Original Article

Strategies to Minimize Sternal and Leg Wound Complications after Coronary Artery Bypass Grafting Using No-Touch Saphenous Vein Grafts

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Purpose: The aims of the present study were to examine sternal and saphenous vein (SV) harvest site wound complication rates, and to assess the strategies to minimize the sternal and leg wound complications after coronary artery bypass grafting using a no-touch (NT) SV.

Methods: Patients who underwent coronary artery bypass grafting (CABG) using internal thoracic artery (ITA) and/or NT SV grafts from March 2021 to June 2023 (N = 166) at a newly opened cardiac surgical program were included. We obeyed the current guidelines for the prevention of sternal wound infection. In addition, unilateral ITA was used in most of the patients and the sternal wound was meticulously closed using multiple sternal wires (≥7) and ZipFix. For the NT SV harvesting, the LigaSure device was used to minimize thermal injury, and the wound was meticulously closed.

Results: Sternal wound infections developed in 3/166 (1.8%) patients; all three patients showed superficial sternal wound infections. Leg wound complications were present in 2/153 (1.3%) patients, who recovered after secondary intention healing.

Conclusion: Sternal wound complications after CABG could be minimized by the unilateral ITA usage, meticulous closure of the sternal wound in addition to compliance with the current guidelines. Wound complications after NT SV harvest may also be minimized by preoperative evaluation, careful harvesting, and meticulous wound closure.

Keywords: coronary artery bypass grafting, internal thoracic artery, saphenous vein, complications

Purpose

Wound complications following cardiac surgery increase morbidity and mortality, prolong hospital stay, and increase medical costs.[1–3] Multiple predisposing factors, such as poorly controlled diabetes, obesity, smoking, advanced age, reoperation, anemia, and chronic hypoxemia, are known to be associated with wound complications after cardiac surgery.[3,4]

Wound complication is of particular concern in patients undergoing coronary artery bypass grafting (CABG) because there have been studies demonstrating increased sternal wound infection in patients who received bilateral internal thoracic arteries (ITA) despite improved long-term outcomes.[5–7] Saphenous vein (SV) is the widely used conduit for CABG, along with the ITA; however, it has been known to have disadvantages of declining patency with time and worse clinical outcomes when compared with arterial conduits.[8,9] The SV harvested with the no-touch (NT) technique has shown favorable biochemical,

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histological properties and improved long-term patency when compared with the SV harvested with the conventional technique.[10–12] However, higher leg wound complication rates were reported in patients who received NT SV.[13,14]

The aims of the present study were (1) to examine the sternal and leg wound complication rates and (2) to assess the strategies to minimize the sternal and leg wound complications in CABG patients who received NT SV at a newly opened cardiac surgical program.

Materials and Methods

Patient characteristics

From March 2021 to June 2023, 166 patients underwent CABG using ITA and/or NT SV grafts at a newly opened cardiac surgical program. Thirty-three patients were female, median EuroSCORE II was 1.7 [0.9;3.8]%, and estimated risk of mortality by the Society of Thoracic Surgeons (STS) score was 1.1 [0.6; 2.7]% (**Table 1**). Revascularization was performed using NT SV composite graft based on the in situ left ITA in 136 patients (81.9%), in situ left ITA and free NT SV grafting in 13 patients (7.8%), in situ left ITA in 7 patients (4.2%), NT SV composite graft based on the in situ right ITA in 4 patients (2.4%), right gastroepiploic artery composite graft based on the in situ left ITA in 2 patients (1.2%), in situ right ITA in 2 patients (1.2%), and right ITA composite graft based on the in situ left ITA in 2 patients (1.2%) (**Fig. 1**).

Table 1 Patient characteristics

Age	66.7 ± 10.4 years
Female	33 (19.9%)
Body mass index (kg/m^2)	24.4 [22.6,26.6]
Smoking	
Never-smoker	39 (23.5%)
Former smoker	76 (45.8%)
Current smoker	51 (30.7%)
Hypertension	116 (69.9%)
Diabetes mellitus	84 (50.6%)
Dyslipidemia	88 (53.0%)
History of stroke	21 (12.7%)
Chronic renal failure	22 (13.3%)
Acute renal failure	10 (6.0%)
Chronic obstructive pulmonary disease	13 (7.8%)
Atrial fibrillation/flutter	17 (10.2%)
Peripheral vascular disease	49 (29.5%)
History of percutaneous coronary intervention	47 (28.3%)
Redo-surgery	3 (1.8%)
Left ventricular dysfunction (ejection fraction <35%)	39 (23.5%)
Stable angina	32 (19.3%)
Unstable angina	53 (31.9%)
Postinfarct angina	72 (43.4%)
Acute myocardial infarction	9 (5.4%)
Left main disease	29 (17.5%)
3-vessel disease	89 (53.6%)
2-vessel disease	54 (32.5%)
1-vessel disease	23 (13.9%)
EuroSCORE II (%)	1.7 [0.9; 3.8]
Risk of mortality (STS score) (%)	1.1 [0.6; 2.7]

