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Improved Stratification of Perioperative Cardiac Risk in Patients Undergoing Noncardiac Surgery Using New Indices of Dobutamine Stress Echocardiography

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Abstract

Objectives. Prediction of perioperative cardiac events associated with noncardiac surgery remains difficult in patients whose functional capacity cannot be evaluated by exercise testing. Dobutamine stress echocardiography(DSE)has been used in these patients to improve risk stratification, but the results of standard DSE provide only a binary index of risk(positive or negative). Two new semiquantitative indices of DSE(semi-DSE)were retrospectively examined to determine the prediction of perioperative cardiac events compared to standard DSE.

Methods and Results. Clinical assessment of cardiac risk factors and standard DSE were performed safely in 122 consecutive patients(73 men, 49 women)undergoing noncardiac surgery. Preoperative revascularization was performed in 12 patients. The perioperative cardiac events consisted of 2 deaths, 4 cases of heart failure, and 2 cases of angina pectoris. For the semi-DSE indices, the extent of ischemia was indexed as the number of wall segments(SEG)displaying biphasic or worsening segmental wall-motion score, and the severity of ischemia(SI)was indexed as the sum of the differences in wall-motion scores between peak stress and rest divided by the number of affected segments. The optimal cut-off values of these indices for predicting cardiac events were 4.0 for SEG and 1.0 for SI. The risk stratification was further refined by these indices(high-, moderate-, and low-risk groups). The diagnostic accuracy of the semi-DSE indices, evaluated by the area under the receiver operating characteristic curves, was better than that of standard DSE($p < 0.001$).

Conclusions. Semi-DSE may improve cardiac-event risk stratification compared to standard DSE in patients undergoing noncardiac surgery whose functional capacity cannot be evaluated by exercise stress testing.

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Key Words

■**Echocardiography, transthoracic** ■**Stress echocardiography (dobutamine)**
■**Risk factors (cardiac)**

INTRODUCTION

Guidelines for perioperative cardiovascular evaluation of patients undergoing noncardiac surgery were published in 1996[1]. These guidelines emphasize the importance of identifying and evaluating

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cardiac risk by reviewing the clinical predictors that are based upon medical history, physical findings and electrocardiography, the patient's functional capacity, and the type of surgery scheduled. However, how to assess the cardiac status or how to predict perioperative cardiac events when the patient cannot perform an exercise tolerance test and the functional capacity remains unclear[2,3].

Patients who cannot exercise or can exercise only submaximally account for about 40% of the whole population in a stress-testing laboratory[4]. In this situation, dobutamine stress echocardiography (DSE) may be useful for clinical decision making, especially for the prediction of perioperative cardiac events[2,5,6]. However, few reports have attempted to stratify perioperative cardiac risk with semiquantitative analysis of DSE in patients undergoing noncardiac surgery.

The present study retrospectively assessed two semiquantitative DSE (semi-DSE) indices of the extent and severity of cardiac ischemia for the prediction of perioperative cardiac events, and compared these indices with standard DSE.

SUBJECTS AND METHODS

Subjects

This study included 122 consecutive patients, 73 men and 49 women aged 48 to 90 years [mean age 68 ± 9 (SD) years], who were scheduled for noncardiac intermediate-risk surgery at Nippon Medical School Hospital during the period from November 1996 to March 2001. The patients had intermediate predictors and underwent standard DSE for cardiac evaluation because they were unable to perform an exercise tolerance test. The intermediate predictors were defined according to the American College of Cardiology/American Heart Association (ACC/AHA) guidelines[1] and comprised the following: mild angina pectoris, prior myocardial infarction, compensated or prior congestive heart failure and diabetes mellitus. Thirty eight patients had a history of coronary artery disease, 83 patients had suspected coronary artery disease, and one had a history of chronic heart failure. Noncardiac intermediate-risk surgery was performed for gastric cancer in 32 patients, colon cancer in 25, cholecystitis or cholelithiasis in 15, orthopedic surgery in 20, cancer of the liver, bile duct or pancreas in 5, urogenital cancer in 5, gynecological cancer in 5, head and neck cancer in 4, and benign abdominal disease in the remaining 11.

Clinical risk factors were determined from the medical history, physical examination findings, and 12-lead electrocardiography. After obtaining informed consent, the patients underwent standard DSE. Treatment with β-blocking agents was discontinued for at least 24 hr before DSE.

