.

### Primary outcome measure

Occurrence of leg wound complications following harvest of the saphenous vein.

### Secondary outcome measures

Additional leg incision, leg incision length, and harvest time.

### Assessment of study eligibility

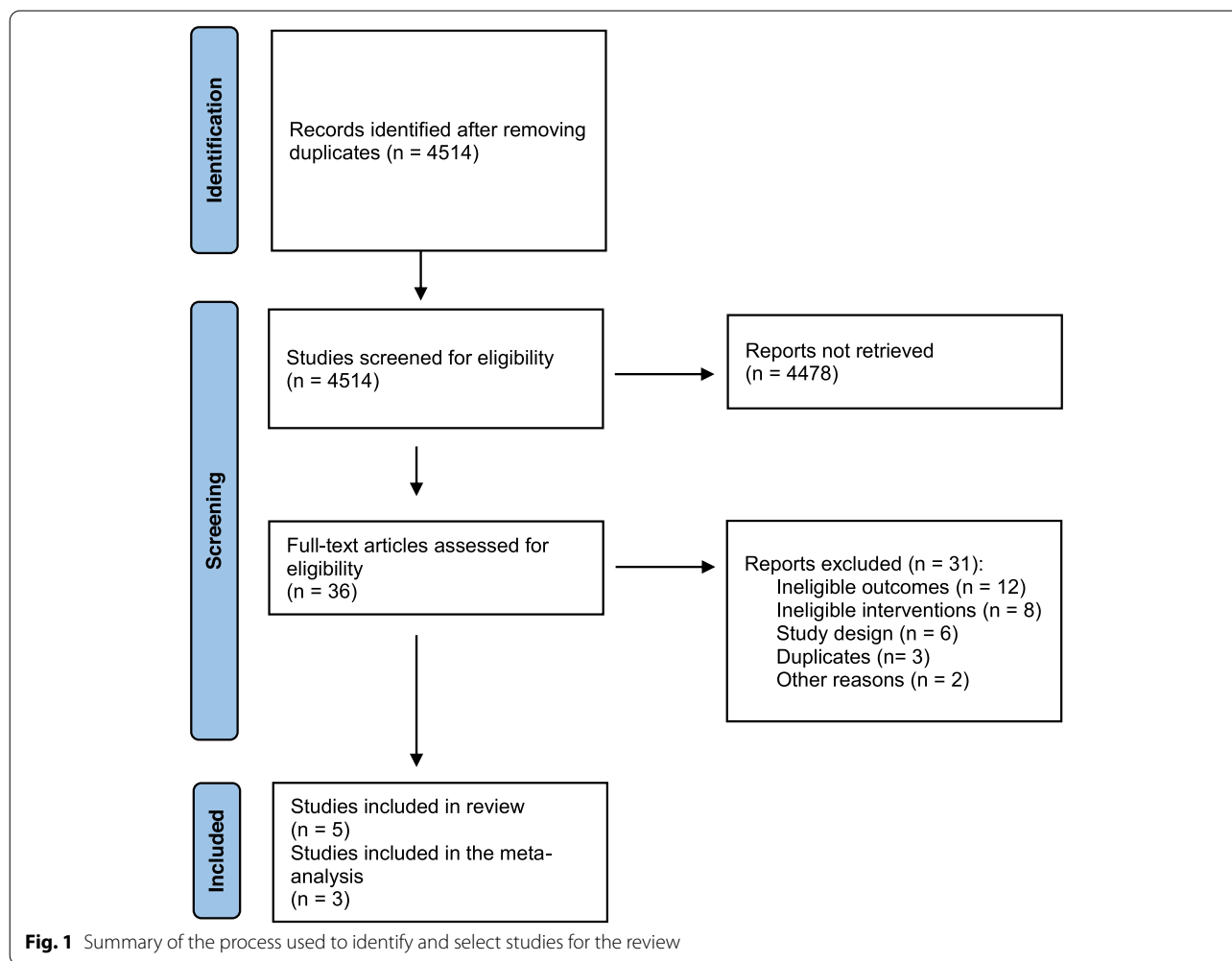
In accordance with the inclusion and exclusion criteria, titles and abstracts were screened on Covidence software ([www.covidence.org](http://www.covidence.org)) independently by two authors (AIE-A, RR). Full-texts articles were assessed for eligibility using a modified Cochrane Data Extraction Template. The review authors were not blinded to the authors' names and affiliations. A consensus of the two reviewers was needed to include the studies in the literature review (Fig. 1).