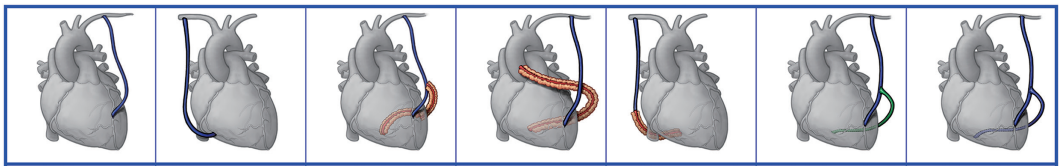
STS: The Society of Thoracic Surgeons

Preoperative management

We obeyed the current guidelines for the prevention of sternal wound infection.[3] Smoking cessation and aggressive pulmonary toilet were performed in patients who were active smokers and those with chronic obstructive pulmonary disease. Preoperative hypoalbuminemia (<3.0 g/mL) was corrected before surgery if possible. In diabetic patients, efforts were made to optimize and maintain perioperative serum glucose levels <180 mg/dL. All patients underwent nasal swabs for *Staphylococcus* species. Routine nasal mupirocin ointment was initiated within 24 hours of surgery and continued for 5 days. Patients underwent presurgical bathing with chlorhexidine. After anesthetic induction, skin preparation was performed using a surgical antimicrobial solution (Duraprep; 3M, St. Paul, MN, USA), and the surgical field was covered with an antimicrobial incise drape (3M IOBAN; 3M). A 2nd generation cephalosporin (cefotetan) was given intravenously within 60 minutes before the skin incision and was continued for 48 hours postoperatively. In patients who were undergoing an operation involving an intracardiac implant or a vascular graft, or in cases when methicillin-resistant *Staphylococcus aureus* (MRSA) was of special concern, vancomycin and aminoglycoside (amikacin) were used instead. Vancomycin was administered 60 minutes before the skin incision and continued for 48 hours postoperatively and amikacin was administered two times, preoperatively and postoperatively.

Operative strategy

Preoperative thoraco-abdominal multidetector computed tomography (CT) angiography was performed in



7 (4.2%)	2 (1.2%)	136 (81.9%)	13 (7.8%)	4 (2.4%)	2 (1.2%)	2 (1.2%)

Fig. 1 Diagram of the performed CABG.

patients undergoing CABG to assess their vascular status from the neck to femoral vessels due to their high atherosclerotic steno-occlusive risk.[15] If the patient had any exertional leg symptoms or had significant steno-occlusive disease of a lower extremity, an ankle brachial index (ABI) test was performed. An ABI ratio of 0.7 or less in any lower limb suggested moderate-to-severe peripheral arterial disease and harvesting the ipsilateral SV was avoided to prevent skin wound complications.[16] Lower extremity vein CT angiography was performed at the same time as thoracoabdominal CT without additional contrast material for a thorough evaluation of lower extremity veins. After anesthetic induction, Doppler ultrasonography mapping was performed to reassess the course, size, quality, and tributaries of the SV.[16]

Bone wax was not used for application to the cut edges of the sternum, and topical antibiotics were applied to the cut edges of the sternum on opening and before closing because they have been found to significantly reduce the incidence of sternal wound infections.[3]

The unilateral left ITA harvested with a semi-skeletonization technique was used in most of the patients. Multiple sternal wires (≥7) and two sternal bands (ZipFix; Depuy Synthes CMF, West Chester, PA, USA) were used for the sternal closure (**Fig. 2**). In patients with sternal fractures or in high-risk patients who were more prone to develop sternal dehiscence (obesity [body mass index >30 kg/m^2], insulin-dependent diabetes, chronic obstructive pulmonary disease, reoperations, and bilateral ITA grafting), the figure-of-eight sternal closure technique was used. The fascia and subcuticular tissue layers were closed with multiple interrupted sutures, and the skin was closed using a noninvasive skin closure system (Zip skin closure; ZipLine Medical, Inc., Campbell, CA, USA). After the chest indwelling catheters were removed, the external chest support vest (Posthorax sternum vest; Epple Inc., Vienna, Austria) was applied. The patient was advised to wear the vest for 2 months postoperatively.