Dobutamine stress echocardiography

The DSE protocol was reported previously[7]. We used a commercially available echocardiography system (SONOS 5500, Philips Medical Systems) with a 2.5-MHz transducer. Infusion of dobutamine was started at $5\ \mu g \cdot kg^{-1} \cdot min^{-1}$ and was increased stepwise to 10, 20, 30, or $40\ \mu g \cdot kg^{-1} \cdot min^{-1}$. Atropine (5 mg) was given intravenously in patients who did not achieve 85% of their age-predicted maximal heart rate and who had no symptoms or signs of ischemia. The criteria for stopping this test included: development of new or worsening segmental wall motion abnormalities determined by continuous echocardiographic monitoring, achievement of 85% of the target heart rate, ST segment depression ≥ 2 mm on the electrocardiogram, development of chest pain or symptoms suggestive of myocardial ischemia associated with new or worsening segmental wall motion abnormalities, delivery of the maximum dose of dobutamine ($40\ \mu g \cdot kg^{-1} \cdot min^{-1}$) and administration of atropine, development of severe hypotension (systolic blood pressure < 90 mmHg) or severe hypertension (systolic blood pressure > 220 mmHg), and development of significant ventricular arrhythmia.

All echocardiographic images were recorded on videotape, digitally obtained on-line, and edited in quad-screen cineloop format with simultaneous display of the resting, low-dose, peak-dose, and recovery stages. According to the recommendation of the American Society of Echocardiography[8], the left ventricle was divided into 17 segments and the segmental wall motion was scored on a 7-point scale by visual evaluation: -1 = hyperkinesis, 0 = normal, 1 = mild hypokinesis, 2 = moderate hypokinesis, 3 = severe hypokinesis, 4 = akinesis, and 5 = dyskinesis. Hypokinesis was differentiated into three grades according to the rate of increase of wall thickness. The images were analyzed by two observers, who were unaware of the clinical data, angiographic findings and other echocardiographic test results. The inter- and intraobserver variability

of the results of analysis were 90%, and 96%, respectively[7]. The patterns of segmental response to dobutamine were defined[9]: as Biphasic, improvement of wall motion score ≥ 1 grade during the low-dose dobutamine study followed by deterioration during the high-dose dobutamine study; Worsening, deterioration of wall motion during dobutamine infusion; No change, absence of improvement or worsening during dobutamine infusion; Sustained improvement, improvement without deterioration of wall motion from low to peak dose of dobutamine. A positive finding for dobutamine-atropine stress echocardiography was declared only if at least two wall segments served by the same coronary artery displayed wall motion abnormalities of the biphasic or monophasic deteriorating type, as defined above.

Coronary angiography

Based on the results of standard DSE and clinical risk assessment, 38 patients underwent coronary angiography. Percutaneous coronary intervention (PCI) or coronary artery bypass grafting was performed in patients who developed ischemia or based on the recommendation of the attending cardiologist.

Detsky's index

Cardiac risk assessment was based on Detsky's modified version of Goldman's cardiac risk index[10,11] for evaluation of assay sensitivity. The following eight items were assessed: past history of coronary artery disease, symptoms of coronary artery disease, pulmonary edema, valvular heart disease, arrhythmia, general condition, age, and emergency versus elective surgery.

Semi-DSE indices

Two semiquantitative indices were created retrospectively, the first to reflect the extent of myocardial ischemia (SEG) and the second to reflect the severity of myocardial ischemia (SI) detected by stress echocardiography. SEG was defined as the number of segments exhibiting deteriorating wall motion during stress at the stage of peak stress. SI was defined as the summation of the difference of the scores (wall motion score at peak stress minus wall motion score at rest) divided by the number of segments exhibiting deteriorating wall motion at the peak stress. If SEG was zero, SI was defined as zero. The images were analyzed by two observers, who were unaware of the clinical data, angiographic findings and other echocardiographic test results.

Perioperative cardiac events

Perioperative cardiac events were defined as events during the operation plus events that occurred within 1 month postoperatively, including fatal arrhythmias, heart failure, angina pectoris, myocardial infarction and cardiac death. The diagnosis of these events was based on the symptoms, physical findings, chest radiography, 12-lead electrocardiography and cardiac enzyme levels.

