

The Predictive Value of Intraoperative ST-segment Monitoring as a Marker of Myocardial Injury

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Abstract

Aim: To evaluate the usefulness of dynamic intraoperative ST-monitoring in high-risk patients comparing it to preoperative clinical assessment and concurrent biochemical markers of cardiac injury. **Materials and Methods:** Twenty-three patients clinically assessed as being at high risk for perioperative cardiac complications were recruited into this prospective, observational study in a public hospital. All had serial ECGs, cardiac enzymes and troponin-T measurements. The sensitivity, specificity, positive and negative predictive value of ST-segment changes in terms of predicting cardiac complications were calculated. We investigated the relationship between ST changes and biochemical markers of ischaemia and the predictive value of nonspecific (ASA) and specific (Goldman) clinical scores for cardiac complications. **Results:** When correlated with cardiac complications, ST-segment monitoring had sensitivity 45.4%, specificity 100%, positive predictive value 100% and negative predictive value 66.7%. The correlation with CK-MB and troponin T was sensitivity 16.7% and 25%, specificity 73.3% and 75%, positive predictive value 20% and 20%, and negative predictive value 68.8% and 80%, respectively. The percentage of patients with cardiac complications increased with poor Goldman and ASA clinical scores; 25%, 40%, 62.5% and 100% in Goldman risk index groups of 0-5, 6-12, 13-25 and >25, respectively; and 33.3% and 52.6% in ASA II and ASA III, respectively. **Conclusions:** This study demonstrates the importance of the anaesthesiologist preoperative assessment of cardiac risk. The probability that a patient with significant ST-depression will develop subsequent cardiac complications is 100%, which reflects its usefulness in this high-risk pre-selected sample. However, the test has a low sensitivity (45.4%).

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Introduction

Patients with ischaemic heart disease have a high incidence of perioperative ischaemia resulting in an increased risk of cardiac events in the post-surgical period.¹ Goldman et al² formulated the "cardiac risk index", implicating previous myocardial infarction (MI), heart failure and unstable angina as major determinants of postoperative cardiac events. More recent studies have shown that the presence of myocardial ischaemia before, during or in the early period after operation to be predictors of postoperative cardiac morbidity. Improved perioperative monitoring and treatment can reduce the rate of myocardial reinfarction^{3,4} and treatment aimed at reducing perioperative ischaemia may reduce postoperative cardiac morbidity.^{5,6}

The ECG is used as a routine monitor during anaesthesia. The detection of heart rate and arrhythmias is accurate, but

ST-segment analysis has poor sensitivity and specificity. This is due to poor monitor design, limited lead selection and failure in observation by clinicians.⁷ This low observation rate can be improved by using monitoring capable of continuous computer analysis and display of ST-segment trends, as first described by Kotrly and colleagues.⁸

Hence, we aim to determine the prognostic value of intraoperative ST segment monitoring in terms of predicting cardiac morbidity in a subgroup of patients who were assessed on clinical grounds as being at high risk.

Patients and Methods

This prospective, observational study was approved by the hospital ethics committee to take place over a one-year period. Twenty-three patients who were assessed by 2

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specialist anaesthesiologists as being at increased cardiac risk, as to require intensive care admission, were recruited to the study following informed written consent. Each patient was in addition scored according to the Goldman Risk Index {Risk factor: (number of points) - S3 gallop, increased JVP: (11), MI <6 months: (10), PVCs >5/min: (7), non sinus rhythm: (7), age >70: (5), emergency surgery: (4), severe aortic stenosis: (3), poor general condition: (3), intraperitoneal or intrathoracic surgery: (3)} and by the American Society of Anesthesiologists (ASA) anaesthetic risk classification.

All patients had continuous automated dynamic ST-segment (lead II and V5) monitoring intraoperatively using a 5-lead system (Hewlett-Packard™ Merlin M1166A) and the results recorded on hard copy. Dynamic intraoperative ST depression is significant if there is more than 1 mm depression, 60 msec from the J-point of more than 30 minutes duration.^{9,10}

All patients had preoperatively and serial postoperative 12-lead ECGs performed. Serum CK-MB was measured daily over 3 postoperative days. Troponin T was measured in the first 24 hours. An untoward cardiac event was defined as newly diagnosed MI, cardiac failure, stroke and death due to cardiac causes within six months of surgery.

Analysis

The sensitivity, specificity, positive and negative predictive value of positive ST-segment changes in terms of predicting cardiac complications were calculated. The relationship between ST changes and biochemical markers of ischaemia (CK-MB and troponin T) was investigated. The predictive value of nonspecific (ASA) and cardio-specific (Goldman) clinical scores for post-cardiac complications was investigated.

Results

The mean age ($\pm$ SD) of the study population was 67.5 ± 11.3 years. There were no patients of ASA status 1, 3 of ASA status 2, 19 of ASA status 3 and 1 of ASA status 4. Four patients had Goldman Cardiac Risk Score of ≤ 5 points, 10 with Goldman Cardiac Risk Score of 6 to 12 points, 8 with Goldman Cardiac Risk Score of 13 to 25 points and 1 patient with Goldman Cardiac Risk Score of >25 points.

Sixteen patients were under treatment for coronary heart disease. Of these, 1 had unstable angina, 6 had previous myocardial infarctions, 2 were in congestive heart failure, 1 also had severe aortic stenosis and 1 had a history of transient ischaemic attacks. Thirteen patients had hypertension and 8 patients were diabetics. Twelve had peripheral vascular disease, of whom 3 had abdominal aortic aneurysms.

