Deep sternal wound infection after bilateral internal thoracic artery grafting: Insights from a Japanese national database

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ABSTRACT

Objectives: Despite its survival benefits, bilateral internal thoracic artery (BITA) grafting is not commonly utilized due to concerns over deep sternal wound infection (DSWI). The present study investigated the early outcome of BITA grafting and analyzed the risk of DSWI using a Japanese national database (the Japan Adult Cardiovascular Surgery Database).

Methods: Data from 560 hospitals were used. Between April 2012 and December 2015, BITA was harvested in 14,249 patients, corresponding to 32.6% of isolated coronary artery bypass cases. DSWI was defined as a wound infection requiring surgical intervention and/or the administration of antibiotics. Multiple logistic regression analysis was employed to model the risk of DSWI.

Results: The mean age was 67.1 years. The prevalence of diabetes, renal failure, hemodialysis, and liver dysfunction was 51.8%, 21.2%, 7.8%, and 1.2%, respectively. The incidence of DSWI and operative mortality was 1.6 (234 patients) and 1.6% (226 patients), respectively. The operative mortality rate in patients with DSWI was 13.7% (32 patients). The off-pump technique was used in 72.8%, with a conversion rate of 2.5%. Female sex, diabetes mellitus, chronic lung disease, renal failure, liver dysfunction, ejection fraction $\leq 60\%$, shock status, reoperation, preoperative intra-aortic balloon pump use, and an increased operative time were independent risk factors for DSWI after BITA grafting. The off-pump technique did not reduce the risk of DSWI.

Conclusions: The present study showed that early outcomes of BITA grafting were satisfactory regarding DSWI and operative mortality. The current data are informative to predict the risk of DSWI when performing BITA grafting. (J Thorac Cardiovasc Surg 2019;157:166-73)

In situ bilateral internal thoracic artery grafting to the left coronary artery.

Central Message

Bilateral internal thoracic artery grafting in isolated CABG provides an acceptable rate of deep sternal wound infection and mortality in a national database, even with a high rate of BITA use.

Perspective

The current study, using a Japanese national database with a high rate of bilateral internal thoracic artery grafting, showed satisfactory outcomes regarding mortality and the incidence of deep sternal wound infection. The risk model of deep sternal wound infection developed in the present study is informative when considering bilateral internal thoracic artery grafting.

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Bilateral internal thoracic artery (BITA) grafting provides survival benefits over single internal thoracic artery (ITA) grafting.¹⁻⁵ However, the rate of utilizing BITA grafting is

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Abbreviations and Acronyms

AUC	= area under the curve
BITA	= bilateral internal thoracic artery
CABG	= coronary artery bypass grafting
DSWI	= deep sternal wound infection
ITA	= internal thoracic artery
JACVSD	= Japan Adult Cardiovascular Surgery Database
STS	= Society of Thoracic Surgeons

still low—up to 5% in the United States⁶⁻⁸ and 10% in Europe^{9,10}—due to concerns over technical difficulties, a longer operative time, and/or higher incidence of wound complications, especially in patients with multiple comorbidities.^{6,7,11-13} Deep sternal wound infection (DSWI) is a devastating complication, associated with mortality, a longer hospital stay, and higher cost of medical care.^{11,14-16} In the Society of Thoracic Surgeons (STS) practice guideline, BITA use should be considered for patients who do not have an excessive risk of sternal complications as a Class IIa indication.¹⁷ However, it is difficult to predict the risk because the availability of BITA and incidence of DSWI are low,^{3,8,9,18} and most reports were from single-center studies and lacked statistical power.^{15,16,18,19} The aim of this study was to review the early outcomes and analyze the risks of DSWI after BITA grafting using the Japan Adult Cardiovascular Surgery Database (JACVSD), in which the rate of BITA grafting is more than 30% of isolated coronary artery bypass grafting (CABG).^{13,20,21}

PATIENTS AND METHODS**Database**

The JACVSD is a national web-based database that incorporates clinical datasets from 560 hospitals in 2015, corresponding to nearly all cardiovascular units in Japan.^{20,22} The data registration project was approved by the institutional review board and informed consent regarding data registration was obtained from all patients at each participating hospital. The data collection form has a total of 255 variables (definitions are available online at www.jacvds.umin.jp in Japanese), and these are almost identical to those in the STS National Database (<http://sts.org>). The JACVSD is a web-based data collection system, and each patient's consent was obtained before data entry. The data manager of each participating hospital was responsible for forwarding his or her data electronically to the central office. The rate of data entry was annually monitored in the central office to ensure comprehensive input of the data. The accuracy of submitted data was maintained through a data audit; administrative office members and investigators who previously used the JACVSD for clinical studies randomly visited a participating hospital every month. The present study was approved by the JACVSD Board.