Statistical analysis

Univariate analysis of categorical variables was performed with the χ^2 test and Fisher's exact test, and continuous variables were analyzed by Student's *t*-test. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were obtained as usual. Stepwise logistic regression was employed to identify predictors of cardiac events. All variables, regardless of their significance in univariate analysis, were entered into the multiple logistic regression analysis. Differences were considered significant at $p < 0.05$. Receiver operating characteristics (ROC) curves[12] were used to determine the "optimal" cut-off point for prediction of cardiac events with semi-DSE and to compare the efficacy of diagnostic tests. Statistical analysis was performed using SPSS software (Release 10.0, SPSS Inc.).

RESULTS

Perioperative outcome

Eight perioperative cardiac events occurred in the 122 patients: 5 episodes of heart failure, 2 of unstable angina and 1 of myocardial infarction. The events occurred at mean 5.4 days postoperatively. Two patients died, one of myocardial infarction and the other of congestive heart failure followed by multiple organ failure, but the other six patients recovered with medical treatment (**Table 1**).

Clinical characteristics and perioperative cardiac events

The clinical features and clinical test data of the patients with and without perioperative cardiac events are shown in **Table 2**. Univariate analysis showed that the significant clinical predictors of perioperative cardiac events were history of valvular heart disease ($p < 0.05$), standard DSE ($p <$

Table 1 Clinical characteristics of the patients with perioperative cardiac events

No.	Age (yr)	Sex	Diagnosis	Clinical characteristics	CAG	LVEF (%)	SEG	SI	Cardiac events
1	68	M	Prostate cancer	ECG abnormality	#9 : 90% #14 : 90%→50%(PTCA)	47	5	1.40	Variant angina
2	74	F	Gastric cancer	HT, COPD, CVA, AF	Stenosis (−)	63	4	1.75	CHF
3	74	F	Uterine cancer	OMI, CRF	ND	59	10	1.10	CHF
4	70	F	Colon cancer	OMI, HL	#3, 4 : 75%, #6 : 75%, #9 : 90% #10 : 75%, #12 : 90%, #13 : 90%, #14 : 75%	63	6	1.67	CHF
5	59	M	Femoral fracture	HT, DM, CRF	ND	54	9	1.56	AMI to death
6	68	F	Colon cancer	OMI, HL	#2 : 100%, #6 : 75%, #11 : 100%→0%(Stent)	49	6	1.00	AP
7	76	M	Colon cancer	ECG abnormality, HL, DM	#1 : 90%→25%(Stent) #13 : 90%→50%(PTCA)	71	4	2.25	CHF to death
8	75	M	Laryngeal cancer	AP	#1 : 75%, #7 : 75%	71	6	1.33	CHF

CAG＝coronary angiography; LVEF＝left ventricular ejection fraction; SEG＝number of segments; SI＝score index; M＝male; F＝female; ECG＝electrocardiography; HT＝hypertension; COPD＝chronic obstructive pulmonary disease; CVA＝cerebrovascular accident; AF＝atrial fibrillation; OMI＝old myocardial infarction; HL＝hyperlipidemia; DM＝diabetes mellitus; CRF＝chronic renal failure; AP＝angina pectoris; PTCA＝percutaneous transluminal coronary angioplasty; ND＝not detectable; CHF＝congestive heart failure; AMI＝acute myocardial infarction.

0.01), SEG($p < 0.01$)and SI($p < 0.01$). Age, sex, other features of the history, and Detsky's index did not differ statistically in patients who had a cardiac event from patients who did not. In addition, resting left ventricular ejection fraction, cardiac output, and the ratio of peak early rapid filling velocity to atrial contraction velocity(E/A ratio)were not univariate predictors of perioperative cardiac events. The maximum dosage of dobutamine, rate-pressure product, duration of surgery, and hourly fluid balance were also not predictive.

Dobutamine stress echocardiography and clinical course

Of the 122 patients, 63 were positive by standard DSE and 59 were negative(**Fig. 1**). Among the 63 positive patients, 28 patients who had multiple cardiac risk factors and showed worsening of wall motion at a low dose of dobutamine underwent coronary angiography. Twenty-five of these 28 patients had significant coronary stenosis(＞75%), and 11 patients underwent preoperative PCI and one patient underwent coronary artery bypass grafting(CABG). Despite preoperative revascularization, 3 of these 11 patients suffered from postoperative cardiac events, and one patient died of multiple organ failure that was preceded by heart failure. Although the remaining 13 patients were not considered to be at risk based on clinical findings and data, two who developed heart failure postoperatively had high SEG and SI(**Table 1**). Among the three patients who did not have coronary artery stenosis, one patient developed tachycardic atrial fibrillation which precipitated heart failure that could be controlled by medical therapy.