### Data extraction

The following data were extracted from the eligible studies: demographic information, study design, intervention details, and all reported outcomes. Data were only extracted if stated in the text or tables of the article, not in graphic representations.

### Quality assessment

The possible risk of bias was assessed using either the Cochrane Risk of Bias Assessment [18] or the ROBINS-I tool [19] for the RCTs [20, 21] and non-RCTs [6, 12, 22], as appropriate (Table 1). Both risk of bias assessment tools include several domains whereby in which regard each study is evaluated independently. The two reviewers completed the risk of bias assessments independently and any disagreement was resolved by discussion.



**Statistical analysis**

Due to the considerable differences regarding levels of evidence between the RCTs and cohort studies, the results from the RCTs were evaluated independently and the results from cohort studies were pooled in a meta-analysis. The meta-analysis was calculated using the Mantel-Haenszel estimator. The primary outcome was tested according to the null hypothesis that there is no difference in the risk of leg wound complications. The fixed or random effect was utilized depending of the heterogeneity of the studies included in the meta-analysis using  $I^2$ , i.e., if heterogeneity was small ( $I^2 \leq 50\%$ ) the fixed-effect model was used while the random-effects model was assumed in case of high heterogeneity ( $I^2 > 50\%$ ). The effect size of the meta-analysis was reported in log risk ratio and presented as exponent values.

The statistical analysis was performed using Stata (StataCorp. 2019. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC).

**Results**

**Description of included studies**

Of 4514 papers screened in this systematic review, 36 papers underwent full-text assessment with final inclusion of five studies [6, 12, 20–22] (Fig. 1). Of the five included studies, two were RCTs [20, 21] and three were cohort studies [6, 12, 22], respectively. Studies were mainly excluded as the outcomes of interest were not reported.

**Quality of the included studies**

An overview of the methodological assessment of the included studies is displayed in Table 1. The Oxford Centre for Evidence Based Medicine tool was used to classify the quality of included studies [23]. Only one of the included studies used concealed allocation [21]. One of the randomized studies [20] did not provide information regarding the randomization protocol. None of the studies used blinding.

**Table 1** Quality assessment of included studies. The Cochrane risk of bias tool was used to assess the quality of the randomized controlled trials while the ROBINS-I tool was used to assess the non-randomized trials

Study	Sequence Generation	Allocation concealment	Blinding of participant and personnel	Blinding of outcome assessors	Incomplete outcome data	Selective outcome reporting	
<i>Cochrane Risk of Bias Tool</i>							
Zarepur et al. [21]	U	L	H	H	L	L	
Luckraz et al. [20]	H	H	H	H	L	L	
Study	Bias due to confounding	Bias due to selection of participants	Bias in classification of interventions	Bias due to deviations of intended interventions	Bias due to missing data	Bias in measurements of outcomes	Bias in selection of the reported results
<i>ROBINS-I Tool</i>							
Aguirre et al. [6]	S	M	M	S	L	M	L
Lopes et al. [22]	S	S	M	M	NI	M	L
Temizkan et al. [12]	M	L	M	M	NI	M	L

Abbreviations: H high risk of bias, L low risk of bias, U unclear risk of bias, S serious risk bias, M moderate risk of bias, NI no Information

### Baseline characteristics

Patient baseline characteristics are reported in Table 2. Apart from two studies, there was no statistically significant difference in baseline characteristics between the two groups. In Temizkan et al. [12], the mean age of patients and the rate of hypertension were higher in the unmapped group ( $p = 0.038$ ). In the randomized study by Zarepur et al. [21] there was a significantly higher number of diabetic patients in the mapped group (US) ( $p = 0.024$ ).

### Outcomes

All five studies reported occurrence of leg wound complications following harvest of the saphenous vein as an outcome. Details of the included studies is shown in Table 3. Outcome measures varied notably between the studies.

### Harvest wound complications

Due to significant differences in the study designs and quality, we chose to assess the RCTs individually separating them from the non-RCTs, thus pooling the results from the three non-RCTs in a meta-analysis. In the meta-analysis, we found a statistically significant reduction in the risk of leg wound complications in the ultrasound group with a risk ratio of 0.32 (0.19–0.55) compared to the group without preoperative ultrasound mapping (Fig. 2). As the  $I^2$  value was very low, the fixed-effect model was assumed.

In Zarepur et al., each leg wound complication type was reported separately [21]. No statistically significant difference was found between the two groups regarding postoperative infection ( $p = 1.000$ ), nor incidences of edema, hematoma, or deep vein thrombosis.

