LV Function Following Revascularization

Positron Emission Tomography and Recovery Following Revascularization (PARR-1): The Importance of Scar and the Development of a Prediction Rule for the Degree of Recovery of Left Ventricular Function

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OBJECTIVES

The aim of this study was to determine whether the extent of viability or scar is important in the amount of recovery of left ventricular (LV) function, and to develop a model for predicting recovery after revascularization that could be tested in a randomized trial.

BACKGROUND

F-18-fluorodeoxyglucose (FDG) positron emission tomography (PET) is used to define viable myocardium in patients with coronary artery disease (CAD) and severe LV dysfunction and to guide revascularization decisions. Whether this approach improves clinical outcomes has not been tested in a randomized trial. Before doing so, an objective model for prediction of recovery is required.

METHODS

A total of 82 patients with CAD and an ejection fraction (EF) ≤35% had FDG PET perfusion imaging before revascularization. Complete follow-up was available on 70 patients (86%). Patients had radionuclide angiograms at baseline and three months post-revascularization.

RESULTS

Diabetes (p = 0.029), time to operation (p = 0.008), and scar score (p = 0.001) were significant independent predictors of the change in EF. Previous coronary artery bypass graft confounded the effect of age. There was a significant interaction between the perfusion tracer used and mismatch score (p = 0.02). The multivariable prediction model incorporating PET and clinical variables had a goodness of fit with p = 0.001. Across tertiles of scar scores (I: small: 0% to 16%; II: moderate: 16% to 27.5%; III: large: 27.5% to 47%), the changes in EFs were 9.0 ± 1.9%, 3.7 ± 1.6%, and 1.3 ± 1.5% (p = 0.003: I vs. III), respectively.

CONCLUSIONS

In patients with severe LV dysfunction, the amount of scar was a significant independent predictor of LV function recovery after revascularization. A combination of PET and clinical parameters predicts the degree of recovery. This model is being applied in a large randomized controlled trial to determine the effectiveness of therapy guided by FDG PET.

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FDG positron emission tomography (PET) imaging may have impact on patient outcome (2,5,7,20). However, there are no large prospective randomized controlled trials that focus on patients with severe LV dysfunction, the group of patients where FDG PET may have the greatest benefit. Recent data have shown that FDG PET imaging can impact clinical decision making (6,20–25). However, the integration of both viability and clinical parameters may be helpful in optimizing therapy decisions for patients with severe LV dysfunction. Before undertaking a randomized controlled trial of FDG PET on patient outcome, it is necessary to understand what degree of viability will predict what level of LV function recovery, and how integration with other clinical parameters will affect the prediction of recovery.

The aim of this study was to determine whether the extent of viable or scarred myocardium is important in the level of recovery of LV function among patients with severe coronary disease and severe LV dysfunction, and to develop a model that incorporates viability and clinical parameters for predicting the degree of recovery after revascularization that could be tested in a similar patient population in a prospective randomized controlled trial.

METHODS

Patient population and study design. This was a prospective multicenter cohort study. Included were patients with coronary artery disease (CAD) and severe LV dysfunction with an ejection fraction (EF) ≤35% by any quantitative technique, who were being scheduled for revascularization. Excluded were those patients with myocardial infarction within the preceding six weeks, severe valve disease requiring valve replacement, requirement for aneurysm resection, and inability to obtain informed consent. Patients had evaluation of myocardial viability at the Cardiac PET Centre of the University of Ottawa Heart Institute (64 patients enrolled from eastern Ontario, northern Ontario, and western Quebec) or the E. S. Garnett Memorial PET Centre of McMaster University (18 patients enrolled from southwestern Ontario at McMaster University Medical Centre, University of Toronto Health Sciences Network, and London Health Sciences Centre).

Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>CAD</td>
<td>coronary artery disease</td>
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<tr>
<td>EF</td>
<td>ejection fraction</td>
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<tr>
<td>FDG</td>
<td>F-18-fluorodeoxyglucose</td>
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<tr>
<td>LV</td>
<td>left ventricle/ventricular</td>
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<tr>
<td>PET</td>
<td>positron emission tomography</td>
</tr>
<tr>
<td>RNA</td>
<td>radionuclide angiography/angiography</td>
</tr>
<tr>
<td>SPECT</td>
<td>single photon emission computed tomography</td>
</tr>
<tr>
<td>Tc</td>
<td>technetium</td>
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After providing informed consent, patients underwent baseline perfusion imaging and FDG PET. Clinical assessment of functional class, radionuclide angiography (RNA), quality of life questionnaire, and 6-min walk test were done within two weeks of the FDG PET scan, before revascularization. The RNA was repeated after three months of follow-up. The absolute change in EF between baseline and follow-up was then determined.