The other 35 patients, most of whom had no symptoms, risk factors or past history, did not undergo coronary angiography despite the positive standard DSE. Two of these 35 patients had cardiac events, one case of postoperative heart failure and one of fatal acute myocardial infarction. Neither patient had preoperative coronary angiography because of chronic renal failure. However, these two patients showed high score of SEG and SI with maximum dosage of dobutamine.

Among the 59 patients who were negative by standard DSE, 10 patients had a history of coronary artery disease and underwent coronary angiography. One of these patients had a 75% coronary artery stenosis, but cardiac function was maintained by collateral vessels. These 10 patients underwent surgery without any perioperative events. Among the 49 patients who did not undergo coronary angiography, none had perioperative cardiac events.

Throughout the standard DSE test, there were no major adverse effects. Mild symptoms such as nausea, headache, chills, and palpitation developed in a few patients, but the test was completed without any other complications in all patients.

Semi-DSE indices

SEG and SI were significantly higher in patients

Table 2 Clinical characteristics and predictors of perioperative cardiac events in patients with or without events

	Cardiac events (n=8)	No cardiac events (n=114)	p value
Age (yr)	71±6	68±6	NS
Sex (M/F)	4/4	69/45	NS
History			
OMI (<6M)	1(12.5)	2(1.8)	NS
OMI (≥6M)	2(25)	44(38.6)	NS
Angina pectoris	6(75)	39(34.2)	NS
Heart failure	0	6(5.3)	NS
Valvular disease	4(50)	19(16.7)	<0.05
Arrhythmia	1(12.5)	35(30.7)	NS
HT	6(75)	60(52.6)	NS
HL	3(37.5)	44(38.6)	NS
HU	1(12.5)	19(16.7)	NS
DM	2(25)	35(30.7)	NS
COPD	1(12.5)	20(17.5)	NS
CVA	1(12.5)	15(13.2)	NS
CRF	2(25)	6(5.3)	NS
Anemia	2(25)	34(29.8)	NS
Obesity	3(37.5)	36(31.6)	NS
Smoking	3(37.5)	60(52.6)	NS
Detsky 's index	10.0±8.9	7.1±5.6	NS
Echocardiography			
LVEF (%)	60±10	61±11	NS
E/A ratio	0.7±0.2	0.7±0.3	NS
Heart rate threshold (beats/min)	108.5±18.5	119.2±19.6	NS
Ischemic threshold (%)	72.0±11.6	72.3±12.1	NS
Surgery			
Duration of surgery (min)	233±104	189±100	NS
Fluid balance (ml/hr)	430±229	417±214	NS
DSE			
Standard DSE (positive/negative) ※	8/0	58/56	<0.01
Max dose of DOB ($\mu g \cdot kg^{-1} \cdot min^{-1}$)	28±13	26±10	NS
RPP ($mmHg \cdot beats \cdot min^{-1}$)	16,030±3,438	17,010±4,141	NS
SEG	6.3±2.2	2.2±2.9	<0.01
SI	1.5±0.4	0.7±0.8	<0.01

Continuous values are mean±SD. ( ): %.

※Positive indicates myocardial ischemia detected by standard DSE, negative indicates no myocardial ischemia by standard DSE.

HU=hyperuricemia; E/A=peak early rapid filling velocity/peak inflow velocity due to atrial contraction; DSE=dobutamine stress echocardiography; DOB=dobutamine; RPP=rate-pressure product. Other abbreviations as in Table 1.

with perioperative cardiac events than in those without perioperative cardiac events (**Table 2**). Analysis of clinical and DSE variables using stepwise logistic regression revealed only two predictors of perioperative cardiac events, history of angina and SEG (**Table 3**). Moreover, the likelihood ratio chi-square test statistic that resulted, $\chi^2 = 1.62$ ($p = 0.20$), indicates that PCI was not a statistically significant confounder for Detsky 's index and standard DSE as predictors of cardiac events.