Luckraz et al. assessed the presence of postoperative leg wound complications by an ASEPSIS score (additional treatment, serous discharge, erythema, purulent exudates, separation of deep tissues, isolation of bacteria, stay as patient prolonged over 14 days) [20, 24]. The ASEPSIS score ranges from 0 to 70 with higher scores indicating higher probability of infection. There was a statistically non-significant higher mean ASEPSIS score of 25 in the group without ultrasound mapping compared to a mean score of 10 in ultrasound group ( $p = 0.08$ ).

### Leg incision

Only the study by Lopes et al. [22] reported the risk for bilateral leg incision. Six patients in the unmapped group (8.95%) required an additional incision, and this outcome did not occur in the mapped group ( $p = 0.0067$ ). Furthermore, in the RCT by Luckraz et al. there was a significant reduction in the leg wound incision length in the mapped group (mean 16.8 vs 24.1 cm,  $p = 0.005$ ) [20].

### Harvest time

Aguirre et al. reported that the median harvest time was significantly shorter in the mapped group (25 min [19, 21–30] vs 40 min [30–50];  $p = 0.001$ ) [6]. Similarly, Luckraz et al. found a significantly shorter time for vein harvesting per length of vein graft for the mapped group ( $36 \pm 13$  min compared to  $47 \pm 17$  min for the non-mapped group,  $p = 0.04$ ) [20].

### Discussion

This systematic review assessed the existing literature regarding the effects of preoperative ultrasound mapping of the LSV on harvest site infections in patients

**Table 2** Demographics and comorbidities of the study population

Study ID	Male/female		Age		Diabetes		Hypertension		Smoking		PVD		BMI	
	+US	-US	+US	-US	+US	-US	+US	-US	+US	-US	+US	-US	+US	-US
Termizkan et al. [12]	111/25 (18%)	135/43 (24%)	62 ± 12	64 ± 10	50 (37%)	51 (29%)	65 (48%)	106 (60%)	58 (43%)	59 (33%)	10 (7%)	14 (8%)	NR	NR
Zarepur et al. [21]	26/24 (48%)	35/15 (30%)	62	61	25 (50%)	14 (28%)	30 (60%)	23 (46%)	NR	NR	NR	NR	NR	NR
Aguirre et al. [6]	20/12 (38%)	55/14 (20%)	65 ± 11	65 ± 11	18 (56%)	25 (36%)	NR	NR	NR	NR	5 (16%)	4 (6%)	32 ± 8	30 ± 5
Lopes et al. [22]	55/29 (35%)	48/19 (28%)	62 ± 9	64 ± 8	45 (54%)	36 (54%)	NR	NR	29 (35%)	22 (33%)	3 (4%)	0	28 ± 5	29 ± 5
Luckraz et al. [20]	24/7 (23%)	22/8 (27%)	65	67	6 (20%)	9 (30%)	NR	NR	22 (71%)	20 (67%)	3 (10%)	6 (20%)	NR	NR

Abbreviations: BMI body mass index (kg/m<sup>2</sup>), NR not reported, PVD peripheral vascular disease, +US ultrasound mapped group  
 Gender presented as male/female-ratio and percentage of female patients. Age reported as means ± standard deviation. NS = no significant difference

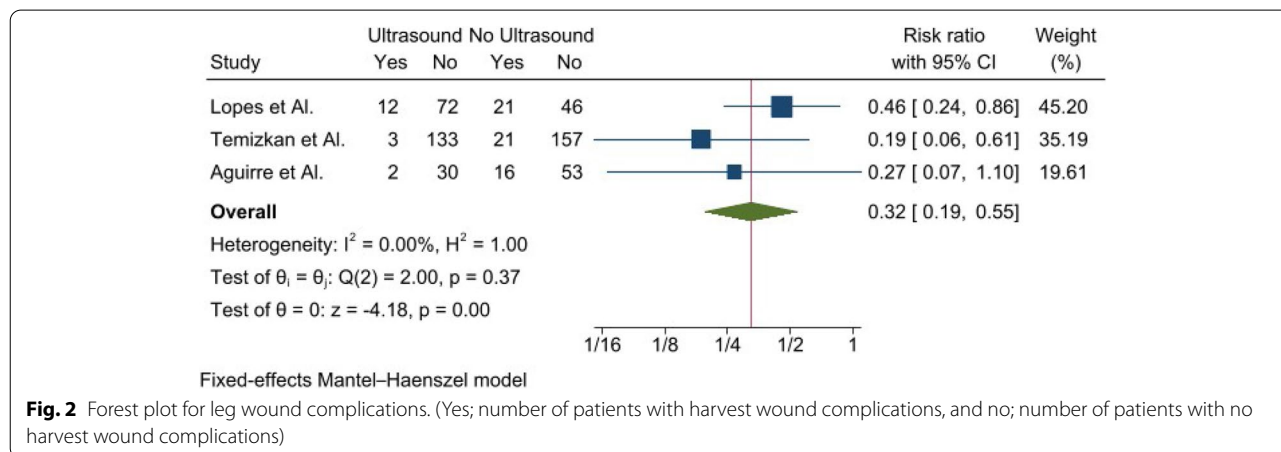
**Table 3** Main results of the included studies

