Scintigraphic, Electrocardiographic, and Enzymatic Diagnosis of Perioperative Myocardial Infarction in Patients Undergoing Myocardial Revascularization

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To assess the incidence of perioperative myocardial infarction, 214 consecutive patients were evaluated 1–5 days after coronary bypass surgery, using Tc-99m pyrophosphate (TcPPi) myocardial imaging, serial electrocardiograms (ECG), and enzyme levels (SGOT, LDH, CPK).

On the basis of the clinical course and scintigraphic, enzymatic, and ECG changes, the diagnosis of perioperative infarction was definite in 17 of 214 cases (7.9%) and probable in six of 214 (2.8%). In all of these 23 patients, TcPPi scans were abnormal; one additional patient had a false-positive scintigram. Only 13 of the 23 had ECG evidence of infarction, but there were no false positives. We set the threshold for abnormality of enzyme changes quite high, owing to experience in more than 900 postoperative patients (SGOT > 200, LDH > 500, CPK > 500 on the same day). Using these criteria, 22 of the 23 infarcted patients had abnormal enzymes, and six others were falsely positive. These results indicate a relatively low sensitivity for the ECG in diagnosing perioperative infarction, but the lack of false positives suggests high specificity. The sensitivity and specificity of the enzymes and the TcPPi image were both excellent and quite similar; the main difference was a reduction of certainty of infarction with the enzyme criteria, caused by the six patients whose enzyme values were falsely positive. Considering its sensitivity, specificity, and ability to locate and to a certain extent quantitate necrosis, TcPPi imaging is probably the most valuable means of diagnosing perioperative myocardial infarction.


Aortocoronary bypass surgery is currently the most commonly performed cardiovascular surgical procedure in this country, with more than 75,000 patients expected to undergo operation during 1978. Past experience indicates that at least 10% of these patients will sustain myocardial infarction during the perioperative period (1–4). This circumstance presents a special challenge for clinical diagnosis and management. Enzyme measurements, including the myocardial band of CPK, are difficult to interpret because of their routine elevation in noninfarcted patients as a consequence to the surgical trauma. In addition, differences in surgical approach—including such factors as cardiopulmonary bypass and aortic cross-clamp times—require that each institution establish its own normal and abnormal enzyme values, and thus it is difficult if not
impossible to compare published reports between institutions (3). The surgical process also produces ischemic pattern changes in the ECG in virtually all patients, and even the presence of new Q waves may indicate unmasking of a previous infarction in some patients, rather than signifying a new event (5). Stimulated by these diagnostic deficiencies, we undertook this investigation to evaluate the potential of technetium pyrophosphate myocardial imaging in the diagnosis of perioperative infarction.

METHODS

Two hundred and fourteen aortocoronary bypass (ACB) patients, selected at random, were followed after surgery with daily ECG and a Tc-99m pyrophosphate (TcPPI) study made between the first and sixth postoperative days. In addition, SGOT, LDH, and CPK serum enzyme values were obtained daily during the first 3 postoperative days.

Patients were routinely imaged 2½ hr after an i.v. injection of 15 mCi of TcPPI. A delay of 3½-4 hr was used in the older patients because of delayed blood clearance of the tracer, and even longer in patients with renal insufficiency. Either a large-field-of-view scintillation camera or a portable one with high-resolution parallel-hole collimator was used for imaging. Anterior, left anterior oblique, and left lateral views were obtained in all patients.

The threshold for abnormal enzyme levels was set quite high because of previously published data and subsequent experience in more than 1,000 postoperative patients (SGOT > 200, LDH and CPK > 500, all occurring at 24 or 48 hr after surgery) (6). The ECG was considered positive for infarction if persistent new Q waves greater than 0.04 sec in duration appeared postoperatively. If marked ischemic changes (ST-segment elevation > 3 mm and localized to one wall, or localized ST-segment depression > 1 mm with T-wave inversion > 5 mm) occurred and persisted for at least 72 hr, the ECG was considered suspicious. The TcPPI scintigrams were interpreted as positive only if discrete rather than diffuse activity was present in the region of the ventricles, with an activity level equal to or greater than that in the ribs. A diagnosis of perioperative myocardial infarction (POMI) was considered definite if the ECG demonstrated new Q waves, or if the enzymes and scintigrams were both positive. Infarction was considered probable in patients showing persistent ischemic changes on ECG, plus either positive enzymes or a positive scintigram.