Evaluation of functional capacity and quality of life. Canadian Cardiovascular Society angina classification and New York Heart Association dyspnea classification were recorded based on patient self-report. The Minnesota Living with Heart Failure questionnaire was used to assess health-related quality of life (26,27). Functional score using this approach ranges from 0 (good) to 105 (poor). Submaximal exercise capacity was determined using the 6-min walk test as a safe and objective means for evaluating the functional status of patients (28,29).

RNA. The RNAs were acquired using a standard electrocardiogram-gated equilibrium blood pool imaging protocol, using Tc-99m-labelled red blood cells (6,13–15,17,22). The EF was measured from the left anterior oblique 45° acquisition. The RNA analysis was performed in a central core laboratory by observers (R.M. Iwanochko and R. J. Burns, Toronto Hospital) who were blind to any clinical or imaging data (30,31).

FDG PET. A standardized protocol for static FDG PET imaging was used. Patients without diabetes were studied in the postprandial state after a 50-g oral glucose load. Those patients with diabetes or glucose intolerance also received insulin according to a standardized protocol (2,4–6,14,15,22,32,33).

Initial PET transmission scanning was performed to allow for attenuation correction. A 30-min emission scan was acquired starting 40 min after injection of 75 to 370 MBq of FDG in a whole-body PET camera (CTI/Siemens ECAT ART, Knoxville, Tennessee). The FDG uptake images were reconstructed using a Hann window cutoff at 0.2 cycles/pixel.

Perfusion imaging. Where PET perfusion imaging was available, this was performed using either N-13 ammonia or rubidium-82. Both of these have been used routinely in previous studies for perfusion imaging, often interchangeably (2,4,5,7,13–15,32,34,35). A dose of 370 to 740 MBq of rubidium-82 or 300 to 370 MBq of N-13 ammonia was administered intravenously. Standard perfusion imaging acquisition protocols were used (32,36–41). Sites without the capability of PET perfusion imaging performed Tc-99m sestamibi single photon emission computed tomography (SPECT) to assess perfusion (4,6,17,22,42). A dose of 740 MBq of Tc-99m sestamibi was administered intravenously, followed 1 h later by standard 30-min 180° SPECT imaging protocol. All patients were studied under resting conditions. The SPECT images were reconstructed with the same resolution as the PET images and transferred to the PET computer system for analysis.

Perfusion/FDG image data analysis. The heart was divided into 460 sectors by an automated analysis program (41,43). For each sector, tracer activity was expressed as a
percentage of the maximum uptake for the patient's myocardium. The sum of the percentages of all sectors, corrected for the maximum possible score (maximum score: 46,000 = 460 sectors × 100%), defined the total "raw perfusion" score and the total "raw FDG" score, respectively. To normalize the FDG to perfusion, sectors that were ≥80% of the maximum perfusion were defined as normal. FDG uptake was then normalized by scaling the percent FDG uptake to be equal to perfusion in the "maximum zone" sectors. After this normalization, sectors with a value >100% FDG were assigned a value of 100%. The sums of all sectors were calculated again to define the total "normalized perfusion" and the total "normalized FDG" uptake, respectively.

**Tissue characterization.** In the "abnormal" sectors with <80% perfusion, the extent and severity of hibernating myocardium ("mismatch" score) and "scar" score could be defined as a percentage of the total LV myocardium. Thus, for abnormal sectors:

\[ \text{Scar score} = \frac{\sum (100 - \text{FDG})}{46,000} \times 100 \% \text{ of LD} \]

In sectors with FDG < perfusion, the perfusion score was substituted for the FDG score in the above equation.

In sectors with FDG > perfusion:

\[ \text{Mismatch score} = \frac{\sum (\text{FDG} - \text{perfusion})}{46,000} \times 100 \% \text{ of LD} \]

The score parameters consider the combination of extent and severity. Using this method, sectors with reduced perfusion can have a mixture of both mismatch and scar scores. The sum of perfusion, mismatch, and scar scores for any abnormal sector equals 100%. To evaluate size alone, the number of sectors defined as scar or mismatch were considered. Figure 1 shows examples of the polar maps to determine scar and mismatch scores in three patients.