We examined isolated CABG cases between January 1, 2013, and December 31, 2015, using this database, and collected 43,658 isolated CABG cases. The left ITA was harvested in 37,971 patients (87.0%). Of these, 14,249 patients (32.6% of isolated CABG) whose BITA had been harvested were retrospectively analyzed based on the intention-to-treat principle.

Surgical Procedures

ITA was generally harvested with electrocautery and/or an ultrasound scalpel. The method of harvesting ITA as pedicled or skeletonized; pump use; graft arrangement, including in-situ, composite, or aortocoronary bypass grafting; and fashion of anastomosis were determined at each institute. Distal anastomosis was generally performed with 7-0 or 8-0 polypropylene suture. Information on the following was not available in the JACVSD database: ITA harvesting technique, the method of sterilization, chest preparation (eg, hair removal), hemostatic agent application to the sternum, the method of closing the chest, placement of a chest tube, pre- and perioperative administration of antibiotics, and perioperative blood glucose management.

End Points and Definition

The primary end points were DSWI and operative mortality. DSWI was defined as a wound infection involving muscle, bone, and/or the mediastinum, that meets any of the following conditions: wound opened with excision of tissue or re-exploration of mediastinum, positive culture, or treatment with antibiotics. The definition of operative mortality in JACVSD was exactly the same as in the STS National Database. This includes any patient who died within the index period of hospitalization, regardless of the length of hospital stay, as well as any patient who died after being discharged from hospital up to 30 days from the date of the operation. Stroke was defined as a new neurologic deficit persisting for more than 72 hours. Postoperative renal failure was defined as a patient with newly required hemodialysis or a patient showing a creatinine increase ≥ 2 -fold the preoperative baseline and ≥ 2.0 mg/dL.

Preoperative factors were defined as liver dysfunction (liver enzymes ≥ 100 IU, total bilirubin ≥ 1.5 mg/dL, or presence of cirrhosis), renal failure²³ (the presence of proteinuria, serum creatinine ≥ 1.3 mg/dL, or estimated glomerular filtration rate < 60 mL/min/1.73 m²), or moderate degree of chronic lung disease (forced expiratory volume 1.0 $< 60\%$, steroid use, oxygen tension ≤ 60 mm Hg, or carbon dioxide tension ≥ 50 mm Hg).

Statistical Analysis

Continuous variables are expressed as mean $\pm$ standard deviation. The differences between groups were compared using Student *t* test for normally distributed continuous data, or the Mann-Whitney *U* test for nonnormally distributed continuous variables, and using the χ^2 test for categorical variables. Data on age and all categorical variables, including sex and 30-day and hospital mortality, were available for all patients. The mode was used in the event of missing data for the following continuous variables: body mass index ($n = 1$), preoperative creatinine ($n = 43$), operative time ($n = 3$), and postoperative creatinine ($n = 40$). The statistical method applied was the forward stepwise regression model. The odds ratio for DSWI was estimated after adjustment. All variables significant at the $P < .05$ level were entered into the model provided they were present in at least 1% of the sample (Table E1). We entered the annual case volume of each institute into the model: ≤ 50 cases as a reference, 51 to 100 cases, 101 to 200 cases, and ≥ 201 cases. A multivariable forward stepwise logistic regression analysis was then performed. In the case of continuous variables, in which the relationship with the outcome was not linear, we determined cutoff points, such as body mass index. To evaluate model calibration, the Hosmer-Lemeshow test for goodness of fit was applied ($P = .884$) (Figure 1). The area under the receiver operating characteristic curve (AUC) was used to assess how well the model could discriminate between patients with and without events. AUC < 0.7 was considered poor, 0.7 to 0.8 was acceptable, and > 0.8 was excellent. SPSS version 24.0 (IBM-SPSS Inc, Armonk, NY) was used for all analyses.

