Original Article

Concomitant off-pump coronary artery bypass and non-cardiovascular surgery

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Background: Reports on concomitant cardiac and non-cardiovascular surgeries have noted disadvantages in the use of extracorporeal circulation. We assessed the results of concomitant off-pump coronary artery bypass (OPCAB) and non-cardiovascular surgery, and compared them with isolated OPCAB results.

Methods: Of 2,439 patients who underwent OPCAB between 1999 and 2014, 115 patients underwent concomitant OPCAB and non-cardiovascular surgery. Combined non-cardiovascular diseases included 63 malignant and 52 benign diseases. Concomitant non-cardiovascular surgeries performed were general (n=62), thoracic (n=47), orthopedic (n=3), urologic (n=2) and otolaryngologic surgeries (n=1). Operative results were compared between the OPCAB patients who underwent concomitant non-cardiovascular surgeries (group 1, n=115) and isolated OPCAB patients (group 2, n=2,251). Because preoperative characteristics of the two groups were different, a 1:2 propensity score-matched analysis was performed and operative results of the two matched groups were compared.

Results: Operative mortality rates were 0.9% (1/115) in group 1 and 1.0% (22/2,251) in group 2 (P=0.909). Although there were differences in preoperative patient characteristics, postoperative complications, including atrial fibrillation (36.5% *vs.* 28.8%), perioperative myocardial infarction (MI) (4.3% *vs.* 5.2%), acute renal failure (1.7% *vs.* 4.9%), mediastinitis (0.9% *vs.* 0.8%), bleeding reoperation (0.9% *vs.* 2.9%), and respiratory complications (2.6% *vs.* 2.1%), did not show significant differences between the two groups. After a 1:2 propensity score-matched analysis, there were no statistical differences in operative complications between the two groups.

Conclusions: Concomitant OPCAB and non-cardiovascular surgeries were not associated with increased mortality and postoperative morbidities when compared with isolated OPCAB.

Keywords: Coronary artery bypass grafting (CABG); off-pump CABG; concomitant cardiothoracic operations

Submitted May 26, 2016. Accepted for publication Jun 23, 2016.
doi: 10.21037/jtd.2016.07.80
View this article at: http://dx.doi.org/10.21037/jtd.2016.07.80

Introduction

Due to an aging patient population, the number of patients with both cardiac and non-cardiovascular surgical diseases is increasing (1). Non-cardiovascular surgical disease can be found during preoperative evaluation of a patient who is to undergo coronary artery bypass grafting (CABG), or significant coronary artery disease requiring revascularization can be found during preoperative evaluation of a patient who is to undergo non-cardiovascular surgery. One previous study demonstrated that prior successful CABG was protective by significantly lowering the perioperative cardiac complication rate among patients who underwent high-risk noncardiac surgery (2). However, the exact timing of CABG and composition of an appropriate patient population remained undefined. In addition, the staged procedures were associated with higher cost, delay in surgery for non-cardiovascular malignant disease, and longer hospital stays (3). Although concomitant operations avoid the need for a second operation and reduce the overall hospital stay and cost, surgeons are reluctant to perform concomitant cardiac and non-cardiovascular operations because of concerns about systemic heparin administration and exposure of two different operative fields (4).

Recent treatment guidelines for cardiac patients who also have non-cardiac vascular disease such as carotid or peripheral arterial disease have evaluated and summarized all available evidence (5); however, the surgical treatment strategy of concomitant cardiac and non-cardiovascular surgical disease remains controversial. The aims of the present study were: (I) to assess the operative mortality and postoperative morbidities of concomitant OPCAB and non-cardiovascular surgeries; (II) to compare the results of concomitant OPCAB and non-cardiovascular surgeries with those of isolated OPCAB.

Methods

The study protocol was reviewed by the Institutional Review Board and approved as a minimal risk retrospective study (approval number: H-1511-096-721) that did not require individual consent based on the institutional guidelines for waiving consent.