**Statistical analysis.** Univariable comparisons evaluated possible significant associations between potential covariates and absolute changes in EF, the response variable. Separate analyses considered relative changes in EF. Size and score values were considered for the following PET-related variables: raw FDG, normalized FDG, raw perfusion, normalized perfusion, mismatch score, and scar score. Each of these variables was modeled as a normal distribution. The following demographic and clinical variables were considered: age, gender, baseline EF, previous revascularization, time to revascularization, symptom class, and diabetes. Candidate demographic and clinical variables were selected based on prior evidence of important prognostic factors in the setting of revascularization (44,45). Although associations with other variables were plausible, the study had sample size constraints. Therefore, in addition to obtaining a satisfactory fit of the data, a secondary goal of the analysis was to limit the number of variables in the model so that there would be at least 10 cases per variable in order to avoid overfitting (44,45).

Multivariable analyses were performed by using stepwise multiple regression methods. The criterion for possible inclusion in the multivariable model was an adjusted p value <0.2. The criterion for remaining in the multivariable model was an adjusted p value <0.05. Goodness of fit was based on assessment of overall model fit and graphic comparison of observed versus adjusted values residual plots to identify outlying or influential observations or systematic patterns (46). To illustrate the association between scar score and the absolute change in EF on RNA between baseline and post-revascularization follow-up, the scar score was compared across tertiles. Interaction terms were considered. Thus, an indicator variable was included in the model to account for the potential differences in perfusion tracer, as the use of PET or SPECT tracers could potentially affect the degree of scar or mismatch defined (8,47,48) (tracer variable = 1 for PET, 0 for SPECT perfusion).

**RESULTS**

**Patient characteristics.** Between July 1996 and October 1999, 101 patients were considered for the study. Of these, two patients (2%) could not complete both tests before the scheduled revascularization. Thirteen patients (13%) underwent aneurysm resection, ventricular reconstruction, or mitral valve replacement and were excluded. Four patients (4%) had surgery cancelled. Thus, 82 patients (82%) with baseline FDG PET and RNA met inclusion criteria. Of these 82 patients, 2 patients (2%) died before follow-up, 1 patient before undergoing surgery and the other patient in the early postoperative period. One patient had a large stroke and could not return for follow-up. Six other patients (7%) were lost to follow-up. Three patients (4%) had technical difficulties with baseline or follow-up PET or RNA that could not be analyzed. Thus, 70 patients (85% of those eligible) had complete follow-up data and were included in the analysis. The baseline demographic characteristics of these patients are shown in Table 1. There were 51 patients (73%) that had class III to IV dyspnea, whereas 35 patients (50%) had class III to IV angina. The patients' previous angiography showed that three-vessel CAD and/or left main coronary artery disease was present in 49 patients (70%). Every attempt was made to proceed to revascularization as soon as possible after the PET and RNA images. In 51 patients (71%), revascularization was performed within six weeks of the FDG PET scan.

**Independent predictors of change in LV function.** The following factors were independently and significantly associated with absolute change in EF after adjustment for other factors (Table 2): scar score (p = 0.001), tracer (p = 0.043), time to operation (within 6 weeks) (p = 0.008), and diabetes (p = 0.029). The independent effect of the mismatch score was not significant. After adjustment for a statistically significant interaction between mismatch and
perfusion tracer, the net effect of the mismatch score when using PET perfusion was significant ($p = 0.085$) for mismatch score, $p = 0.043$ for tracer, $p = 0.021$ for the interaction term). Because of this interaction the net effect of mismatch is better understood by considering the fitted values (discussed in the following text and in Table 3). Prior coronary artery bypass graft was included in the model because it confounded the estimate for age.