RESULTS**Preoperative Characteristics**

Table 1 shows preoperative characteristics. The mean age was 67.1 ± 9.9 years. The prevalence of triple-vessel disease

FIGURE 1. Deep sternal wound infection risk model calibration.

and a left main lesion was 78% and 41.9%, respectively. Diabetes mellitus was diagnosed in 51.8% of patients (7376 out of 14,249). Twenty-three percent of patients had a previous history of percutaneous coronary intervention (PCI).

The prevalence of diabetes mellitus; chronic lung disease; renal failure, including hemodialysis; congestive heart failure; a low ejection fraction; unstable angina; previous myocardial infarction; cardiogenic shock; and reoperation was significantly higher in patients with DSWI. The proportion of female patients was higher in the DSWI group. The rates of using steroids, antiplatelet agents except for aspirin, and an intra-aortic balloon pump were significantly higher in patients with DSWI.

Operative Outcomes

Of 14,249 patients from whom BITA was harvested, it was utilized in 13,484 patients (94.6%) (Table 2). The mean operative time was significantly longer in patients with than without DSWI (370 ± 102 minutes vs 350 ± 98 minutes, respectively; $P < .001$). The median number of distal anastomoses was 3 (mean, 3.5 ± 1.1) in each group. The great saphenous vein was used in 64.4% of patients, followed by the gastroepiploic artery (12.5%) and left radial artery (10.0%). An off-pump procedure was performed in 10,375 patients (72.8%), with a conversion rate of 2.5%. The aorta-no-touch technique was used in 46.5% of off-pump CABG cases.

Postoperative Outcomes

The total incidence of DSWI was 1.6% in BITA grafting. In patients with diabetes, the incidence of DSWI was 2.3% (168 out of 7376). Annual incidences of DSWI after BITA harvesting were 1.6% in 2013, 1.9% in 2014, and 1.4% in 2015 ($P = .202$). The 30-day and operative mortality rates of BITA grafting were 0.8% and 1.6%, respectively (Table 3). The incidence of reoperation for bleeding of BITA grafting was 1.2%.

The operative mortality rate in patients with DSWI was significantly higher than in the control group (13.7% vs 1.4%; $P < .001$). The incidence of morbidities, including reoperation for bleeding, stroke, renal failure, and prolonged ventilation, was significantly higher in patients with DSWI. Patients with DSWI had higher incidences of postoperative atrial fibrillation, pneumonia, urinary tract infection, gastrointestinal bleeding, and readmission. The length of hospital stay was significantly longer in patients with DSWI.

Risk Model

Logistic regression analysis demonstrated that female sex, diabetes mellitus, renal failure, moderate or greater chronic lung disease, liver dysfunction, shock status, reoperation, ejection fraction $< 60\%$, preoperative intra-aortic balloon pump use, and increased operative time were independent risk factors for DSWI (Table 4). The total number of cases at each center was not a significant risk factor for DSWI. AUC of this risk model was 0.7003, representing an acceptable discrimination power (Figure 2).

DISCUSSION

The present study using the JACVSD showed satisfactory early outcomes of BITA grafting with a higher usage rate of BITA in isolated CABG, and a risk model of DSWI was developed. The major reason operators hesitate to perform BITA grafting is concern over DSWI, especially in patients with multiple preoperative risk factors such as diabetes mellitus, a low ejection fraction, lung disease, and chronic kidney disease.^{11,16,18,19} Indeed, the present study showed that the rate of serious postoperative complications, including hospital death and major morbidities, was significantly higher in DSWI patients. Nonetheless, the survival benefits of BITA grafting for these high-risk patients have been reported compared with single ITA grafting.^{3-5,13} Therefore, an appropriate risk assessment of DSWI is essential to minimize the risk and maximize the long-term benefits derived from BITA use. Furthermore, the current analysis using a national database with high rates of BITA harvesting may provide significant insight beyond that offered by previous studies from leading centers.^{1-3,5,15}

