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CORRESPONDENCE

Research Correspondence

The Incidence and Clinical Outcome of Constrictive Physiology After Coronary Artery Bypass Graft Surgery

To the Editor: Previous reports have shown changes in the etiologic spectrum of constrictive pericarditis, characterized mainly by a declining incidence of tuberculous pericarditis and an increase in cases resulting from cardiac surgery (1). Constrictive physiology (CP) not only is found in patients with symptomatic constrictive pericarditis but is also more commonly observed in post-cardiac surgery patients when assessed with comprehensive echocardiographic examination. However, few data are available with regard to echocardiographically observed post-operative CP. Therefore, the purpose of this study was to investigate the incidence and clinical course of CP observed on post-operative echocardiographic examination in patients who had undergone isolated coronary artery bypass graft (CABG) surgery.

Our study population consisted of 454 consecutive patients who underwent isolated CABG with comprehensive pre- and post-operative transthoracic echocardiography (TTE) at the Severance Cardiovascular Hospital from 2004 to 2006. The patients were divided into 2 groups (the CP group vs. the No-CP group) according to the presence or absence of the following CP findings on post-operative TTE (2): abnormal ventricular septal motion, dilated inferior vena cava, typical respiratory variations in mitral or hepatic venous flow, and preserved or exaggerated early diastolic mitral annular velocity.

Seventy-eight (17%) of 454 patients showed CP on post-operative TTE (Table 1). In the CP group, no patient showed right ventricular dysfunction, and 5 patients (6%) showed severe tricuspid regurgitation. There were no significant differences in preoperative baseline characteristics between the 2 groups. However, on post-operative TTE, which was conducted a median of 7 days (interquartile range [IQR]: 6 to 9 days) after CABG in the CP group and a median of 7 days (IQR: 6 to 9 days) after CABG in the No-CP group ($p = 0.863$), left ventricular ejection fraction (LVEF) was higher (59 ± 12% vs. 55 ± 13%, $p = 0.030$), and the frequency of regional wall motion abnormality was lower (36% vs. 51%, $p = 0.019$) in the CP group. Also, pericardial effusion on TTE was more commonly observed in the CP group (39% vs. 19%, $p < 0.001$). Cardiac multi-detector computed tomography (MDCT) was performed within 1 month after CABG to assess immediate graft patency if possible. Of the patients who performed MDCT, the rate of graft patency and pericardial thickening were similar between the 2 groups. There were no significant differences of post-operative clinical symptoms—including dyspnea, chest pain, peripheral edema, or fever—between both groups.

Multivariate logistic regression analysis was performed to identify factors independently associated with post-operative CP (Table 1). Variables with p value <0.100 from univariate analysis were included in multivariate analysis. However, pre-operative TTE parameters were excluded to avoid collinearity problems with corresponding post-operative TTE values. The presence of post-operative pericardial effusion was independently associated with post-operative CP (odds ratio: 2.64, 95% confidence interval [CI]: 1.52 to 4.58, $p = 0.001$).

During follow-up (614 ± 357 days vs. 623 ± 292 days after CABG, $p = 0.802$), the rates of composite clinical events including heart failure, death due to heart failure, constrictive pericarditis, or cardiac tamponade were not different between both groups by the log-rank test (6.0% vs. 4.4%, $p = 0.325$) (Fig. 1A, Table 1).

Sixty-one patients (78%) of the CP group underwent follow-up TTE (Fig. 1B). Of them, 50 (82%) showed complete resolution of CP a median of 466 days (IQR: 244 to 738 days) after CABG. The other 11 (18%) still showed residual CP until the last follow-up TTE, which was conducted a median of 757 days (IQR: 78 to 1,142 days) after CABG. Of these 11 patients, only 1 progressed to clinically symptomatic constrictive pericarditis with symptoms of dyspnea, engorged jugular veins, friction rub, and thickened pericardium on MDCT. The remaining 10 patients did not have any of these features.

Our study showed that post-operative CP is a relatively common finding (17% after CABG) compared with typical constrictive pericarditis, which is a well-recognized but rare complication after CABG, occurring in 0.2% to 0.3% of patients (3). Comprehensive TTE have contributed significantly to the ability of physicians to easily and reliably detect CP without invasive catheterization or operative findings.