Fig. 2 Sternal closure with multiple wires and sternal ZipFix.

The NT SV harvesting was performed after systemic heparinization during the ITA harvest. It was performed by an open technique with two or three interrupted skin incisions along the SV course, with 1 to 2 cm of intervening skin bridges. The NT SV harvest was performed using Ligasure (Medtronic, Inc., Minneapolis, MN, USA) device to minimize thermal injury. Immediately after the harvest, the reversed SV was anastomosed to the left ITA to construct a Y-composite graft in the majority of patients. A Jackson–Pratt drain was placed in the SV harvest site, and the leg wounds were closed in layers; interrupted 3-0 absorbable sutures to the subcutaneous tissue, interrupted 4-0 subcuticular absorbable sutures, and additional noninvasive zip surgical closure method for the skin (**Fig. 3**). The Jackson–Pratt drain was removed when the amount of drained fluid decreased to less than 10 mL daily. An elasticated bandage was

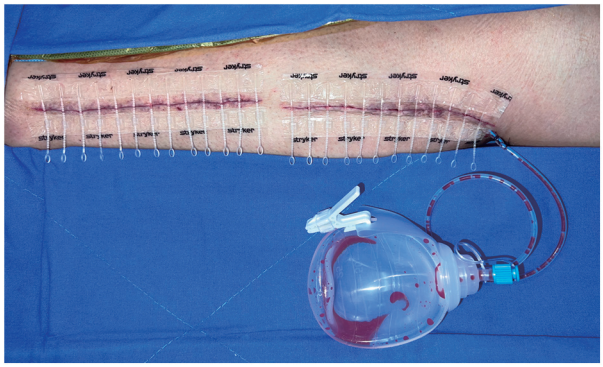


Fig. 3 Wound closure of the saphenous vein harvest site with Jackson-Pratt drain insertion.

applied to the leg wound after surgery and was replaced by a compression stocking from the 2nd postoperative day. The compression stocking was kept in place for 1 to 2 months postoperatively for prevention of leg swelling.

Collection of data

Data were collected based on electronic medical records. Patient's preoperative demographic data and data on the presence of sternal wound complications and SV harvest site wound complications were collected. The median time of Jackson–Pratt drain removal was analyzed. Sternal wound complications include superficial sternal wound infections (SSWI) and deep sternal wound infections (DSWI).[4] A SSWI involves only the skin, subcutaneous tissue, and/or pectoralis fascia, and there is no bony involvement. A DSWI requires the presence of one of the following criteria: (1) an organism isolated from the culture of mediastinal tissue or fluid, (2) evidence of mediastinitis seen during operation, or (3) presence of either chest pain, sternal instability, or fever (>38°C), and purulent drainage from the mediastinum, or isolation of an organism present in a blood culture or a culture of the mediastinal area. Leg wound complications in the SV harvesting site were defined as infection or wound disruption that needed additional repair or secondary intention healing.

Statistical analysis

Statistical analysis was performed using R software (Vienna, Austria), version 4.1.2. Continuous data were expressed as the mean ± standard deviation for normally distributed variables or as medians (interquartile ranges) for nonnormally distributed variables according to the Shapiro–Wilk test, and categoric data were expressed as count (percentage).

Results

Sternal wound infections were present in 3 of 166 (1.8%) patients; all three patients showed SSWI and none of the patients had DSWI. The patients were treated with conservative management, including antibiotics and a vacuum-assisted closure device.

The Jackson–Pratt drain placed in the SV harvest site was removed at median 4 [interquartile range; 1,7] days postoperatively. Leg wound complications were present in 2 of 153 (1.3%) patients. The 2 patients suffered from partial wound disruption and recovered after secondary intention healing.

Discussion

The present study demonstrated two main findings: First, sternal wound complications after CABG could be minimized by compliance with the current guidelines, unilateral ITA usage, and meticulous closure of the sternal wound. Second, leg wound complication rates after NT SV harvest may also be minimized by preoperative evaluation of the vascular status of the lower limb, careful harvesting of the vein, placement of a drain into the vein harvest site, and meticulous wound closure.