The incidence of DSWI in the present cohort (1.6%) was acceptable compared with reports of BITA grafting from multiple centers or nationwide cohorts (1.4%-5.2%).^{7-9,20} In terms of patients with diabetes, the incidence of DSWI receiving BITA grafting is reported to be from 2.9 to 11.6%,^{3,13,15,20} and in the present study was 2.3%. As for the preoperative characteristics of the present cohort, the prevalence of diabetes (51.8% in the present cohort vs 18.2%-33.3% in patients who underwent BITA grafting in previous studies),^{1,6-8,14} renal failure (21.2% vs 1.7%-7.7% in patients who underwent BITA grafting in previous studies)^{6-8,14,24} including chronic hemodialysis (7.8% vs 0.5%-1.2% in patients who underwent BITA

TABLE 1. Patient characteristics

Characteristics	All (N = 14,249)	Deep sternal wound infection (n = 234)	No deep sternal wound infection (n = 14,015)	P value
Age (y)	67.1 ± 9.9	67.6 ± 10.7	67.1 ± 9.9	.465
Male	11,850 (83.2)	11,675 (74.5)	11,675 (83.3)	.001
Body surface area (m ²)	1.68 ± 0.18	1.67 ± 0.20	1.68 ± 0.18	.420
Body mass index	24.0 ± 3.5	24.4 ± 3.8	24.0 ± 3.5	.088
Body mass index ≥30	756 (5.3)	15 (6.4)	741 (5.3)	.447
Hypertension	10,981 (77.1)	188 (80.3)	10,793 (77.0)	.229
Hyperlipidemia	9476 (66.5)	151 (64.5)	9325 (66.5)	.519
Diabetes mellitus	7376 (51.8)	168 (71.8)	7208 (51.4)	<.001
Diabetes with treatment	6206 (43.6)	143 (61.1)	6063 (43.2)	<.001
Peripheral artery disease	2212 (15.5)	41 (17.5)	2171 (15.5)	.395
Smoking history	7715 (54.1)	115 (49.1)	7600 (54.2)	.122
Smoking ≤1 mo	2588 (18.2)	44 (18.8)	2544 (18.2)	.798
Chronic lung disease moderate or greater	272 (1.9)	10 (4.3)	262 (1.9)	.008
Renal failure	3025 (21.2)	88 (37.6)	2937 (21.0)	<.001
Hemodialysis	1114 (7.8)	41 (17.5)	1073 (7.7)	<.001
Creatinine (mg/dL)	0.90 (0.76-1.14)	0.94 (0.76-1.74)	0.90 (0.76-1.14)	<.001
Estimated glomerular filtration rate (mL/min/1.73 m ²)	47.1 ± 25.9	41.9 ± 24.6	47.2 ± 25.9	.001
Liver dysfunction	169 (1.2)	10 (4.3)	159 (1.1)	<.001
Cerebrovascular disease	1576 (11.1)	32 (13.7)	1544 (11.0)	.198
Carotid stenosis	1089 (7.6)	17 (7.3)	1072 (7.6)	.826
Atrial fibrillation	458 (3.2)	13 (5.6)	445 (3.2)	.041
Operation emergent	524 (3.7)	7 (3.0)	517 (3.7)	.574
Congestive heart failure	3265 (22.9)	80 (34.2)	3185 (22.7)	<.001
New York Heart Association functional class IV	784 (5.5)	24 (10.3)	760 (5.4)	.001
Shock	282 (2.0)	19 (8.1)	263 (1.9)	<.001
Left main disease	5971 (41.9)	95 (40.6)	5876 (41.9)	.683
Triple-vessel disease	11,109 (78.0)	189 (80.8)	10,920 (77.9)	.296
Canadian Cardiovascular Society classification IV	2302 (16.2)	56 (23.9)	2091 (14.9)	<.001
Angina	12,041 (84.5)	206 (88.0)	11,853 (84.5)	.132
Unstable angina	4233 (29.7)	86 (36.8)	4147 (29.6)	.017
Percutaneous coronary intervention	3407 (23.9)	58 (24.5)	3349 (23.9)	.751
Old myocardial infarction	4661 (32.7)	95 (40.6)	4566 (32.6)	.010
Ejection fraction 30%-60%	6173 (43.3)	136 (58.1)	6037 (43.1)	<.001
Ejection fraction <30%	742 (5.2)	15 (6.4)	727 (5.2)	.404
Reoperation	106 (0.7)	5 (2.6)	101 (0.7)	.012
Aortic stenosis	371 (2.6)	6 (2.6)	365 (2.6)	.969
Aortic regurgitation ≥2	924 (6.5)	14 (6.0)	910 (6.5)	.753
Mitral regurgitation ≥2	2087 (14.6)	47 (20.1)	2040 (14.6)	.018
Tricuspid regurgitation ≥2	1055 (7.4)	26 (11.1)	1029 (7.3)	.029
Aspirin ≤5 d	5191 (36.4)	82 (35.0)	5109 (36.4)	.656
Other antiplatelet agent ≤5 d	1161 (8.1)	30 (12.8)	1131 (8.1)	.008
Anticoagulant medication ≤48 h	1517 (10.6)	29 (12.4)	1488 (10.6)	.382
Beta blockers	4668 (32.8)	90 (38.5)	4578 (32.7)	.061