Author, date, journal, country Study type (level of evidence) Patient group	Key results
Temizkan et al. 2013, <i>The Heart Surgery Forum</i> , Turkey [12] Retrospective cohort study (level 2b) Total: 314 patients +US group: 136 -US group: 178	Drainage of leg incision, mL (mean $\pm$ standard deviation) +US: $2.9 \pm 5.8$ -US: $13.5 \pm 11.3$ ( $p = 0.001$ ) Complication of incision site, $n$ (%) +US: 3 (2.2%) -US: 21 (11.8%) ( $p = 0.002$ )
Zarepur et al. 2016, <i>Electronic Physician</i> , Iran [21] Randomized controlled trial (level 1b) Total: 100 patients +US group: 50 -US group: 50	Wound infection, $n$ (%) +US: 3 (6%) -US: 4 (8%) ( $p = 1.000$ ) Edema, $n$ (%) +US: 6 (12%) -US: 4 (8%) ( $p = 0.741$ ) Hematoma, $n$ (%) +US: 1 (2%) -US: 4 (8%) ( $p = 1.000$ ) DVT, $n$ (%) +US: 1 (2%) -US: 2 (4%) ( $p = 1.000$ ) Length of incision, cm (mean $\pm$ standard deviation) +US: $29.20 \pm 3.71$ -US: $28.98 \pm 3.72$ cm ( $p = 0.768$ )
Aguirre et al. 2019, <i>Heart, Lung and Circulation</i> , Australia [6] Prospective non-randomized cohort study (level 2b) Total: 101 patients +US group: 32 -US group: 69	Wound complications, $n$ (%) +US: 2 (6.2%) -US: 16 (23.2%) ( $p = 0.04$ ) Harvest time, min (mean [Lwr CI-Upp CI]) +US: 25 [20–30] -US: 40 [30–50] ( $p = 0.001$ ) Patient satisfaction +US: 96.9% -US: 91.2% ( $p = 0.29$ ) Mobility affected by wound +US: 3.1% -US: 19.1% ( $p = 0.03$ ) Leg measurement, mean [Lwr CI-Upp CI] +US: 0.5 [0–3] -US: 3.5 [0–6.6] ( $p = 0.002$ )
Lopes et al. 2018, <i>Braz J Cardiovasc Surg</i> , Brazil [22] Prospective cohort study (level 2b) Total: 151 patients +US group: 84 -US group: 67	Bilateral leg incision, $n$ (%) +US: 0 (0) -US: 6 (8.95%) ( $p = 0.0067$ ) Wound complications day 1, $n$ (%) +US: 0 (0) -US: 3 (4.5%) Wound complications within 30 days, $n$ (%) +US: 12 (14.8 %) -US: 21 (35 %) ( $p = 0.008$ )

**Table 3** (continued)

Author, date, journal, country Study type (level of evidence) Patient group	Key results
Luckraz et al. 2008, <i>Interact CardioVasc Thorac Surg</i> , UK [20] Randomized control trial (level 1b) Total: 61 patients +US group: 31 -US group: 30	Asepsis score, median [IQR] +US: 10 [8–20] -US: 25 [10–26] ( $p = 0.08$ ) Mean length of wound, cm (mean $\pm$ standard deviation) +US: 16.8 $\pm$ 4.0 -US: 24.1 $\pm$ 10.4 ( $p = 0.005$ ) Harvest time, min (mean $\pm$ standard deviation) +US: 36 $\pm$ 13 -US: 47 $\pm$ 17 ( $p = 0.04$ )

Abbreviations: DVT deep vein thrombosis, US ultrasound mapping



**Fig. 2** Forest plot for leg wound complications. (Yes; number of patients with harvest wound complications, and no; number of patients with no harvest wound complications)

undergoing CABG. We screened 4514 studies with final inclusion of 5 studies; 2 RCTs and 3 non-RCTs. Furthermore, we assessed reporting regarding additional leg incisions, incision length, and harvesting times.