Patient characteristics

A total of 2,604 patients underwent isolated CABG between January 1999 and December 2014 at our institution, and OPCAB was performed in 2,439 patients (93.7%). Of the 2,439 OPCAB patients, 115 underwent concomitant OPCAB and non-cardiovascular surgery (group 1) and 2,251 underwent isolated OPCAB (group 2) and were included in the study. Informed written consent, including the possible benefits and risks of concomitant OPCAB and non-cardiovascular surgery, was obtained from all patients.

The remaining 73 patients who underwent concomitant OPCAB and non-cardiac vascular surgery, such as carotid endarterectomy, peripheral arterial bypass and abdominal aortic replacement, were excluded from the study because recent guidelines for such patients have already evaluated and summarized all available evidence (5). Preoperative patient characteristics revealed that group 1 patients were significantly older (67.9±9.4 *vs.* 64.2±9.4 years, P<0.0001), had less unstable angina (35.7% *vs.* 60.5%, P<0.0001) and required less emergent or urgent operation (6.1% *vs.* 17.0%, P=0.002) than group 2 patients. A propensity score model was constructed to adjust differences in preoperative characteristics and intraoperative data between the two groups, and 112 patients in group 1 and 224 patients in group 2 were extracted by 1:2 matching. There were no differences in demographic data and preoperative risk factors between the two propensity score-matched groups (*Table 1*). Combined non-cardiovascular diseases included 63 malignant (24 stomach cancers, 18 lung cancers, 13 colorectal cancers, and 8 other cancers), and 52 benign (15 pulmonary bullous emphysemas, 13 benign gallbladder diseases, 5 hernias, and 19 other benign conditions) diseases. Concomitant non-cardiovascular surgeries performed were general (n=62; 24 gastrectomies, 14 cholecystectomies, 13 colorectal resections, and 11 other general surgeries), thoracic (n=47; 15 bullectomies, 13 wedge resections, 5 thymectomies, 4 lobectomies, and 10 other thoracic surgeries), orthopedic (n=3), urologic (n=2), and otolaryngologic surgeries (n=1) (*Table 2*).

Operative technique

The basic surgical procedures and strategies of OPCAB have been previously described (6,7). During the study period, we changed revascularization strategies based on our patency study after OPCAB (6); however, the left internal thoracic artery has continuously been used as the first conduit of choice for CABG. Patients were given an initial dose of heparin (1.5 mg/kg) and periodic supplemental doses to maintain an activated clotting time of >300 seconds. Protamine was given to neutralize the effect of heparin at the end of OPCAB procedures. Group 1 patients stopped taking aspirin 5 days before the operation at the request of the non-cardiovascular surgeon; however, most of group 2 patients took aspirin until the day of surgery. All patients resumed aspirin as soon as possible after surgery. Therefore, patients stopped aspirin for a short perioperative period.

After myocardial revascularization and full neutralization of heparin to ensure a relatively dry field, a concomitant non-cardiovascular surgery was performed by a non-cardiovascular surgeon of each subspecialty in all group 1 patients. Thoracic surgeries such as lobectomy and pulmonary wedge resection

