Septal and Anterior Reverse Mismatch of Myocardial Perfusion and Metabolism in Patients With Coronary Artery Disease and Left Bundle Branch Block

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Abstract: The effects of left bundle branch block (LBBB) on left ventricular myocardial metabolism have not been well investigated. This study evaluated these effects in patients with coronary artery disease (CAD).

Sixty-five CAD patients with complete LBBB (mean age, 61.8 ± 9.7 years) and 65 without LBBB (mean age, 59.9 ± 8.4 years) underwent single photon emission computed tomography, positron emission tomography, and contrast coronary angiography. The relationship between myocardial perfusion and metabolism and reverse mismatch score, and that between QRS length and reverse mismatch score and wall motion score were evaluated.

The incidence of left ventricular septum and anterior wall reverse mismatching between the 2 groups was significantly different (P < 0.001 and P = 0.002, respectively). The incidences of normal myocardial perfusion and metabolism in the left ventricular lateral and inferior walls were also significantly different between the 2 group (P < 0.001 and P < 0.001, respectively). The incidence of septal reverse mismatching in patients with mild-to-moderate perfusion was significantly higher among those with LBBB than among those without LBBB (P < 0.001). In CAD patients with LBBB, septal reverse mismatching was significantly more common among those with mild-to-moderate perfusion than among those with severe perfusion defects (P = 0.002). The correlation between the septal reverse mismatch score and QRS length was significant (P = 0.026).

In patients with CAD and LBBB, septal and anterior reverse mismatching of myocardial perfusion and metabolism was frequently present; the septal reverse mismatch score negatively correlated with the QRS interval.

(Key Words: 18F-FDG = 18F-fluorodeoxyglucose, 99mTc-MIBI = 99mTc-methoxyisobutyl isonitrile, CAD = Coronary Artery Disease, CT = computed tomography, DCM = dilated cardiomyopathy, IMP = intramyocardial pressure, LBBB = Left Bundle Branch Block, LVEF = Left ventricular ejection fraction, PET = positron emission tomography, SPECT = single-photon emission computed tomography.)

INTRODUCTION

The prevalence of coronary artery disease (CAD) is significantly higher in patients with left bundle branch block (LBBB) than in those without LBBB.1 LBBB induces inhomogeneous activation and deformation of the ventricles, leading to inefficient contraction2 and causing delayed activation of the left ventricle.3 Spontaneous LBBB is associated with increased cardiovascular and overall mortalities.4–6

Assessment of myocardial perfusion by single-photon emission computed tomography (SPECT) is commonly performed in patients with LBBB to detect CAD.7 However, most previous studies evaluating the characteristics of myocardial perfusion imaging in LBBB patients8–11 have focused on patients with LBBB and dilated cardiomyopathy (DCM)5.12–17 or with LBBB and ischemic cardiomyopathy.18,19 Rest myocardial perfusion SPECT with technetium compounds is useful for localising healed myocardial infarction in patients with LBBB, and exercise (+dipyridamole) SPECT has a high positive predictive value and specificity for the diagnosis of coronary stenosis in these patients.17 18F-fluorodeoxyglucose (18F-FDG) myocardial metabolic imaging showed septal uptake reduced in relation to septal 99mTc-methoxyisobutyl isonitrile (99mTc-MIBI) uptake, and is defined ‘‘reversed mismatch,’’3,8–10,18 Most of these studies included patients with DCM;2,3,12,13 few have reported results from patients with ischemic cardiomyopathy16 or CAD.5,8–10

This study evaluated the characteristics of myocardial perfusion and metabolism in patients with angiographically significant CAD and LBBB. Furthermore, the correlations of the reverse mismatch scores with the QRS durations and with the echocardiographic wall motion scores were assessed.

MATERIALS AND METHODS

Study Patients

Sixty-five consecutive patients with complete LBBB and suspected or known CAD underwent 99mTc-MIBI SPECT, 18F-FDG positron emission tomography (PET), and, between July 2009 and July 2013, to evaluate their myocardial viability at Fu Wai Hospital (Beijing, China), and underwent coronary angiography were included in this study. A control group was
also included that comprised consecutive patients undergoing 99mTc-MIBI SPECT, 18F-FDG PET, and coronary angiography between June 2011 and April 2013. The clinical and imaging data were retrospectively reviewed and analyzed. Patients were excluded if they had myocarditis, valvular heart disease, hypertrrophic cardiomyopathy, alcoholic cardiomyopathy, or diastolic heart failure. All patients provided signed informed consent, and the study was approved by the institutional review board.