RESULTS

The distribution of the test results is indicated in Table 1. Under the preceding criteria, the incidence of definite POMI was 7.9% (17/214), and probable infarction 2.8% (6/214), resulting in a total of 23 patients with perioperative infarction out of 214 (10.7%). In all of the 23 infarct patients, the TcPPI image was abnormal. One additional patient had a false-positive image that increased in intensity between the fourth and sixth postoperative days; accordingly, it most likely represents a true positive occurring after the immediate postoperative period. Only 13 of the 23 infarct patients had ECG evidence of infarction; thus there were ten false negatives, but there were no false positives. Twenty-two of the 23 infarct patients had abnormal enzymes—a very similar incidence of true positives compared with that obtained by scintigram. However, six other patients were considered falsely positive by the enzyme criterion, because neither the ECG nor the TcPPI image was abnormal.

The posterior probabilities of the test results are listed in Table 2. Because there were no false pos-

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TABLE 1. DIAGNOSIS OF PERIOPERATIVE INFARCTION OCCURRING IN 23 OF 214 AORTOCORONARY BYPASS PATIENTS

<table>
<thead>
<tr>
<th>Test</th>
<th>True (+)</th>
<th>True (-)</th>
<th>False (+)</th>
<th>False (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>13/23</td>
<td>191</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Enzymes (CPK, LDH, SGOT)</td>
<td>22/23</td>
<td>185</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>TcPPI image</td>
<td>23/23</td>
<td>190</td>
<td>1*</td>
<td>0</td>
</tr>
</tbody>
</table>

* Scintigram became positive on 4th postsurgical day, increasing in intensity from 2+ to 3+ on Day 6.

TABLE 2. POSTERIOR PROBABILITIES OF TEST RESULTS (23 INFARCTS/214 PATIENTS)

<table>
<thead>
<tr>
<th>Test</th>
<th>Probability* of perioperative infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>100%</td>
</tr>
<tr>
<td>Enzymes (CPK, LDH, SGOT)</td>
<td>79%</td>
</tr>
<tr>
<td>TcPPI image</td>
<td>96%</td>
</tr>
</tbody>
</table>

* Determined by Bayesian analysis for this patient population only. The incidence of positive and normal test results might be different in a larger series of perioperative infarcts.
ties, the probability of infarction with positive ECG criteria was 100%. Since six patients had en-
zyme values that were falsely positive, the prob-
ability of infarction with positive enzymes was only
79%. With a positive scintgram, the probability of
infarction was 96%. Ten of the 23 infarct patients
had a falsely negative ECG, thus establishing a rel-
atively high probability of infarction (5%) in spite
of a negative ECG. The probability of infarction
with normal enzymes (0.5%) or a normal scintgram
(0%) could be essentially discounted.

DISCUSSION

The incidence of POMI appears to have dimin-
ished as the experience of surgical teams has in-
creased during the past few years, and currently it
occurs in approximately 10% of patients undergoing
aortocoronary bypass vein grafting. Previous think-
ing that POMI is more benign than the usual non-
surgical infarct has proven to be untrue, since the
reported mortality rate of 20–40% for POMI is sim-
ilar to that occurring in nonoperative myocardial
infarction (1). The speculation that persistent new
Q waves on the ECG in some patients represents
only an electrical phenomenon has also been dis-
proved. There is no evidence that persistent new Q
waves do not represent POMI, except in the rare
circumstance where they signify unmasking of a
previous inferior infarction following revasculari-
zation of the contralateral wall (5,7). POMI, there-
fore, constitutes a serious clinical entity that must
be recognized during the postoperative period so
that appropriate therapeutic measures can be taken
and such patients not be prematurely discharged
from the hospital.