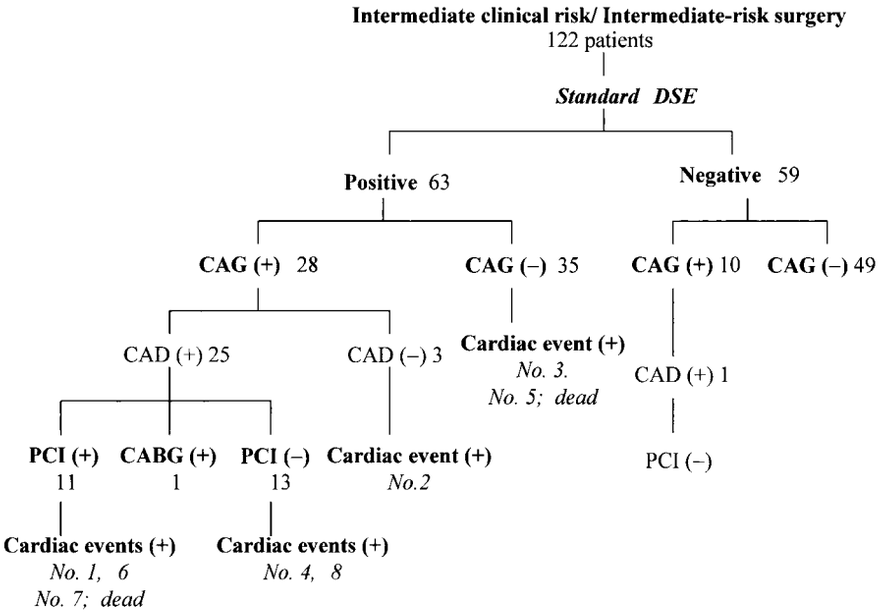

Fig. 1 Results of dobutamine stress echocardiography and preoperative coronary angiography
Flow chart of the procedure for prediction of perioperative cardiac events based on standard DSE and clinical assessment. Patient numbers correspond to those with cardiac events in Table 1.
CAG(+)=coronary angiography performed; CAG(−)=coronary angiography not performed; CAD(+)=findings of significant coronary artery disease; CAD(−)=no findings of signficant coronary artery disease; PCI=percutaneous coronary intervention; CABG=coronary artery bypass grafting. Other abbreviation as in Table 2.

Table 3 Stepwise logistic regression analysis for predictors of cardiac events

	Odds ratio	95% CI	*p* value
Angina pectoris	7.3	1.09−48.7	0.041
SEG	1.5	1.11−1.90	0.007

CI=confidence interval. Other abbreviation as in Table 1.

The optimal cut-off values for predicting perioperative cardiac events were defined by ROC curve analysis as 4.0 for SEG and 1.0 for SI. According to these SEG and SI values, the patients were divided into three groups. Among 35 patients with a high score for both SEG and SI(high-risk group), eight patients had perioperative cardiac events. Among 30 patients with an intermediate score (moderate-risk group)and 57 with a low score (low-risk group), no patient had a cardiac event (**Table 4**). Detsky's index was significantly higher in the high-risk group than in the low-risk group ($p<0.01$; **Table 4**). Based on Detsky's index, patients with a score of more than 10 were defined as belonging to Detsky's high-risk group[10]. Although 52 of the 122 patients were included in Detsky's high-risk group, there were only three patients with perioperative cardiac events. Four of the remaining five patients with cardiac events had a score of 5, and the other had a score of 0.

Diagnostic efficacies of standard DSE vs semi-DSE

Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the two tests for predicting perioperative cardiac events are listed in **Table 5**. The diagnostic efficacies of these tests for cardiac events were analyzed by the area beneath the ROC curve. Semi-DSE was significantly better than standard DSE($p<0.001$; **Table 5**).

DISCUSSION

DSE has been considered to be a very useful method to evaluate ischemia, but in most cases the results of this test are expressed as only positive or negative, so standard DSE cannot discriminate the extent or severity of ischemia. This study demonstrates that the semi-DSE indices for predicting perioperative cardiac events can be used to differentiate high-risk patients from low-risk patients more accurately than standard DSE. Furthermore,

Table 4 Clinical characteristics and predictors in patients grouped according to SEG and SI values