Our meta-analysis based on three non-RCTs indicated a significant reduction of postoperative leg wound complications following preoperative ultrasound mapping [6, 12, 22]. The two RCTs included were assessed independently, and neither showed effects of preoperative vein mapping on harvest site infections [20, 21]. One of the RCTs, Zarepur et al. reported wound complications separately, indeed a higher number of patients would be needed to find any statistically significant difference between the groups. Only two studies [6, 22] reported the mean BMI as a confounder, while the study by Luckraz et al. [20] reported a mean body surface area, which is an important factor correlated with leg wound healing and complications.

Furthermore, one study showed statistically significant reduction in incision lengths, one study showed reduced risk of additional incisions, and two studies showed

significantly shorter harvesting times. However, these outcomes are highly dependent on the experience of the surgeon performing the procedure which was not specified in the studies. Moreover, these secondary outcomes were not reported consistently in all of the included studies.

Despite the above reservations regarding the findings of the present systematic review and meta-analysis, our findings indicate that preoperative vein mapping leads to a better preoperative qualitative assessment of the LSV thus possibly reducing harvest site infection, incision lengths, the need for additional incisions, and harvesting times as compared to blind leg incision.

Other aspects of significance not within the scope of this present study are the learning curve and interobserver variability of utilizing ultrasound mapping as well as the cost-benefit aspects. All of these factor should be considered and investigated into before we can encourage the routine use of preoperative ultrasound mapping of the LSV. None of the included studies mentioned the effects of preoperative ultrasound mapping of the LSV



on long term graft patency or perioperative graft strategy. Furthermore, as endoscopic vein harvesting was not within the scope of this study, this technique is known to reduce the risk of leg wound complications [26–30]. However, endoscopic equipment increases the cost of surgery and has different impediments as compared to a conventional harvesting technique. Therefore, open vein harvesting is still a widely used technique and efforts to improve this approach are warranted.

The strength of this study is a large comprehensive literature search performed using multiple databases by two independent reviewers. Thereby, the potential risk of missing relevant studies was very low. The meta-analysis in this study is based on three observational studies only, which is a considerable limitation. Furthermore, the findings from the meta-analysis regarding reduced harvest site infections were not confirmed by the two RCT's. All included studies were ranked as lower quality studies with poor methodical quality. Furthermore, the lack of blinding and concealment in the included studies might induce a type 1 error, as the investigators might possibly evaluate the wounds of the UL group more favourably. The lack of randomization could lead to both type 1 or type 2 errors, while we find it more plausible the UL sound assessment were used more frequently on indication leading to utilizing UL on patients with more complex anatomy, possibly leading to type 2 errors.

## Conclusions

Postoperative wound complications are a major concern following coronary bypass surgery. This systematic review including a metanalysis showed that the existing evidence in this field is of low quality. However, the studies suggest that preoperative ultrasound mapping might be beneficial in terms of reducing wound complications and harvest times while preventing unnecessary leg incisions. Indeed, these findings encourage large-scale randomized prospective studies in this field.

## Abbreviations

BMI: Body mass index; CI: Confidence interval; CABG: Coronary artery bypass graft surgery; CAD: Coronary artery disease; DVT: Deep vein thrombosis; EVH: Endoscopic vein harvesting technique; H: High risk of bias; LSV: Long saphenous vein; L: Low risk of bias; NR: Not reported; OR: Odds ratio; PVD: Peripheral vascular disease; +W : Presence of wound complications; RCTs: Randomized controlled trials; RR: Risk ratio; US: Ultrasonography; +US: Ultrasound mapped group; U: Unclear risk of bias.

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## Authors' contributions

All authors contributed to the analysis and interpretations of results, and to writing and revision of the manuscript. All authors read and approved the final manuscript.

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## Availability of data and materials

Not applicable

## Declarations

### Ethics approval and consent to participate

Not applicable

### Consent for publication

All authors have agreed for publication of the manuscript.

### Competing interests

The authors declare that they have no competing interests.

### Author details

<sup>1</sup>Department of Cardiothoracic and Vascular Surgery, Aarhus University Hospital, Palle Juul-Jensens Blvd 99, 8200 Aarhus N, Denmark. <sup>2</sup>Department of Clinical Medicine, Aarhus University, Aarhus, Denmark.

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