(Continued)

TABLE 1. Continued

Characteristics	All (N = 14,249)	Deep sternal wound infection (n = 234)	No deep sternal wound infection (n = 14,015)	P value
Steroids	158 (1.1)	6 (2.6)	152 (1.1)	.032
Inotropic agents	152 (1.1)	3 (1.3)	149 (1.1)	.741
Intra-aortic balloon pump	1915 (13.4)	55 (23.5)	1860 (13.3)	<.001

Values are presented as mean $\pm$ standard deviation, n (%), or median (interquartile range).

grafting in previous studies),^{6,8,15} previous percutaneous coronary intervention (23.9% vs 3.2%-16.7 in patients who underwent BITA grafting in previous studies),^{2,10,15} and peripheral artery disease (15.5% vs 6.5%-9.5% in patients who underwent BITA grafting in previous studies)^{1,7,15} was higher compared with other reports. Possible reasons are that the mean age was older in the present compared with previous studies (67.1 years vs 56.0-60.1 years), and the above preoperative risks might interact with each other and increase the prevalence.^{1,6,8,9}

In the present risk model, 10 variables were identified as predictors of DSWI after BITA grafting with an acceptable accuracy of prediction. Of these, female sex, diabetes mellitus, renal failure, and chronic lung disease have been

recognized as major risk factors for DSWI.^{9,12,16,18} Preoperative liver disease is associated with postoperative liver/renal failure, bleeding, and poor wound healing; however, it is not included in the variables of the STS risk score or European system for cardiac operative risk evaluation II. The present study showed that liver dysfunction is a strong risk factor for DSWI after BITA grafting. The preoperative hemodynamic status, such as ejection fraction < 60%, preoperative intra-aortic balloon pump use, and shock status were also identified as independent risk factors for DSWI. These results are reasonable because a low output status has been recognized as a risk factor for infection.^{18,19} An increase in the operative time is directly associated with an increased risk of DSWI;

TABLE 2. Operative details

Characteristics	All (N = 14,249)	Deep sternal wound infection (n = 234)	No deep sternal wound infection (n = 14,015)	P value
BITA harvest	14,249 (100)	234 (100)	14,015 (100)	—
BITA use	13,484 (94.6)	225 (96.2)	13,249 (94.5)	.297
Left ITA use	13,991 (98.2)	230 (98.3)	13,761 (98.2)	.907
Right ITA use	13,698 (96.1)	227 (97.0)	13,476 (96.2)	.484
Saphenous vein	9176 (64.4)	161 (68.8)	9015 (64.3)	.156
Left radial artery	1423 (10.0)	16 (6.8)	1407 (10.0)	.105
Right radial artery	244 (1.7)	5 (2.1)	239 (1.7)	.614
Gastroepiploic artery	1783 (12.5)	29 (12.4)	1754 (12.5)	.955
Number of distal anastomosis	3 (3-4)	3 (3-4)	3 (3-4)	.755
2	2501 (17.6)	41 (17.5)	2460 (17.6)	
3	5188 (36.4)	91 (38.9)	5097 (36.4)	
≥ 4	6560 (46.0)	102 (43.6)	6458 (46.1)	.701
Operative time, min	351 $\pm$ 98	370 $\pm$ 101	350 $\pm$ 98	.002
≤ 3 h	185 (1.3)	3 (1.3)	182 (1.3)	
3-4 h	1283 (9.0)	17 (7.3)	1266 (9.0)	
4-5 h	3015 (21.6)	37 (15.8)	2978 (21.2)	
5-6 h	3842 (27.0)	56 (23.9)	3768 (26.9)	
6-7 h	2919 (20.5)	59 (25.2)	2860 (20.4)	
≥ 7 h	3002 (21.1)	62 (26.5)	2940 (21.0)	.057
Off-pump	10,375 (72.8)	163 (70.0)	10,212 (72.9)	.274
Conversion from off-pump	259/10,375 (2.5)	4/163 (2.5)	255/10,212 (2.5)	1.00
Aorta-no-touch	4820/10,375 (46.5)	76/163 (46.6)	4744/10,212 (46.5)	.660
Transfusion	8922 (62.6)	169 (72.2)	8753 (62.5)	.002