	High risk group (n=35) SEG≥4 & SI≥1.0	Moderate risk group (n=30) SEG≥4 & 1>SI≥0 4>SEG>0	Low risk group (n=57) SEG=SI=0	p value
Cardiac events	8	0	0	<0.01
Age(yr)	71±9	70±8	66±10	NS
Sex(M/F)	25/10	20/10	28/19	NS
Detsky 's index	10±7	8±5	5±5	<0.01
CAG	20	8	10	<0.01
PCI/CAD(+)	10/18	2/7	0/1	
TTE				
LVEF(%)	59±10	58±11	65±10	NS
E/A	0.7±0.4	0.6±0.2	0.7±0.2	NS
Operation				
Duration(min)	177±113	194±94	200±97	NS
Fluid balance(ml/hr)	476±249	431±187	374±198	NS
DSE				
Max dose of DOB($\mu g \cdot kg^{-1} \cdot min^{-1}$)	23±11	25±10	28±9	NS
RPP($mmHg \cdot beats \cdot min^{-1}$)	17,181±4,007	15,223±3,795	17,707±4,096	NS
SEG	6.5±2.3	2.0±1.0	0	<0.01
SI	1.6±0.6	1.2±0.3	0	<0.01

Continuous values are mean±SD.
TTE=transthoracic echocardiography. Other abbreviations as in Tables 1, 2, Fig. 1.

Table 5 Diagnostic text index values of each method for cardiac events

Method	Sensitivity (%)	specificity (%)	PPV (%)	NPV (%)	AUC	95% CI
Standard DSE	100	52	13	100	0.76	0.645−0.873
Semi-DSE	100	76*	23	100	0.87*	0.814−0.949

*p<0.001, standard DSE vs semi-DSE.
PPV=positive predictive value; NPV=negative predictive value; AUC=area-under-the receiver operating characteristic curve. Other abbreviations as in Tables 2, 3.

since DSE did not result in any fatal complications in this study, the semi-DSE indices can also be used for perioperative cardiac risk stratification in patients undergoing noncardiac intermediate risk surgery.

Dobutamine stress echocardiography for preoperative evaluation

Several studies have suggested that wall motion abnormalities and/or wall motion changes at a low dose of dobutamine are especially important for predicting the risk of cardiac event during major vascular surgery[2,3,5,6,13]. At present, an increasing number of cases are scheduled for intermediate-risk surgery. Furthermore, there are many patients who cannot undergo an exercise tolerance test due to their poor general condition or physical disabilities. In such patients, DSE has a few limitations, but also has many advantages such as noninvasive, very safe, relatively inexpensive, and feasible in most hospitals[6,13]. In this series of patients, there were no major adverse events with DSE and the test was completed without any fatal complications.

Dobutamine stress echocardiography for noncardiac intermediate-risk surgery

Among the clinical characteristics, history of valvular heart disease was the only predictor of

perioperative cardiac events by univariate analysis (**Table 2**), but there were no remarkable characteristics in patients with valvular heart disease with positive DSE. Other variables, such as Detsky's index, were not significant predictors, in contrast to previous reports[5,6,13–15]. However, stepwise multiple regression analysis showed only history of angina pectoris and SEG were significant independent predictors of cardiac events. This result suggests that some of the variables were influenced by each other. Accordingly, the risk of perioperative cardiac events appears to be difficult to identify without a stress test.

Although standard DSE is one of the significant predictors of perioperative cardiac events, it is difficult to perform coronary angiography in all patients who have a positive standard DSE because standard DSE identifies a lot of false positive cases and coronary angiography is invasive and very costly. This study showed that the SEG and SI indices derived from semi-DSE are more accurate than standard DSE for the identification of high-risk patients.

Prediction of perioperative cardiac events based on both the severity and the extent of ischemia has previously only been used to stratify risk prior to major vascular surgery[16].

Can dobutamine stress echocardiography predict perioperative "soft" cardiac events?

DSE detects cardiac ischemia and myocardial viability by assessing wall motion abnormalities since the occurrence of such abnormalities are usually considered to be specific for myocardial ischemia[17,18]. This study evaluated both "hard" events (myocardial infarction or cardiac death) and "soft" events (arrhythmia, heart failure, and ischemia). Among our six patients with soft events, five were considered to have cardiac ischemia that led to heart failure, but one did not have coronary artery disease. Although these five patients had relatively good left ventricular ejection fraction at rest, the ischemia seemed to be induced postoperatively. The other patient might have had abnormalities in myocardial metabolism or perfusion without any proximal stenotic coronary segments[19–21], because the SEG and SI were 4 and 1.75, respectively. Taking these results into account, there is also a possibility that semi-DSE is a useful tool for predicting soft events such as heart failure and arrhythmia based on myocardial ischemia.