The wound infections after cardiac surgery are associated with increased morbidity and mortality, decreased long-term life expectancy, prolonged hospital length of stay, and raised hospital costs.[1–3] In addition, wound complications may interfere with the establishment of a good rapport with patients and their families. They may have a negative influence on the center's reputation, especially in a newly opened cardiac surgery center. When we opened a newly designed cardiac surgical program, we followed the recent recommendations for the prevention of wound infections during the perioperative periods.[3] Preoperatively, smoking cessation, screening for nasal carriers of Staphylococcus, using nasal disinfectants, presurgical bathing with chlorhexidine, and correction of hypoalbuminemia (<3.0 g/mL) were performed. Preoperative serum glucose levels were maintained at <180 mg/dL in diabetic patients. A 2nd generation cephalosporin was given intravenously within 60 minutes before the skin incision and was continued for 48 hours postoperatively. In cases when MRSA was of special concern, vancomycin and aminoglycoside were used instead.

Intraoperatively, the use of bone wax was prohibited for application to the cut edges of the sternum, and topical antibiotics were applied to the cut edges of the sternum on opening and before closing of the sternum. Topical antibiotics such as vancomycin or gentamicin-collagen sponges applied to the cut edges of the sternum have been found to significantly reduce the incidence of sternal wound infections.[3] Multiple sternal wires (≥7) and two sternal bands (ZipFix) were used for the sternal closure. In patients with sternal fractures or in high-risk patients who were more prone to develop sternal dehiscence, the figure-of-eight sternal closure technique was often used. The fascia and subcuticular tissue layers were closed with multiple interrupted sutures. Previous studies demonstrated that the use of additional sternal wires (≥7) was associated with a lower incidence of sternal wound infection compared with standard technique (≤6 sternal wires).[17,18] Rigid sternal fixation with bands or plates may reduce sternal dehiscence and wound infections, and decrease pain.[3,19]

Despite improved long-term outcomes in CABG patients who received bilateral ITA graftings, the use of bilateral ITAs has been known to be one of the predictors of sternal wound infection after CABG.[5–7] Harvesting bilateral ITAs from the patient's sternum would block out the blood supply and affect wound healing because the ITA is a major source of blood supply in the sternum. A multicenter randomized controlled study demonstrated that the sternal wound complication (3.5% vs. 1.9%, $P = 0.005$) and sternal reconstruction (1.9% vs. 0.6%, $P = 0.002$) rates were higher in the bilateral ITA group than in the single ITA group.[20] However, another study showed that bilateral ITA grafting was associated with similar deep sternal wound infection and operative mortality rates when compared with single ITA grafting.[21] In the present study where the current guidelines for the prevention of sternal wound infection, including using unilateral ITA instead of bilateral ITA in almost all of the patients (98.8%; 164/166) and using multiple sternal wires (≥7) and additional 2 sternal bands, were obeyed, none of the patients had DSWI or needed sternal reconstruction.

The NT SV harvesting technique has shown improved long-term patency rates of SV compared with the conventional SV harvesting technique.[22] Despite its improved patency rates, there is a concern that NT SV harvesting may cause increased wound complications by disruption of more tissues. Leg wound complication rates have been reported to be 6% to 23% in the NT SV groups, which were higher than in the conventionally harvested SV groups.[13,14] To minimize the development of wound complications after NT SV harvest, preoperative evaluation of lower limb vascular status, selection of an adequate vein, creation of a precise incision, careful harvest, placement of a drain in the vein harvest site, and meticulous skin wound closure were performed in this study.[16]

We believe that prevention of serosanguinous fluid and blood collection and alleviating dead space by using an appropriate drain are mandatory for decreasing the potential risk of wound complications. Another study after endoscopic SV harvesting also showed that the use of a high vacuum leg drain was associated with decreased hematoma formation, higher patient satisfaction, and reduced antibiotic administration.[23] The present study showed the leg wound complication rates of 1.3% (2 of 153), which was much lower than previous studies, and all 2 patients recovered after secondary intention healing.

Conclusion

Sternal wound complications after CABG may be minimized if we obey the current guidelines in addition to the unilateral ITA usage and meticulous closure of the sternal wound. Wound complication rates after NT SV harvest after CABG may also be minimized by preoperative evaluation of the vascular status of the lower limb, selection of adequate vein, creation of a precise skin incision, careful harvesting of the vein, placement of a drain into the vein harvest site, and meticulous closure of the wound.

Declarations

Ethics approval and consent to participate

The study protocol was reviewed by the Institutional Review Board and approved as a minimal-risk retrospective study (Approval Number: MJH 2023-08-008) that did not require individual consent based on the institutional guidelines for waiving consent.

Funding

Not applicable.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Authors' contributions

M-S Kim contributed to the study conception and design, data collection, analysis and interpretation of the

results, and manuscript preparation. SW Hwang contributed to the study conception and design. K-B Kim contributed to the study conception and design. All authors reviewed the results and approved the final version of the manuscript.

Disclosure statement

Not applicable.

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