It is now well recognized that the ECG and my-
ocardial isoenzyme studies leave a great deal to be
desired in the diagnosis of POMI. Although the
specificity of the ECG is excellent, many patients
with POMI cannot be diagnosed by this test, since
our 43% false negatives indicate a relative insensi-
tivity (8). In addition, it is not surprising—consider-
ing the patient population selected for ACB sur-
gery—that a significant number have preoperative
Q waves that render postoperative evaluation quite
difficult. The use of serial enzyme levels, including
the myocardial band of CPK, improves the sensi-
vitivity of detection of POMI, but errs in the opposite
direction by generating a substantial number of
false-positive results (9,10). The MB band of CPK
by itself is virtually useless in the perioperative
period, since in the great majority of patients it
becomes positive soon after surgery. Righetti et al.
(11) have recently reported a quantitative determi-
nation for MB-CPK that shows some promise in
being more specific for the diagnosis of POMI, but
it requires frequent blood sampling during the first
48 hr after surgery.

The most reliable test for diagnosing POMI in
this investigation proved to be the TcPPI imaging of
the myocardium, with no false negatives and only
one false positive in the series of 214 patients,
23 of whom had POMI. The false-positive image
was probably a true positive occurring after the
immediate postoperative period. No false positives
owing to heavy valve calcification were encoun-
tered (11). Since no patient in this series had a left-
ventricular aneurysm preoperatively, no conclu-
sions can be drawn from this study regarding the
incidence of false-positive scans postoperatively
owing to unresected aneurysms. In addition to its
demonstrated accuracy, the scintigram provides in-
formation concerning the size, location, and extent
of myocardial damage, thus adding to its signifi-
cance as a diagnostic modality (12,13).

Preoperative TcPPI images were not done, and
they would have been helpful in evaluating the
overall significance of the postoperative TcPPI ab-
normalities. However, all patients in this series had
normal serum enzyme levels before surgery, and
no electrocardiographic evidence of acute infarc-
tion. These factors, together with the absence
of patients with ventricular aneurysm, diminish the
likelihood that a postoperative focal TcPPI abnor-
mality of 2+ or greater had also existed before
surgery. We stress that low-grade diffuse patterns
of TcPPI uptake were not considered positive be-
cause of difficulties in interpretation (14,15). Resid-
ual blood-pool activity may be confused with dif-
use uptake when clearance of the tracer is delayed,
such as occurs in many elderly patients and in those
with diminished renal function. Diffuse uptake pat-
terns have also been reported with subendocardial
infarction, pericarditis, and unstable angina (16).
Therefore, some patients with diffuse uptake would
be expected to have myocardial damage, and the
lack of false negatives in our series probably does
not reflect their true rate of occurrence in a larger
population. However, the technical capability for
defining focal uptake in the myocardium has im-
proved since TcPPI imaging was introduced, be-
cause of recent advances in the imaging character-
istics of scintillation camera systems, including
improved resolution and image-manipulation de-
vices that provide contrast enhancement.

The ultimate utilization of TcPPI imaging will be
influenced mainly by the outcome of the continuing
controversy concerning surgical compared with
medical treatment of coronary-artery disease (2,-
17,18). In question primarily are the relative sur-
vival rates, with some of the surgical proponents
comparing their results with life-insurance actuarial data. The Veteran's Administration study reported by Murphy et al. (19) found no difference in survival between medically and surgically treated patients followed for 21-30 mo, but this study has been severely criticized because of poor vein-graft patency (20). The question therefore remains as to the relative efficacy of current medical therapy (including beta adrenergic blockade with drugs such as propranolol) compared with the surgical approach of vein bypass grafting. In the meantime, it has been established that the major positive influence of bypass surgery is the sustained and complete relief of angina pectoris in approximately two-thirds of patients. This circumstance alone constitutes a significant stimulus for the surgical treatment of coronary-artery disease, and thus the role of TcPPI imaging should have prominent clinical significance during at least the next several years.

REFERENCES