Values are presented as n (%), mean $\pm$ standard deviation, or n/n (%). BITA, Bilateral internal thoracic artery; ITA, internal thoracic artery.

TABLE 3. Postoperative results

Outcomes	All (N = 14,249)	Deep sternal wound infection (n = 234)	No deep sternal wound infection (n = 14,015)	P value
30-d mortality	120 (0.8)	4 (1.7)	116 (0.8)	.135
Operative mortality	226 (1.6)	32 (13.7)	194 (1.4)	<.001
Reoperation for bleeding	165 (1.2)	10 (4.3)	155 (1.1)	<.001
Stroke	207 (1.5)	10 (4.3)	197 (1.4)	<.001
Prolonged ventilation	381 (2.7)	28 (12.0)	353 (2.5)	<.001
Renal failure	309 (2.2)	25 (10.7)	284 (2.0)	<.001
Newly requiring dialysis	211 (1.5)	19 (8.1)	192 (1.4)	<.001
Perioperative myocardial infarction	102 (0.7)	1 (0.4)	101 (0.7)	1.00
Cardiac tamponade	103 (0.7)	4 (1.7)	99 (0.7)	.090
Transient ischemic attack	134 (0.9)	9 (3.8)	125 (0.9)	<.001
Atrial fibrillation	1725 (12.1)	47 (20.0)	1678 (12.0)	<.001
Anticoagulation-related complications	46 (0.3)	4 (1.7)	42 (0.3)	.007
Gastrointestinal bleeding	137 (1.0)	15 (6.4)	122 (0.9)	<.001
Inferior leg infection	163 (1.1)	10 (4.3)	153 (1.1)	<.001
Pneumonia	246 (1.7)	23 (9.8)	223 (1.6)	<.001
Urinary tract infection	122 (0.9)	8 (3.4)	114 (0.8)	<.001
Hospital stay (d)	16 (12-22)	55 (34-87)	16 (12-21)	<.001
Readmission ≤30 d	298 (2.1)	14 (6.0)	284 (2.0)	<.001

Values are presented as n (%) or median (interquartile range).

therefore, surgeons should make a concerted effort to shorten the operative time when conducting BITA grafting. Obesity was not an independent risk factor in the present study. This may be because the prevalence of overweight and obesity is lower in Asians (mean body mass index, 23-24)^{4,18,20,22} compared with that in Western populations (mean body mass index, 28-29).^{6,10}

A recent subanalysis of the Arterial Revascularization Trial trial clearly demonstrated that a skeletonized BITA lowers the risk of DSWI compared with a pedicled

BITA.⁹ A limitation of the present study was that data on the harvesting technique were not available despite the skeletonization technique is widely available in Japan (Video 1).^{4,18,21} A rate of off-pump revascularization higher than 60% is another feature of CABG in Japan.^{4,13,20,21} The nonuse of cardiopulmonary bypass is expected to reduce the

TABLE 4. Multiple logistic regression analysis of deep sternal wound infection

Variables	Odds ratio	95% Confidence interval	P value
Male	0.57	0.42-0.77	<.001
Diabetes mellitus	2.13	1.59-2.85	<.001
Renal failure	1.80	1.37-2.38	<.001
Chronic lung disease moderate or greater	2.19	1.13-4.25	.021
Liver dysfunction	2.92	1.48-5.75	.002
Shock	2.88	1.66-4.98	<.001
Reoperation	2.64	1.04-6.67	.041
Ejection fraction <60%	1.54	1.16-2.04	.003
Intra-aortic balloon pump	1.44	1.01-2.02	.043
Operative time	1.001	1.0003-1.002	<.001

FIGURE 2. The areas under the receiver operating characteristic curve (AUC) for deep sternal wound infection. The AUC was 0.701.