Preoperative coronary revascularization

In this study, the decision to perform preoperative coronary revascularization was based on standard DSE and the patient's clinical status. In the high-risk group, eight patients did not undergo PCI despite pre-existing coronary artery disease for the following reasons: risk of the surgery was intermediate, coronary stenosis was not critical, and potential complications of PCI. In the moderate risk group, two patients underwent PCI for critical stenosis of distal lesions. Three of the 11 patients who underwent PCI still suffered perioperative cardiac events.

Recently, patients who have undergone CABG were reported to have a low rate of perioperative cardiac events[22–25]. In this study, only one patient underwent CABG and did not have any perioperative cardiac events, although the interval from CABG to noncardiac surgery was 56 days. There is a tendency for a lower incidence of cardiac death in patients with PCI before noncardiac surgery[26–28], However, there is some difficulty comparing patients treated by PCI and patients without PCI in this study, because this was an uncontrolled retrospective study and determination of prophylactic preoperative PCI depended upon other factors in addition to the results of standard DSE. Thus, the efficacy of prophylactic preoperative PCI for reducing untoward perioperative cardiac complications remains unknown. The present study was too small to determine which therapy was appropriate, and further studies will be necessary to assess the efficacy of coronary revascularization for reducing perioperative cardiac events.

Limitations of this study

This study was retrospective, so we could not avoid changes in management based on the discretion of the attending physicians, clinical findings, and the results of standard DSE. This study was also uncontrolled, so there are some difficulties in interpreting the results and in assessing the usefulness of DSE for the prediction of perioperative cardiac events. As the result of many uncontrolled variables, there were inconsistencies in the results of assessments of predictive efficacy of some indices. For example, SI was one of the most powerful predictors in the univariate analysis, whereas history of angina pectoris and SEG were the only significant predictors in the multivariate analysis.

Although objective interpretation of the results

of DSE is now of interest[29], DSE still involves subjective semiquantitative interpretation of echocardiographic images based on a scoring system. The ischemic threshold during DSE is useful for prediction of perioperative cardiac events related to major noncardiac surgery[30]. The ischemic threshold is quantified by expressing the heart rate at which ischemia is first noted as a percentage of the age-predicted maximum. However, heart rate is altered by physical conditioning or medical treatment, and the ischemic threshold was not an accurate predictor in our study.

CONCLUSIONS

The present study demonstrated that in patients with poor general condition whose functional capacity cannot be evaluated by exercise stress testing, DSE can be performed safely, and that the semi-DSE indices, SEG and SI, can stratify the risk of cardiac events more accurately than standard DSE. These new indices can be considered as appropriate and highly sensitive parameters for predicting perioperative cardiac events.

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要　　約

ドブタミン負荷心エコー図法の新たな指標による非心臓手術周術期心臓合併症発生リスクの層別化

横島　友子　　本間　博　　草間　芳樹
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目　的: 運動負荷試験ができずに運動耐容能の評価が困難な症例では，周術期心臓合併症をいかに予測するかが問題となる．ドブタミン負荷心エコー図法(DSE)は，そのような症例に対して適応となるが，従来の評価法(standard DSE)では陽性か陰性かの判定のみであった．本研究では，後ろ向きに2つの新たな指標(semi-DSE)を用いて，周術期心臓合併症の検出率を従来の評価法と比較し検討した．

方法と結果: 非心臓手術を受ける122例(男性73例，女性49例)に対して臨床上の心血管危険因子とstandard DSEによる評価を行った．術前，冠血行再建術は12例に施行されたが，周術期心臓合併症の発生は8例で，その内訳は，死亡2例，心不全4例，狭心症2例であった．虚血の拡がりを壁運動の悪化した区画数として表すSEGと，虚血の程度を壁運動が悪化した区画において負荷ピーク時から安静時の壁運動のスコアを差し引きその区画数で除したSIの2つをsemi-DSEの指標とした．Semi-DSEの指標による後ろ向き評価では，周術期心臓合併症の発生を予測するカット・オフ値はSEG 4.0，SI 1.0であり，これにより高リスク群，中等度リスク群，低リスク群の3群に分類しえた．高リスク群には心臓合併症8例がすべて含まれる．Semi-DSEとstandard DSEの診断精度をreceiver operating characteristics曲線の曲線下面積により比較すると，semi-DSEのほうが有意に検出精度が高かった($p < 0.001$)．

結　論: 運動耐容能が不明で運動負荷試験の施行が困難な非心臓手術予定患者では，standard DSEに比べてsemi-DSEのほうが心臓合併症の発生リスクの層別化が可能となり，臨床上有用と考えられた．

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