Table 1 Characteristics and risk factors of the study patients

Variables	All study patients			Propensity-matched patients		
	Group 1 (n=115)	Group 2 (n=2,251)	P value	Group 1 (n=112)	Group 2 (n=224)	P value
Age, years	67.9±9.4	64.2±9.4	<0.0001	67.6±9.1	68.1±8.0	0.636
Female, n (%)	24 (20.9)	610 (27.1)	0.141	23 (20.5)	53 (23.7)	0.495
Body mass index, kg/m^2	24.1±3.2	24.7±3.0	0.066	24.2±3.1	24.0±2.9	0.482
Risk factors, n (%)						
Smoking	59 (51.3)	980 (43.5)	0.102	57 (50.9)	106 (47.3)	0.516
Hypertension	82 (71.3)	1,535 (68.2)	0.484	79 (70.5)	160 (71.4)	0.874
Diabetes mellitus	51 (44.4)	1,051 (46.7)	0.623	51 (45.5)	103 (46.0)	0.934
Dyslipidemia	43 (37.4)	711 (31.6)	0.193	41 (36.6)	78 (34.8)	0.737
Cerebrovascular accident	12 (10.4)	298 (13.2)	0.384	12 (10.7)	25 (11.2)	0.891
Chronic renal failure	14 (12.2)	245 (10.9)	0.666	13 (11.6)	31 (13.8)	0.579
Chronic obstructive pulmonary disease	4 (3.5)	28 (1.3)	0.069	3 (2.7)	5 (2.2)	0.808
Left ventricular dysfunction (LVEF ≤35%)	9 (7.8)	263 (11.7)	0.206	9 (8.0)	27 (12.1)	0.279
Unstable angina	41 (35.7)	1,361 (60.5)	<0.0001	41 (36.6)	76 (33.9)	0.567
Left main disease	29 (25.2)	729 (32.4)	0.108	29 (25.9)	66 (29.5)	0.437
Redo operation	1 (0.9)	60 (2.7)	0.367	1 (0.9)	2 (0.9)	1.000
Emergent & urgent operation	7 (6.1)	382 (17.0)	0.002	7 (6.3)	19 (8.5)	0.435
Number of anastomoses	3.0±1.0	3.1±1.0	0.195	3.0±1.0	3.0±1.0	0.852

Values are mean ± standard deviation (SD) or n (%). LVEF, left ventricular ejection fraction.

were performed via the median sternotomy approach after OPCAB. General surgeries such as gastrectomy and cholecystectomy were performed by extension of the skin incision to the upper abdomen after closure of the sternum. Other non-cardiovascular surgeries were performed via a separate skin incision after closure of the median sternotomy wound.

Statistical analysis

Statistical analysis was performed with the SPSS (version 22; SPSS Inc., Chicago, IL, USA) and SAS (version 9.2; SAS Institute, Cary, NC, USA) statistical software packages. Data were expressed as mean ± standard deviation (SD), or proportions, and a P value of less than 0.05 was considered as statistically significant.

A propensity score matching analysis was performed to adjust differences in preoperative and intraoperative factors. A propensity score model was constructed by including 16 preoperative and intraoperative variables (P value for Hosmer Lemeshow test =0.6406, and c statistic =0.761). These variables were 15 preoperative factors such as sex, age, body mass index, smoking, hypertension, diabetes mellitus, dyslipidemia, history of stroke, chronic renal failure, chronic obstructive pulmonary disease, left ventricular dysfunction, unstable angina, left main coronary artery disease, redo operation, and urgent or emergent operation; and 1 operative factor (number of distal anastomoses). Because there was a large difference in the number of patients between the two groups, 112 patients in group 1 and 224 patients in group 2 were extracted by 1:2 matching. Comparison between the two groups was performed using the χ^2 test or Fisher exact test for categorical variables and the Student *t*-test or Wilcoxon rank sum test for continuous variables.

Results

The average number of distal anastomoses per patient was similar between the two groups (3.0±1.0 *vs.* 3.1±1.0, P=0.195). Operative mortalities (any death within 30 days, including deaths after hospital discharge) were 0.9% (1 of 115) in group 1 and 1.0% (22 of 2,251) in group 2 (P=0.909). Operative mortality in group 1 developed in an 81-year-old male with advanced stomach cancer who died of pneumonia on postoperative day 26. There were no significant differences in the incidence of postoperative morbidities

Table 2 Combined non-cardiovascular diseases and concomitant non-cardiovascular surgery