Matsuyama et al. (4) suggested that post-operative pericardial effusion and normal LVEF are predictors of constrictive pericarditis after CABG. They explained that there is continuous violent friction between the pericardium and the beating heart under normal LVEF. This friction can potentially result in pericardial injury, inflammation, and pericarditis. Our study showed similar findings. Post-operative pericardial effusion was identified as a predictor of post-operative CP. In addition, post-operative left ventricular systolic function was more preserved in the CP group by univariate analysis. These findings might explain the role of pericardial friction and resultant pericardial inflammation in the pathogenesis of post-operative CP. Although C-reactive protein and erythrocyte sedimentation rate values during post-operative period were available only in 11 patients of the CP group, all of them had elevated C-reactive protein (7.6 ± 5.9 mg/dl, reference range: 0 to approximately 0.8 mg/dl) and erythrocyte sedimentation rate (62 ± 34 mm/h, reference range: 0 to approximately 15 mm/h).

Most (82%) patients in the CP group showed complete resolution of CP. Only 1 (1%) patient progressed to constrictive pericarditis. Furthermore, clinical event rates of the CP group and the No-CP group were similar during follow-up. These findings support the transient and benign nature of post-operative CP. Because CABG is a traumatic procedure with intraoperative irritation to the pericardium by the physical manipulation of

Table 1 Characteristics of the 2 Groups

	Univariate Analysis			Multivariate Analysis		
	CP Group (n = 78)	No-CP Group (n = 376)	p Value	Odds Ratio	95% CI	p Value
Pre-operative period						
Age, yrs	62.2 ± 8.3	62.7 ± 8.2	0.570			
Men	59 (76%)	265 (71%)	0.359			
Smoking history	42 (54%)	164 (44%)	0.099	1.58	0.94–2.66	0.082
Diabetes mellitus	29 (37%)	154 (41%)	0.536			
LVEF, %	59 ± 12	56 ± 15	0.118			
RWMA	32 (41%)	196 (52%)	0.074			
Pericardial effusion on TTE	1 (1%)	12 (3%)	0.707			
Off-pump CABG	55 (70%)	300 (80%)	0.071	0.69	0.38–1.24	0.215
Post-operative period						
LVEF, %	59 ± 12	55 ± 13	0.030	1.01	0.99–1.04	0.297
RWMA	28 (36%)	190 (51%)	0.019	1.68	0.85–3.30	0.134
Pericardial effusion on TTE	30 (39%)	71 (19%)	<0.001	2.64	1.52–4.58	0.001
Newly developed atrial fibrillation	3 (4%)	19 (5%)	1.000			
Low voltage QRS	13 (17%)	28 (7%)	0.010			
Beta blocker	59 (76%)	263 (70%)	0.314			
Patent graft on MDCT	57 (89%)	243 (87%)	0.717			
Pericardial thickening on MDCT	3 (5%)	4 (1%)	0.124			
Clinical symptoms*	14 (18%)	39 (10%)	0.058			
Follow-up duration, days after CABG	614 ± 357	623 ± 292	0.802			
Composite of clinical events†	4 (6.0%)	12 (4.4%)	0.325‡			

Values are mean ± SD or n (%). *Include dyspnea, chest pain, peripheral edema, or fever; †include heart failure, death due to heart failure, constrictive pericarditis, or cardiac tamponade; ‡calculated by the log-rank test.

CABG = coronary artery bypass graft; CI = confidence interval; CP = constrictive physiology; LVEF = left ventricular ejection fraction; MDCT = multi-detector computed tomography; RWMA = regional wall motion abnormality; TTE = transthoracic echocardiography.

surgeons, this pericardial trauma and previously mentioned pericardial friction can possibly cause pericardial inflammation, which is enough to cause transient CP but not enough to cause constrictive pericarditis. No patient in the CP group showed irreversible pericardial adhesion, fibrosis, or calcification on MDCT. These findings might also explain the transient and benign nature of post-operative CP.

Although follow-up echocardiography was recommended in all patients, 17 (22%) patients with post-operative CP did not have serial follow-up TTE for various reasons. Another limitation is small sample size. However, to the best of our knowledge, this is the first study investigating the incidence and clinical outcome of post-operative CP.

