Title: FREQUENCY WITH WHICH ST SEGMENT TRENDS PREDICT INTRAOPERATIVE MYOCARDIAL ISCHEMIA

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INTRODUCTION: Perioperative myocardial ischemia occurs frequently in patients with coronary artery disease undergoing non-cardiac surgery. Such ischemia, as detected by off-line Holter analysis, has been correlated with an increased incidence of myocardial infarction (1), and may occur in the absence of hemodynamic changes (1,2), suggesting changes in oxygen delivery as an etiology of myocardial ischemia. If we knew about such episodes when they occured, we might be able to treat ischemia and improve outcome. Thus, efforts have been made to develop better non-invasive, on-line methods to detect intraoperative myocardial ischemia.

Automated analysis of the trend of ST segment variability has been suggested in an anecdotal report (3) as a method of improving detection of intraoperative myocardial ischemia. Controlled studies of the efficacy of this monitoring modality in the operating room are lacking. Therefore, we undertook a prospective study to determine how frequently a change in ST segment trend analysis would indicate myocardial ischemia when ischemia was detected by either of two other standards.

METHODS: 18 patients undergoing surgery were included in this study, which was approved by our Clinical Investigations Committee. Patients chosen had a history of angina or previous myocardial infarction, peripheral vascular disease, hypertension and left ventricular hypertrophy, diabetes mellitus, or chronic renal failure. Patients were studied during a variety of surgical procedures, including seven lower extremity vascular procedures, five carotid endarterectomies, two colectomies, a coronary bypass grafting, an aortic reconstruction, a pheochromocytoma excision, and a renal transplant.

Upon arrival in the operating room, patients were connected to a Hewlett Packard (HP, Waltham MA) 78534C monitor terminal equipped with ST segment analysis software. This software measured the vertical difference between the isoelectric point (80 msec before the height of the QRS) and the ST segment (at 120 msec after the height of the QRS); these results were displayed continuously and updated every 15 seconds. We measured this difference in leads II and V5; the absolute sums represented ST segment variability from baseline. We simultaneously recorded eight leads of EKG data (I, II, III, AVR, AVL, AVF, MCL1, and V5). In 11 patients, a Marquette Series 7000 monitor (Milwaukee WI) with ST segment analysis capability was simultaneously used; this monitor recorded vertical ST segment variation from baseline at 80 msec after the J point in leads I, II, and V5, and summed the absolute values.

Immediately after induction, a transesophageal echocardiographic (TEE) probe (Diasonics, Milpitas CA) was introduced, and a characteristic short axis view of the left ventricle at the level of the papillary muscles obtained. Simultaneous recordings of the 8-lead EKG, ST segment analyses (HP and Marquette) and TEE (on 1/2" VHS videotape) were obtained at the following times:

(i) awake baseline (EKG, ST segments)
(ii) before endotracheal intubation (EKG, ST segments)
(iii) after endotracheal intubation (EKG, ST segments, TEE)
(iv) before incision (EKG, ST segments, TEE)
(v) after incision (EKG, ST segments, TEE)
(vi) before and after temporary arterial occlusion and release during carotid and aortic reconstruction (EKG, ST segments, TEE)
(vii) upon closure of abdomen or chest or neck (EKG, ST segments, TEE)
(viii) just prior to extubation or leaving the operating room (EKG, ST segments, TEE)

Clinicians were aware of all measured variables, and used them as guides to therapy. EKGs and echocardiograms were later reviewed separately by two different cardiologists, who were blinded to the readings of the other modality and blinded to the clinical scenarios. Criteria for EKG ischemia were defined as a downsloping ST segment $\geq$ 1 mm at 80 msec after the J point in any lead. New T wave abnormalities were considered ischemic only when they occurred in more than one lead.

Echocardiograms were rated for development of new intraoperative ischemia, as defined by worsening of two or more grades of abnormality of regional wall motion abnormality (RWMA). RWMA were rated as mildly, moderately, or severely hypokinetic; akinetic; or dyskinetic. Sensitivity and specificity for the ST segment trend monitors were defined as compared with the standard 8-lead EKG and with TEE.

RESULTS: Judged by any episode of ischemia during an operation, 11 of 18 patients in our group had ischemia by analysis of the 8-lead EKG. Of those 11 patients, the HP segment trend monitor indicated a 1.0 mm or greater change in five patients (sensitivity = 45%); two patients without 8-lead EKG evidence of ischemia had ST segment changes $\geq$ 1 mm by the HP analysis (specificity = 71 %). Judged by a change of 0.5 mm or greater, the HP segment monitor indicated ischemia in 11 patients (sensitivity = 73 %); three false positives occurred (specificity = 57%). Similar results occurred with ischemia detected by the Marquette monitor.

8-lead EKG revealed ischemia in six patients who also had TEE evidence of ischemia. However, three patients experienced EKG-detected myocardial ischemia only during induction; these episodes could not have been detected by 2D TEE. On the other hand, TEE revealed RWMA in four patients without detectable EKG ischemia. Six of ten patients with TEE evidence of myocardial ischemia did not have HP ST segment indication of such (see Table 1).

DISCUSSION: Methods of detection of perioperative ischemia that are simple and inexpensive to use are needed. TEE has been shown to be a more sensitive indicator of ischemia than is EKG (4), but is expensive and requires some specialized training. Ischemia is often not detected intraoperatively by clinicians viewing standard EKG monitors (2). The use of a simple ST segment analysis algorithm, which displays a numeric figure and trends changes in that value, is useful in detecting myocardial ischemia in many patients, with minimal additional labor, expense, or training on the part of the anesthetist. But, at a cutoff of 1.0 mm Δ, ST segment monitors are not as sensitive in detecting myocardial ischemia as an 8-lead EKG or TEE; at a cutoff of 0.5mm Δ, they are not as specific.

REFERENCES:

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TABLE 1:
NUMBER OF PATIENTS WITH FINDINGS ON HP ST SEGMENT MONITOR:

		ST $\geq$ 1.0	ST < 1.0
TEE	ISCHEMIC	4	6
	NON-ISCHEMIC	1	5
	UNVAILABLE	2	0
EKG	ISCHEMIC	5	6
	NON-ISCHEMIC	2	5