**Electrocardiography**

LBBB was defined as a QRS duration ≥120 ms; presence of large, flat or notched R wave in the V5 lead; large, deep S wave showing QS or rS wave in V1 and V2 leads (II, III, aVF and V1 is similar); secondary ST-T wave changes, where the QRS complex up leads (eg, LaVL, V5, etc.) ST segment depression, T waves inversion, main wave in the QRS complex down leads (eg II, aVR, V1, etc.) ST-segment elevation, T wave upright. QRS duration is measured from the beginning of the Q wave to the end of the S wave. A normal range is from 40 to 100 milliseconds (1 small box to 2.5 small boxes).

**Coronary Angiography**

Standard selective coronary angiography was performed within 1 month of the SPECT and PET examinations. Stenosis classification: 1, without stenosis; 2, mild stenosis (<30%); 3, moderate stenosis (30%–50%); 4, severe stenosis (50%–90%); 5, subtotal occlusion (>90%); 6, total occlusion, no blood. Stenosis with ≥50% diameter narrowing were considered significant.

**Echocardiography**

Resting 2-dimensional echocardiography was performed within 2 weeks of the PET study using a 2.5-MHz, multi-frequency probe in harmonic imaging mode. Patients took a left lateral decubitus position and were asked to breathe calmly. Wall motion of the left ventricle was visually evaluated using digital cine loop analysis or tissue Doppler imaging in the apical 4- and 3-chamber views, parasternal short axis views of the left ventricle. After obtaining the images, the left ventricle is divided 17 sections according to the American Heart Association recommended method. Left ventricular ejection fraction (LVEF) was measured by the Simpson rule.

**99mTc-MIBI SPECT**

Myocardial perfusion 99mTc-MIBI SPECT acquisition was performed using a dual-head gamma camera (e.cam; Siemens Healthcare, Erlangen Germany); 90–120 min after injection of 740 MBq of 99mTc-MIBI, at rest, perfusion images were acquired with 64 views (25 s per view) using a zoom factor of 1.23. The cardiac cycle was divided into 8 equal intervals. Images were reconstructed using standard, filtered back-projection with a Butterworth filter (cut-off frequency, 0.4 cycles/cm; order, 5.0) and displayed as short-axis and horizontal and vertical long-axis slices.

**18F-FDG PET**

Myocardial 18F-FDG PET/computed tomography (CT) and 99mTc-MIBI SPECT imaging were performed within 2 days of each other. After an overnight fast of at least 12 h, an oral glucose solution (25–50 g, based on patient serum glucose levels) was administered. Insulin was intravenously administered if the blood glucose level was >9.0 mmol/L, 45 min after administration of the oral glucose solution, with close monitoring of the blood glucose levels. When the blood glucose level was appropriate, 18F-FDG (3 MBq/kg) was intravenously administered. Images were acquired 1–2 h after tracer injection using a Biograph 64 PET/CT scanner (Siemens Healthcare) equipped with high-performance lutetium oxyorthosilicate PET crystals and a 64-slice CT. After a scout CT acquisition (120 kV, 10 mA) was performed to ensure proper patient positioning, a CT transmission scan (140 kV, 35 mA) was performed for attenuation correction and anatomical localization. Images were reconstructed using attenuation-weighted ordered subset expectation maximization iterative reconstruction (8 subsets, 4 iterations).

**Image Analysis**

Based on the standard 17-segment model, the perfusion and metabolism images were visually evaluated by 2 nuclear physicians, blinded to the clinical data. Perfusion imaging segments were scored using a 5-point scoring system (0, normal; 1, mild defect; 2, moderate defect; 3, severe defect; and 4, absent tracer); PET images were scored using the same scoring system. The following terminology was also employed to describe the myocardial perfusion and metabolism: Normal, normal myocardial perfusion and metabolism; Match, concordant reduction of myocardial perfusion and metabolism; Mismatch, reduced myocardial perfusion with preserved metabolism; and Reverse Mismatch, reduced metabolism in comparison with myocardial perfusion. Echocardiographic wall motion was scored using a 4-point scale (1, normal; 2, hypokinetic; 3, akinetic; and 4, dyskinetic).