Operative name	Diagnosis	No.
Gastrectomy	Gastric cancer	24
Bullectomy	Bullous emphysema	15
Cholecystectomy (n=14)	Stone	9
	Adenomyomatosis	1
	Chronic cholecystitis	2
	Cystic duct stone	1
	Cancer	1
Pulmonary wedge resection (n=13)	Non-small cell lung cancer	3
	Small cell cancer	1
	Metastasis	5
	Benign solitary pulmonary nodule	2
	Interstitial lung disease	2
Colectomy	Colon cancer	9
Herniorrhaphy (n=5)	Inguinal hernia	2
	Hiatal hernia	1
	Umbilical hernia	1
	Incisional hernia	1
Paratracheal lymph node biopsy (n=5)	Non-small cell lung cancer	4
	Metastasis of colon cancer	1
Thymectomy (n=5)	Thymoma	1
	Thymic cyst	3
	Thymic carcinoma	1
Low anterior resection	Rectal cancer	4
Lobectomy	Non-small cell lung cancer	4
Diaphragmatic mass excision (n=2)	Schwannoma	1
	Benign tumor	1
Diaphragmatic plication	Diaphragm eventration	2
Perigastric lymph node biopsy (n=2)	Metastasis	1
	Reactive hyperplasia	1
Amputation (n=2)	Arteriosclerosis obliterans	1
	Diabetic mellitus foot	1
Abdominal mass excision	Schwannoma	1
Bipolar hemiarthroplasty	Femur neck fracture	1
Nephrectomy	Renal cell cancer	1
Nephroureterectomy	Ureter cancer	1
Radical mastectomy	Breast cancer	1
Neck mass excision	Squamous cell cancer	1
Tracheal resection and anastomosis	Tracheoesophageal fistula	1
Feeding jejunostomy	Esophageal cancer	1
Gastric wedge resection	Gastrointestinal stromal tumor	1

including atrial fibrillation (36.5% *vs.* 28.8%, P=0.077), perioperative myocardial infarction (MI) (4.3% *vs.* 5.2%, P=0.673), acute renal failure (1.7% *vs.* 4.9%, P=0.177), mediastinitis (0.9% *vs.* 0.8%, P=0.935), bleeding reoperation (0.9% *vs.* 2.9%, P=0.193), and respiratory complications (2.6% *vs.* 2.1%, P=0.705) between the two groups. After 1:2 propensity scoring, there were no significant differences in the postoperative morbidities between the two groups (*Table 3*).

Discussion

The present study demonstrated that concomitant OPCAB and non-cardiovascular surgery did not increase operative mortality and perioperative morbidities when compared with isolated OPCAB, and suggested that the need for second operation would be avoided by performing a combined procedure.

The combination of coronary artery and non-cardiovascular surgical diseases is not uncommon and is expected to increase due to an increasing elderly population. However, the optimal strategy for a patient who has combined cardiac and non-cardiovascular surgical diseases remains controversial. Surgical treatment can be performed separately by 2-stage operations or simultaneously by a concomitant operation. The 2-stage procedure, prior successful CABG followed by non-cardiovascular surgery, has been demonstrated to reduce mortality and morbidities; however, this technique was associated with higher cost, delay in surgery for malignant disease, and longer hospital stay (2,3,8). An unpredictable delay between the two procedures could be detrimental in cases of malignancy. Surgical management of combined surgical diseases at the same time is an ideal approach by virtue of avoiding the need for a second operation.

Previous studies demonstrated that concomitant operations avoided the need for a second operation and reduced the overall hospital stay and cost (4,9). However, concomitant cardiac surgery using cardiopulmonary bypass had a substantial risk of postoperative bleeding due to the inevitable coagulopathy and platelet dysfunction seen when using cardio pulmonary bypass (4).