Post-operative CP is relatively common in patients who underwent CABG. However, it is usually transient and benign. Progression to clinically symptomatic permanent constrictive pericarditis is rare. Therefore, conservative management might be warranted for post-operative CP.

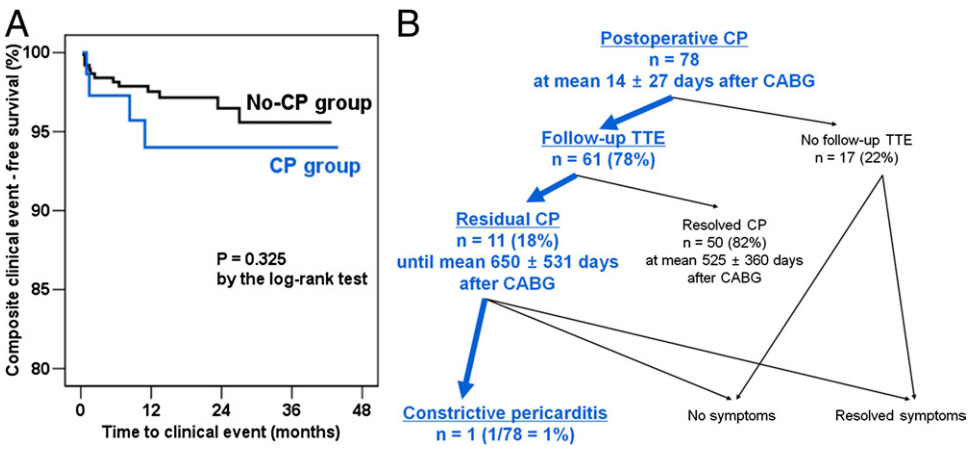

Figure 1 Kaplan-Meier Survival Curves and Follow-Up of Post-Operative CP

(A) Kaplan-Meier survival curves. Comparison of composite clinical event-free survival curves between the constrictive physiology (CP) group and No-CP group. **(B)** Follow-up of post-operative CP. Clinical course of post-operative CP during the follow-up period. CABG = coronary artery bypass graft surgery; TTE = transthoracic echocardiography.

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Letters to the Editor

Predictive Value of 6-Min Walk Test Distance Versus Cardiopulmonary Exercise Testing in Systolic Heart Failure

Same Value for Different Approaches?

The study by Forman et al. (1) increases the perspectives on how the distance of the 6-min walk test (6MWT) and the measured oxygen uptake (VO_2) and ventilatory efficiency (VE/VCO_2 slope) may add to the prognostic workup of heart failure (HF) patients.

By examining these variables in a mild-to-moderate risk HF population, a similar prediction for hospitalization and mortality was observed at univariate analysis, whereas no prognostic discrimination emerged when variables were tested against main demographic and clinical characteristics.

Findings are relevant because they definitively strengthen the 6MWT as a simple test that quantitatively mirrors the severity of HF syndrome. The question is whether this further evidence may restrain clinicians from performing a cardiopulmonary exercise test (CPET) that would not add to the prognostic indications provided by a 6MWT, obviously opting for cost-effectiveness and avoiding some complexity related to a CPET.

We believe that a few considerations may help to critically reconsider this conceivable but perhaps simplistic conclusion, anticipating future directions in pre-specified trials.

Over the past 10 years, survival studies of CPET in HF and statements (2) have defined how an approach that includes multiple variables would better define prognosis based on the assumption that exercise limitation is multifactorial and any single variable may only partially reflect the complex pathophysiology.

Peak VO_2 and VE/VCO_2 slope are strong predictive variables, but it seems important to question how the present findings would have been changed if, for example, the presence of the exercise oscillatory ventilation (EOV) pattern, which has been consistently proven prognostically superior to both peak VO_2 and VE/VCO_2 slope, or the oxygen efficiency slope, had been included in the statistical model. EOV clearly outperformed the 6MWT distance in a previous report (3).

Addressing the role of different exercise modalities by using a multiparametric approach that may truly reflect the whole potentiality of each test will probably provide a balanced view on how 6MWT distance and CPET are equal or when each test may provide better value in the risk stratification among HF populations.

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