| TABLE 1. Patient Characteristics |
|----------------------------------|
| Characteristics | CAD With | CAD Without |
| CAD With LBBB | CAD With LBBB | P |
| Men (total) | 58 (65) | 56 (65) | 0.595 |
| Age (years) | 61.8 ± 9.7 | 59.9 ± 8.4 | 0.217 |
| Smoking, n | 29 | 36 | 0.221 |
| Hypertension, n | 40 | 33 | 0.218 |
| Hyperlipidemia, n | 44 | 35 | 0.107 |
| Diabetes mellitus, n | 27 | 25 | 0.721 |
| Old myocardial infarction, n | 49 | 50 | 0.838 |
| Revascularization, n | 16 | 15 | 0.838 |
| Coronary angiography, n | | | |
| Normal | 2 | | |
| LAD* stenosis | 10 | 1 | |
| LCx stenosis | 2 | | |
| RCA stenosis | 4 | | |
| Ramus | 1 | | |
| LAD/LCx | 5 | 2 | |
| LAD/RCA | 8 | 12 | |
| L CX/RCA | 1 | | |
| LAD/LCx/RCA | 33 | 49 | | |
| QRS, ms | 149.9 ± 21.6 | 94.8 ± 12.2 | <0.001 |
| LVEF, % | 35.5 ± 8.5 | 44.4 ± 11.2 | <0.001 |

CAD = coronary artery disease, LAD = left anterior descending artery, LBBB = left bundle branch block, LCx = left circumflex artery, LVEF = left ventricular ejection fraction, NS = not statistically significant, QRS = Q,R,S; RCA = right coronary artery.
Statistical Analysis

All variables were reported as means ± SD or frequencies when appropriate. Student’s t-test was used to compare mean differences in continuous variables between the 2 patient groups. Likewise, a chi-squared test was used to compare categorical variables between the 2 groups. Correlations between 2 variables were obtained using Spearman’s test. Data analyses were performed using SPSS, version 13.0 (IBM, Armonk, NY). A 2-tailed P-value < 0.05 was considered statistically significant.

RESULTS

Patient Characteristics

A total of 65 CAD patients with and 65 patients without LBBB underwent 99mTc-MIBI SPECT, 18F-FDG PET, and coronary angiography. As shown in Table 1, the numbers of men and the average ages of the patients in the groups were not significantly different. CAD patients, with or without LBBB, had similar frequencies of smoking, hypertension, hyperlipidemia, diabetes mellitus, old myocardial infarctions, and histories of revascularization. LVEF was lower in the patients with LBBB than in those without LBBB. The QRS duration in LBBB patients was also higher than in patients without LBBB.

Characteristics of Myocardial Perfusion and Metabolism Imaging

Results of the regional perfusion-metabolism relationship for all patients are shown in Table 2; only 5 patients showed normal septal myocardial perfusion and metabolism on imaging. The incidences of septal and anterior reverse mismatch were significantly different between patients with and without LBBB (56.9% vs 9.3%, χ² = 33.4, P < 0.001; 18.5% vs 1.5%, P = 0.002, respectively) (Table 2). Normal myocardial perfusion and metabolism in the lateral and inferior walls was significantly different between the 2 groups (84.6% vs 21.5%, χ² = 7.386, P = 0.007; 60.0% vs 2.7%, χ² = 24.8, P < 0.001, respectively) (Table 2). Similarly, reverse mismatching in the apex was also significantly different between the 2 groups (P < 0.001) (Table 2). A typical case of myocardial perfusion and metabolism reverse mismatch is illustrated in Figure 1.

Septal mismatching and septal reverse mismatching between the 2 groups, in patients with mild to moderate myocardial perfusion was significantly different (30.0% vs 67.6%, χ² = 13.0, P = 0.001; 29.4% vs 58.8%, χ² = 9.554, P = 0.003; 60.0% vs 6.25%, χ² = 8.789, P = 0.003; 29.4% vs 58.8%, χ² = 4.113, P = 0.043, respectively) (Table 3). Moreover, the incidences of matched, mismatched, and reverse mismatched myocardial perfusion and metabolism were not significantly different among the patients with severe perfusion defects (Table 4).