Multivariable correlates of change in LV function. Although multivariable models of absolute and relative changes in EF were similar, a better goodness of fit was achieved with absolute change in EF. Therefore, adjusted values were calculated for absolute change in EF (Table 3). The overall fit of the model was significant ($F = 4.35$, $df = 8$, $p = 0.001$). No observations were identified as being outlying or influential. Table 3 describes the overall effect of an incremental change in selected variables on the fitted

**Figure 1.** Examples of reconstructed polar maps for three patients: **A**, **B**, **C**. In each set, the top panel is the raw perfusion (left) and raw F-18-fluorodeoxyglucose (FDG) uptake (right) polar maps; middle panel is the normalized perfusion and FDG uptake; and the lower panel is the scar score (left) and mismatch score (right). (A) Predominantly scar in the inferolateral and anteroseptal walls and apex. Of the total left ventricle (LV) myocardium, 53% was normal, 42% was scar, and 5% was mismatch. The model predicted a change in ejection fraction (EF) of 0%; observed change was from 26% to 25% $\pm 1\%$. (B) Partial mismatch (mixture of scar and hibernating myocardium) in the large defect involving the inferolateral wall and apex extending to the distal anteroseptal wall. Of the total LV myocardium, 62% was normal, 23% was scar, and 15% was mismatch. Model predicted change in EF of 4%; observed change was from 23% to 28% $\pm 5\%$.

**Table 1.** Patient Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>$62 \pm 9$</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>$26 \pm 7$</td>
</tr>
<tr>
<td>Men</td>
<td>$62 ,(89%)$</td>
</tr>
<tr>
<td>LMCA and/or three-vessel disease</td>
<td>$49 ,(70%)$</td>
</tr>
<tr>
<td>Hypertension</td>
<td>$32 ,(46%)$</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>$25 ,(36%)$</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>$6 ,(9%)$</td>
</tr>
<tr>
<td>Dyspnea: NYHA class III–IV</td>
<td>$51 ,(73%)$</td>
</tr>
<tr>
<td>Angina: CCS class III–IV</td>
<td>$35 ,(50%)$</td>
</tr>
<tr>
<td>Quality of life questionnaire score (MLHF)</td>
<td>$48 \pm 23$</td>
</tr>
<tr>
<td>6-min walk test (m)</td>
<td>$347 \pm 128$</td>
</tr>
<tr>
<td>Time to revascularization (&lt;6 weeks)</td>
<td>$50 ,(71%)$</td>
</tr>
</tbody>
</table>

*CABG = coronary artery bypass graft; CCS = Canadian Cardiovascular Society; LMCA = left main coronary artery; MLHF = Minnesota Living with Heart Failure; NYHA = New York Heart Association.*

**Table 2.** Independent Predictors of Change in LV Function

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient Value</th>
<th>SE</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scar score (%LV)</td>
<td>$-0.451$</td>
<td>$0.097$</td>
<td>$0.001$</td>
</tr>
<tr>
<td>Mismatch score (%LV)</td>
<td>$-0.319$</td>
<td>$0.177$</td>
<td>$0.085$</td>
</tr>
<tr>
<td>Tracer</td>
<td>$-0.384$</td>
<td>$3.164$</td>
<td>$0.043$</td>
</tr>
<tr>
<td>Tracer/mismatch interaction*</td>
<td>$0.500$</td>
<td>$0.215$</td>
<td>$0.021$</td>
</tr>
<tr>
<td>Time to OR (&lt;6 weeks)</td>
<td>$0.286$</td>
<td>$1.969$</td>
<td>$0.008$</td>
</tr>
<tr>
<td>Diabetes</td>
<td>$0.237$</td>
<td>$1.878$</td>
<td>$0.029$</td>
</tr>
<tr>
<td>Age</td>
<td>$0.185$</td>
<td>$0.101$</td>
<td>$0.088$</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>$0.110$</td>
<td>$3.164$</td>
<td>$0.295$</td>
</tr>
</tbody>
</table>

*Reflects the contribution of the interaction term.

*CABG = coronary artery bypass graft; LV = left ventricle; OR = revascularization; SE = standard error.*
absolute change in EF while holding all other variables in
the model constant. For this analysis mean values were used
for continuous variables and modal values were used for
categorical variables (tracer/H11005, PET). The mean absolute
change in EF was 4.3\% ± 1.68\%. A 10-point incremental
increase in the extent of scar would reduce the change in EF
by 3.38\% to 0.94\% ± 3.39. A 10-point increase in mismatch
using PET perfusion would increase the change in EF by
1.99\% to 6.31\% ± 2.37\%. The complete model explained
36.4\% of the variance in EF. The observed versus the
fitted absolute changes in EF calculated from the multiple linear
regression are shown in Figure 2 (r = 0.60; p = 0.0003).

