Title: COMPARISON OF TWO AUTOMATED ST-SEGMENT ANALYSIS SYSTEMS, EKG (INCLUDING T WAVE INVERSION ANALYSIS), AND TRANSESOPHAGEAL ECHOCARDIOGRAPHY FOR THE DIAGNOSIS OF INTRAOPERATIVE MYOCARDIAL ISCHEMIA

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INTRODUCTION:

In patients with ischemic heart disease and hypertension, perioperative myocardial ischemia frequently results (1). While only in patients undergoing coronary bypass surgery has this been shown to be associated with poor outcome, such intraoperative ischemia is likely deleterious. ST segment analysis has been suggested in an anecdotal report (2) as a method of improving detection of intraoperative myocardial ischemia. In an attempt to improve and simplify our ability to diagnose intraoperative ischemia in high risk patients, we have evaluated the use of two automated ST-segment analysis systems. We also have compared the efficiency of these two systems to two "gold standards" of ischemia detection, 8 leads of printed EKG and transesophageal echocardiography (TEE).

METHODS: 46 patients undergoing aortic, peripheral vascular, and abdominal 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 or left ventricular hypertrophy, diabetes mellitus, or chronic renal failure.

Upon arrival in the operating room, patients were connected to the Hewlett Packard (HP, Waltham MA) 78534C monitor terminal equipped with ST segment analysis software. The HP 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) in leads II and V5. The median sum of the absolute values of ST segment elevation or depression in lead II and V5 in a 15 second period were displayed.

In 24 of the 46 patients, the Marquette 7000 monitor (MQ) was used simultaneously with the HP monitor. MQ measured the ST segment variability from baseline (0.04 seconds before the start of the QRS complex) at a point 60 msec after the J point, in three leads, I, II, and V5.

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 was obtained. Simultaneous recordings of the 8-lead EKG (I, II, III, AVR, AVL, AVF, MCL1, and V5), ST segment analyses (HP and MQ) and TEE (on 1/2" VHS videotape, except before intubation) were obtained at the following times:

(i) awake baseline
(ii) before and (iii) after endotracheal intubation
(iv) before and (v) after skin incision
(vi) before and after arterial occlusion and release
(vii) upon skin closure
(viii) whenever any of the modalities showed ischemia

Clinicians were aware of all measured variables. 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. For both automated ST segment analysis systems, we prospectively decided to compare the sensitivity and specificity of an increase of 1.0 mm in the absolute sum of ST segment values (from two leads in the HP system, and from three leads in MQ) to ischemia detected by EKG and TEE. We prospectively decided that both ST segment and T wave changes would be used to diagnose ischemia with the EKG. EKG ischemia was defined as: ST elevation or a downsloping ST segment $\geq$ 1 mm at 80 msec after the J point in any lead; new T wave inversions 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) or thickening abnormalities. 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:

In the group of 46 patients, with the EKG as a "gold standard", the HP system was 69% sensitive and 79% specific. The HP system was less sensitive when TEE was considered the "gold standard" of myocardial ischemia (32% sensitive, 75% specific; $P < 0.05$).

When TEE was considered the "gold standard" in these 46 patients, the printed EKG was 50% sensitive and 92% specific for the detection of intraoperative ischemia.

In the 24 patients who had both HP and MQ analyses done, the HP monitor was less sensitive (56% HP vs 67% MQ), but more specific (73% HP vs 53% MQ) when the EKG was used as the "gold standard" (see table 1). Neither sensitivitty nor specificity differences between HP and MQ were statistically significant. When TEE was used as the "gold standard", similar results were obtained (see table 2).

DISCUSSION:

Automated ST segment analysis holds the promise of being a simple, non-invasive method of ischemia detection, which requires minimal additional training or time on the part of the anesthetist. We found that the HP monitor, which sampled only two leads, was tending towards becoming less sensitive than the MQ system; on the other hand, the use of three leads in the MQ system seemed to decrease its specificity. Neither of the automated ST segment system could have been expected to document T wave inversions, which were a frequent sign of ischemia in our population.

In the group of 46 patients undergoing non-cardiac surgery, we found that the EKG was twice as sensitive (50%) in diagnosing myocardial ischemia (with TEE as the "gold standard") as the 25% sensitivity reported by Smith et al (3). The incidence of perioperative ischemia as detected by TEE was similar in the two studies. These differences may have arisen because our study did not include patients undergoing cardiac surgery. In addition, we used T wave inversions as a criteria for EKG ischemia; this may well have improved our sensitvity. In the smaller group of 24 patients which had monitoring with both MQ and HP systems, EKG was even better (80% sensitive and 93% specific) for the detection of ischemia when TEE was the "gold standard."

Ischemia is often not detected intraoperatively by clinicians viewing standard EKG monitors (4). 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 no additional labor and minimal training on the part of the anesthetist. But these monitors cannot detect changes in T wave morphology, which, when considered in this high risk group, enable the 8-lead EKG to approach TEE in sensitivity as a monitor of myocardial ischemia.

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TABLE 1
EKG AS GOLD STANDARD (N =24)

	SENSITIVITY	SPECIFICITY
MQ	6/9 (67%)	7/15 (47%)
HP	5/9 (56%)	9/14 (73%)
EKG	8/9 (89%)	13/14 (87%)

TABLE 2
ECHO AS GOLD STANDARD (n = 24)

	SENSITIVITY	SPECIFICITY
MQ	6/10 (60%)	7/14 (50%)
HP	4/10 (40%)	9/14 (64%)
EKG	8/10(80%)	13/14 (93%)