VIDEO 1. Bilateral internal thoracic artery (BITA) grafting with off-pump technique. Skeletonized BITA was harvested with using an ultrasound scalpel. Both grafts are long enough to reach targets. The in situ right ITA is anastomosed to the left anterior descending artery, and in situ left ITA is anastomosed to the posterolateral branch of the circumflex artery. Video available at: [https://www.jtcvs.org/article/S0022-5223\(18\)32320-1/fulltext](https://www.jtcvs.org/article/S0022-5223(18)32320-1/fulltext).

perioperative systematic inflammatory response; however, off-pump CABG was not identified as an independent factor to reduce DSWI.^{9,18}

In the STS National Database, DSWI involves muscle, bone, and/or the mediastinum and must meet all of the 3 conditions specified in JACVSD definition (see [Methods](#)). Thus, if we applied the criteria of the STS National Database to the present study cohort, the number of DSWI cases in our cohort may be lower. However, it is not possible for us to identify the number of DSWI patients in the present study meeting the same criteria of the STS National Database.

We should note several limitations in this study. First, this was a retrospective study using a nationwide data-entry system. Second, a detailed breakdown of DSWI was not available, such as how many patients were treated solely with antibiotic agents, or underwent mediastinal drainage or sternal reconstruction. Third, detailed operative procedures, such as how ITA was harvested (pedicled or skeletonized) and how the ITA graft was utilized (in situ, free, or composite graft), were not available in JACVSD. Fourth, the exact number of patients not consenting to the data entry is unknown. Fifth, external validation using another database was difficult. Finally, JACVSD does not provide long-term data.

CONCLUSIONS

We reported the results and risks of DSWI after BITA grafting using a nationwide Japanese database. Although early outcomes of BITA grafting were acceptable, the incidences of hospital death and major morbidities after DSWI were higher than those without DSWI. The current data and risk model are informative to evaluate the risk of DSWI when performing BITA grafting.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: bilateral internal thoracic artery, coronary artery bypass grafting, deep sternal wound infection

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TABLE E1. Preoperative and intraoperative variables for entry into the logistic regression model

Preoperative variables
Operation year (2013, 2014, or 2015)
Age
≤ 60 y (reference)
60-65 y
66-70 y
71-75 y
76-80 y
> 80 y
Sex
Smoking history
Smoking ≤ 1 month before surgery
Diabetes mellitus
Diabetes mellitus with treatment
Renal failure
Dialysis
Estimated glomerular filtration rate ≤ 30 mL/min/1.73 m ²
Hyperlipidemia
Hypertension
Cerebrovascular disease
Recent cerebrovascular disease (≤ 2 wk)
Carotid stenosis
Carotid stenosis, bilateral
Chronic lung disease
≥ Moderate
≥ Mild
Liver dysfunction
Extracardiac arterial disease
Peripheral artery disease
Thoracic aortic disease
Percutaneous coronary intervention
Old myocardial infarction
Congestive heart failure
Cardiogenic shock
Atrial fibrillation
Cardiac catheterization
Reoperation
Body mass index
≥ 30
≥ 35
New York Heart Association functional class
4
≥ 3
Canadian Cardiovascular Society grade
4
3
≥ 3
Number of diseased vessels
3
≥ 2
Left main disease
Left ventricular ejection fraction
≤ 30%
≤ 60%
Aortic stenosis

TABLE E1. Continued

Mitral stenosis
Tricuspid stenosis
Pulmonary stenosis
Aortic insufficiency
Mitral insufficiency
Immunosuppression agent
Digitalis
Beta blockers
Intravenous nitrates
Inotropic agents
Aspirin
Other antiplatelets
Anticoagulants
Steroids
Intra-aortic balloon pump
Intraoperative variables
Operation time
Transfusion
Right radial harvest
Left radial harvest
Gastroepiploic artery harvest
Saphenous vein graft harvest
Off-pump
Number of distal anastomosis

(Continued)