**DISCUSSION**

This prospective study demonstrates that in patients with
severe CAD and LV dysfunction, the amount of scar is an
important predictor of the extent of recovery after surgery. The
semiquantitative PET imaging methods allow objective
evaluation of viability. The PET parameters combined with
clinical parameters can be used to estimate the degree of LV
function recovery. To our knowledge, this is the largest such
study to integrate the clinical, demographic, and imaging
information into a prediction model for LV function recov-
ery post-revascularization.

**Scar, mismatch, and LV function recovery.** In the current
study, quantification of the amount of scar was an indepen-
dent predictor of improvement in LV function following
revascularization in patients with severe LV dysfunction.
Previous studies have focused on the importance of mis-
match (or hibernating myocardium) in predicting recovery
of function and improved outcome (2,4,5,7,10,14,18). The
current study indicates that scar should also be considered
and that PET parameters should be considered in the
clinical context.

Recent data from Pagano et al. and reports from Bax et al.
suggest that the number of viable dysfunctional segments
and the amount of mismatch are important for predicting
symptom and LV function recovery (19,49,50). In the study
by Pagano et al. (19) the number of viable segments, de-
defined by the rate of myocardial glucose utilization, was associated
with the change in EF (r = 0.65). Unlike many previous
studies, Pagano et al. (19) defined viability independent of
perfusion. The current study showed similar results in that
the degree of scar (the corollary of the Pagano et al. (19)
utilization) was a significant independent predictor
of LV function recovery. However, it also showed that a
prediction model that includes PET parameters (scar and

**Table 3. Fitted Absolute and Incremental Changes in EF**

<table>
<thead>
<tr>
<th>Variable Change</th>
<th>Fitted Absolute Change in EF</th>
<th>95% CI</th>
<th>Incremental Change in EF*.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean change (theoretical patient)*</td>
<td>4.32</td>
<td>(0.97, 7.68)</td>
<td>-3.38</td>
</tr>
<tr>
<td>10 points increase in scar score</td>
<td>0.94</td>
<td>(-3.39, 5.26)</td>
<td>-1.99</td>
</tr>
<tr>
<td>10 points increase in mismatch score</td>
<td>6.31</td>
<td>(1.58, 11.05)</td>
<td>+1.76</td>
</tr>
<tr>
<td>10 years increase in age</td>
<td>6.08</td>
<td>(1.70, 10.45)</td>
<td></td>
</tr>
<tr>
<td>Presence of diabetes mellitus</td>
<td>8.53</td>
<td>(4.33, 12.73)</td>
<td>+4.21</td>
</tr>
</tbody>
</table>

*The fitted absolute change in ejection fraction (EF) in a patient (with mean values for each of the continuous variables in the
model, and assuming modal values for categorical variables with the tracer variable = 1) is 4.32. The Table expresses the fitted
absolute change and incremental change in EF when an individual parameter is changed in this theoretical patient.

CI = confidence interval.
mismatch) and clinical parameters can be used to estimate
the degree of recovery of LV function following revascular-
ization.

Others have also recently focused on the extent of scar. In
a cohort study, Haas et al. (20) used 50% FDG uptake as
cutoff for viability and defined an extent of scar >40% as
unlikely to recover with revascularization. Using FDG PET
to risk stratify with these cutoffs yielded improved postop-
erative and long-term outcomes compared to an approach
that did not utilize FDG PET (20). Further evidence on the
importance of the total extent of viability comes from
subsequent studies by Haas et al. (51,52). These data
indicate that dysfunctional regions with normal perfusion
(repetitively stunned myocardium) are more common than
mismatch (70% vs. 24% of dysfunctional segments). In
addition such “normal perfusion zones” have less associated
tissue injury and are more likely to demonstrate complete
recovery than mismatch segments (31% vs. 18%, respec-
tively) (51,52).

Retrospective studies evaluating FDG PET and long-
term patient outcome (2,5–7,12,35) suggest that FDG PET
potentially identifies high-risk patients that may benefit
from revascularization. Other studies have shown that FDG
PET is helpful in decision making for revascularization
(22–24), but it is difficult, without prospective randomized
controlled trials, to know whether therapy decisions are
indeed appropriate and impact on outcome. One random-
ized controlled trial has compared FDG PET guided
therapy to Tc-99m-sestamibi guided therapy (53). Al-
though there were minor trends, this study showed no
significant difference in outcome. However, the study
focused on a lower risk group of patients (with mostly
moderate LV dysfunction), used only FDG mismatch to
define viability in hypoperfused segments, and was too small
to detect important differences (54). One of the aims of the
current study was the identification of a prediction model
that incorporates PET and clinical parameters and could be
applied in a prospective randomized controlled trial of
patients with severe LV dysfunction—the patient popula-
tion who will most likely benefit from viability detection.