Surgical procedures carried out included the following: 12 patients had major vascular surgery, 7 patients had major abdominal procedures and 2 had major neurosurgical procedures. There were 3 cardiac deaths out of 4 (the first one had an MI 4 days postoperatively, the second died one month later of ventricular fibrillation and the third had a non-Q MI 9 days postoperatively). Five other patients had non-fatal MI. Three patients developed heart failure, cerebrovascular accident and required coronary artery bypass surgery, respectively.

The relationship between ST changes and cardiac events, CK-MB, serum troponin is shown in Tables I to III.

In this study, higher ASA and Goldman Cardiac Risk Scores were found in patients who developed cardiac complications (Tables IV, V). However, Goldman's scoring has a wider range and is thus more specific for cardiac risk.

TABLE I: RELATIONSHIP BETWEEN ST CHANGES AND CARDIAC EVENTS

	Positive ST	Negative ST	
Positive cardiac complications	5	6	11
Negative cardiac complications	0	12	12
	5	18	

Sensitivity: 5/11 (45.4%); Positive predictive value: 5/5 (100%); Specificity: 12/12 (100%); Negative predictive value: 12/18 (66.7%)

TABLE II: RELATIONSHIP BETWEEN ST CHANGES AND CK-MB

	Positive ST	Negative ST	
CK-MB >12 IU/l	1	5	6
CK-MB <12 IU/l	4	11	15
	5	16	

Sensitivity: 1/6 (16.7%); Positive predictive value: 1/5 (20%); Specificity: 11/15 (73.3%); Negative predictive value: 11/16 (68.8%)

TABLE III: RELATIONSHIP BETWEEN ST CHANGES AND TROPONIN T

	Positive ST	Negative ST	
Troponin T >0.1 µg/l	1	3	4
Troponin T <0.1 µg/l	4	12	16
	5	15	

Sensitivity: 1/4 (25%); Positive predictive value: 1/5 (20%); Specificity: 12/16 (75%); Negative predictive value: 12/15 (80%)

TABLE IV: RELATIONSHIP BETWEEN GOLDMAN CARDIAC INDEX AND CARDIAC COMPLICATIONS

Goldman Cardiac Risk Index	0-5	6-12	13-25	>25
Number of patients	4	10	8	1
% with cardiac complications	25%	40%	62.5%	100%

TABLE V: RELATIONSHIP BETWEEN ASA CLASSIFICATION AND CARDIAC COMPLICATIONS

ASA classification	2	3	4
Number of patients	3	19	1
% with cardiac complications	33.3%	52.6%	0

Discussion

Sensitivity and specificity are intrinsic properties of a test: although independent of the prior or pretest probability of the outcome, they are dependent on the spectrum of patients being studied.¹¹ This principle has direct applications to the assessment of cardiac risk in noncardiac surgery. For example, the risk of perioperative MI has been approximately 1.4% (1% to 2%) and the risk of perioperative cardiac death has been approximately 1% (0.5% to 2%) in a large series of consecutive unselected patients.^{2,12-14} In contrast, in patients with higher risk characteristics, such as those with known or highly suspected coronary artery disease, these risks are increased two-fold.^{12,15-20}

This study demonstrates the importance of the anaesthesiologist's preoperative assessment of cardiac risk. 47.8% of patients in this study developed significant postoperative cardiac complications out of which 27% died of cardiac causes. Prause and colleague²¹ have demonstrated in an unselected large sample that preoperative mortality can be correlated to ASA grade and cardiac risk index. In this present highly selected sample, the value of the specific Goldman Cardiac Risk Score has been demonstrated when compared with the non-specific ASA classification in predicting cardiac complications. In highly selected cardiac risk patients, the Cardiac Risk Score is more useful than a general risk score like the ASA grade.

The probability that a patient with significant ST-depression will develop subsequent cardiac complications (positive predictive value) is 100% which reflects its usefulness in this high-risk pre-selected sample. As the leads used were II and V5, only lateral wall ischaemia and inferior lead ischaemia were detected. However, these are the more common areas of myocardial damage. These dynamic ST changes result from a multitude of factors intraoperatively which include stress of surgery,

haemodynamic factors like tachycardia or hypotension, thrombosis and vasospasm. In essence there is an imbalance between the myocardial oxygen demand and its supply. Therapeutic interventions would centre in correcting this disparity. Measures would include reducing myocardial oxygen demand with β -blockers and nitrates, and avoiding hypertension which increases myocardial wall tension. Myocardial oxygen supply can be increased by avoiding anaemia or hypotension, and administration of calcium channel blockers for coronary artery vasodilation.

However, ST segment monitoring has a low sensitivity (45.4%) as there are many causes of ST depression besides ongoing myocardial oxygen demand/supply imbalance. This would include co-existing interventricular conduction defects, previous myocardial infarction, left ventricular hypertrophy, digitalis effects and various electrolyte abnormalities.

Both CK-MB and troponin T were similarly correlated to ST-segment changes in this study. Troponin T has been shown to have prognostic importance after a myocardial infarction²² or unstable coronary syndromes.²³ In our study, troponin T was sampled too early for it to be useful. This study was done before the half-life profile of troponin T was characterised. The use of more specific markers of myocardial injury may be expected to result in a higher specificity²⁴ when correlated to ST-segment analysis. It would be interesting to repeat the study using Troponin I which is a more sensitive and specific marker than current biochemical assays.^{25,26}

In summary, the high incidence of coronary artery supply/demand imbalance as a cause of preoperative myocardial ischaemia requires monitoring of patients for ischaemia. Automated ST segment trending appears to have a useful role in improving patient care in a high-risk group of patients when complemented by an anaesthesiologist's preoperative clinical assessment. One should note that though ST segment indicates ischaemia, it however does not accurately localise ischaemia. Nevertheless its use allows one to take appropriate early interventional steps before the patient suffers irreversible myocardial injury.

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