In addition, use of cardiopulmonary bypass for cardiac surgery has been shown to have a possible detrimental effect on both cellular and humoral immunity, thereby causing immunosuppression, dissemination, or progression of malignant disease (9-13). In addition, cardiac surgery using cardiopulmonary bypass generally causes systemic tissue edema, which may increase the risk of failure of

Table 3 Mortality & morbidities

Variables	All study patients			Propensity-matched patients		
	Group 1 (n=115)	Group 2 (n=2,251)	P value	Group 1 (n=112)	Group 2 (n=224)	P value
Operative mortality (<30 d)	1 (0.9)	22 (1.0)	0.909	1 (0.9)	0 (0.0)	–
Atrial fibrillation	42 (36.5)	649 (28.8)	0.077	41 (36.6)	71 (31.7)	0.363
Perioperative MI	5 (4.3)	118 (5.2)	0.673	5 (4.5)	6 (2.7)	0.377
Stroke	1 (0.9)	37 (1.6)	0.519	1 (0.9)	5 (2.2)	0.403
Delirium	5 (4.3)	72 (3.2)	0.498	4 (3.6)	7 (3.1)	0.831
Acute renal failure	2 (1.7)	111 (4.9)	0.117	2 (1.8)	12 (5.4)	0.136
Mediastinitis	1 (0.9)	18 (0.8)	0.935	1 (0.9)	4 (1.8)	0.535
LCOS	1 (0.9)	20 (0.9)	0.983	1 (0.9)	1 (0.5)	0.624
Respiratory complication	3 (2.6)	47 (2.1)	0.705	3 (2.7)	5 (2.2)	0.790
Bleeding reoperation	1 (0.9)	66 (2.9)	0.193	1 (0.9)	6 (2.7)	0.273

Values are n (%). MI, myocardial infarction; LCOS, low cardiac output syndrome.

gastrointestinal tract anastomoses (13). A recent trend has been the use of off-pump CABG to avoid the effect of cardiopulmonary bypass and decrease the use of heparin (10,14,15). The off-pump technique could markedly lower the risk of the disadvantages related to use of cardiopulmonary bypass, although other studies found no advantage of using an off-pump technique compared with cardiac surgery using cardiopulmonary bypass (3,13-15).

The present study demonstrated that concomitant OPCAB and non-cardiovascular surgery compared with those of isolated OPCAB did not increase operative mortality and perioperative morbidities, although the majority of patients had concomitant malignant disease and underwent laparotomy (63 patients had combined malignant diseases; 62 patients underwent general surgeries opening the abdominal cavity). In addition, gastrointestinal surgery also carries a risk of bacterial contamination during concomitant cardiac surgery. In the present study, one diabetic patient who received bilateral internal thoracic artery grafts developed mediastinitis in group 1. Incidence of mediastinitis was not higher in group 1 compared with group 2.

There are limitations to the present study that must be recognized. First, the present study was a retrospective observational study in a single institution, although 1:2 propensity score-matched analysis was performed to overcome the limitation of difference in baseline patient characteristics. Second, the results of concomitant OPCAB surgery were not compared with those of concomitant on-pump CABG surgery, because almost all CABG procedures at our institution were performed using OPCAB during the study period. Third, the results of concomitant OPCAB surgery were not also compared with those of the 2-stage operations, because almost all surgical management of combined surgical diseases at our institution were performed using concomitant OPCAB during the study period. Fourth, mid-term or long-term follow up results were not included in the present study. It will be necessary to extend the follow-up and to demonstrate more completely the advantages of concomitant OPCAB and non-cardiovascular surgery, particularly in patients with malignancies.

Acknowledgements

We wish to thank the Medical Research Collaborating Center, Seoul National University Hospital, for providing statistical consultation services.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study protocol was reviewed by the Institutional Review Board and approved as a minimal risk retrospective study (approval number: H-1511-096-721) that did not require individual consent based on the institutional guidelines for waiving consent.

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Cite this article as: Oh HC, Han JW, Choi JW, Kim YH, Hwang HY, Kim KB. Concomitant off-pump coronary artery bypass and non-cardiovascular surgery. J Thorac Dis 2016;8(8):2115-2120. doi: 10.21037/jtd.2016.07.80