Utility of the prediction model. In this study, several
clinical parameters had impact on LV function recovery.
The presence of higher risk parameters, including diabetes,
age, and previous revascularization, increased the degree
of recovery. At first glance, this may appear paradoxical.
However, other studies (55) have shown that the patients at
greatest risk are often those who gain the most benefit
from treatment. It is possible that older patients and those
with previous bypass have better developed collateral
flow, which could facilitate recovery. Alternatively, a selection bias may have occurred whereby subjective criteria for revasculariza-
tion decisions are stricter with the higher risk patients. In
the case of diabetes, it may also indicate that the level of
viable myocardium is greater than apparent on imaging
because patients with diabetes tend to be more difficult to
image (56–60). Examples of applying the model to three
patients in the current study who had small, moderate, and
large scar areas are shown in Figure 1.

Study limitations. Some limitations of this approach are
worth considering. These primarily relate to the patient
population in this study, which included patients who were
predominantly men, predominately between 53 and 71 years
of age (1 standard deviation from the mean), had multivessel
disease, and had bypassable vessels. The generalizability of
the prediction model to a wider patient population is being
tested in a large randomized controlled trial (PET and
Recovery following Revascularization—Phase 2 [PARR-2]).
The current study was intended as a pilot study to
establish the prediction model for subsequent trials. The
sample size was larger than many PET studies evaluating
recovery of function. However, the sample size limited the
parameters that could be included in the prediction model.

Figure 2. Prediction model: observed vs. fitted change in absolute ejection
fraction. Correlation coefficient: $r = 0.60; p = 0.0003$.

Figure 3. Absolute change in ejection fraction (EF) versus scar scores:
small (0% to 16% of left ventricle [LV]), moderate (16% to 27.5% of LV),
and large (27.5% to 47% of LV); $* p = 0.002$, small versus large scar score.
Thus, some potentially important parameters, such as stress-induced ischemia and ventricular volumes, were not included. The number of parameters used simplifies the model for research and clinical use but also means that prediction rules for a given patient must be taken in the context of clinical judgment and image interpretation. The impact of some of these variables on the model will be tested in the larger ongoing randomized control trial.

The use of both PET and SPECT perfusion agents in the current study represents the clinical reality, as many institutions do not have access to PET perfusion agents. This may account for the lack of significance of the independent mismatch term. To account for potential differences in mismatch due to the type of perfusion tracer (PET or SPECT), an interaction variable (tracer variable) was used in the model. When PET perfusion was used, the overall effect of mismatch was for a predicted increase in EF. When SPECT perfusion was used, the mismatch effect was not significant and the confidence limits of the point estimate overlap 0. Thus, interpretation of the effect of mismatch with SPECT perfusion must be done cautiously. This limitation of the model likely reflects the small sample size. Ongoing clinical trials will allow evaluation of each PET variable with greater accuracy.

Although improvement in LV function has been noted at three months of follow-up in many previous studies, recent data suggest that more recovery may be observed with longer follow-up time (51,52,61). The impact of follow-up time on the model could not be addressed in the current study but will be considered in the larger ongoing randomized control trial that will follow up patients up to two years. It could be argued the angiographic data should be included in the model. Clearly this is an important parameter in decision making. However, patients in this study did have suitable anatomy for revascularization. If they did not, they were not generally considered for revascularization and the model would not be applicable. Second, many patients referred for PET (about 50% in our institution) have not had a recent angiogram. Therefore, coronary anatomy data would not always be available to incorporate into the model. The prospective randomized controlled trial (PARR-2) includes patients who have as well as those who have not had recent angiography before the PET study: so the model can be validated in this patient population.

CONCLUSIONS

In patients with severe CAD and LV dysfunction, quantification of the amount of scar with FDG PET and perfusion imaging is important in predicting the extent of recovery of LV function after revascularization. The percent of the LV with scar was the most important predictor. A prediction model that combines PET and clinical parameters can be used to predict the degree of recovery of LV function.

These data set the framework for larger scale future studies evaluating the application of FDG PET. The prediction model is now being applied in a large multicenter randomized controlled trial (PARR-2) to determine the clinical outcome and cost-effectiveness of therapy guided by FDG PET.

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APPENDIX

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