In the CAD patients with LBBB, the incidences of septal match, septal reverse mismatch, and anterior match of myocardial perfusion and metabolism between patients with mild to moderate and severe perfusion defects were significantly different (10.0% vs 62.5%, χ² = 20.0; 30.8% vs 4.6%, χ² = 0.001; 29.4% vs 58.8%, χ² = 9.2; 0.999) (Table 2). In these same patients, the septal mismatch; lateral wall match and mismatch; anterior wall mismatch and reverse mismatch; inferior wall match and mismatch; and apical match, mismatch, and reverse mismatch were no significantly different among the patients with mild to moderate perfusion defects and those with severe defects (Table 5).

| TABLE 2. Wall Characteristics of Coronary Artery Disease Patients With and Without (control) Left Bundle Branch Block (LBBB) |

| Septum, n | Control | LBBB | χ² | P |
|-----------|---------|------|----|---|
| Normal    | Normal  | Match | 5  | 12 | 0.058 |
|           | Normal  | Mismatch | 11 | 37 | 0.001 |
|           | Normal  | Reverse Mismatch | 37 | 6 | 0.001 |
| Lateral, n| Normal  | Match | 55 | 4 | 0.001 |
|           | Normal  | Mismatch | 6 | 6 | 0.001 |
|           | Normal  | Reverse Mismatch | 2 | 2 | 0.001 |
| Anterior, n| Normal | Match | 8 | 20 | 0.001 |
|           | Normal | Mismatch | 25 | 30 | 0.001 |
|           | Normal | Reverse Mismatch | 12 | 1 | 0.001 |
| Inferior, n| Normal | Match | 20 | 14 | 0.001 |
|           | Normal | Mismatch | 30 | 44 | 0.001 |
|           | Normal | Reverse Mismatch | 1 | 2 | 0.001 |
| Apex, n   | Normal  | Match | 9 | 21 | 0.001 |
|           | Normal  | Mismatch | 21 | 32 | 0.001 |
|           | Normal  | Reverse Mismatch | 14 | 21 | 0.001 |

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The correlations between the reverse mismatch scores and QRS lengths are shown in Table 6 and Figure 2. The QRS length negatively correlated with the septal reverse mismatch score \( r = -0.276, \ P = 0.026 \), whereas associations were not observed with the anterior, apex, lateral, or inferior reverse mismatch scores (Table 6). Similarly, a statistically significant correlation was not observed between the wall motion scores and reverse mismatch scores (Table 6).

**DISCUSSION**

This study involved a reasonably large cohort of CAD patients with and without LBBB who underwent myocardial SPECT and \(^{18}\text{F}-\text{FDG}\) PET imaging to evaluate septal myocardial perfusion and metabolism. We demonstrated that the majority of CAD with LBBB patients have septal and anterior reverse perfusion and metabolism mismatching, as determined using SPECT and PET imaging. Additionally, septal reverse mismatching of myocardial perfusion and metabolism was present in CAD patients with LBBB and mild-to-moderate myocardial perfusion defects. Finally, there was a significant negative correlation between the QRS length and the reverse septal mismatch score in CAD patients with LBBB.

**Previous Studies in Patients with DCM and LBBB**

Masci et al. reported a study involving DCM patients with (11) and without (7) LBBB; 29 (60%), 14 (29%), and 5 (10%) of the 48 investigated segments had flow metabolism reverse mismatching in the septum, adjacent regions, and lateral regions, respectively.\(^2\) In another group of 15 patients with DCM and LBBB, \(^{18}\text{F}-\text{FDG}\) uptake was highest in the lateral wall and the lowest in the septum, with intermediate values for the anterior and posterior walls.\(^3\) Another group of 8 DCM patients with LBBB was reported to have severe septal defects, as indicated by \(^{18}\text{F}-\text{FDG}\) uptake and septal flow metabolism reverse mismatching.\(^13\)

**Previous Studies in Patients With CAD and LBBB**

Zanco et al. reported that 29 patients with complete LBBB, but no significant stenosis during coronary angiography, showed reduced septal \(^{18}\text{F}-\text{FDG}\) uptake compared to \(^{13}\text{N}-\text{NH}_3\) uptake. The reverse mismatch involved 18%, 35%, and 47% of the anterior walls, inferior walls, and both walls, respectively; none of the patients had a lateral region reverse mismatch.\(^18\) In another group of 6 patients with CAD, the septal FDG/MIBI ratio was significantly lower in patients with LBBB (0.62 ± 0.12) than in those without LBBB (1.24 ± 0.24, \( P < 0.001 \)) and did not exceed 0.8 in patients with LBBB.\(^8\) Further, a study involving 53 patients with LV dysfunction and ischemic cardiomyopathy showed that among 34 patients with LBBB, 23 (68%) demonstrated septal reverse mismatching and...
In our study, the overall incidence of myocardial flow metabolism reverse mismatching was 56.9% in the septum, 18.5% in the anterior segment, and 21.5% in the apex, similar to the findings of the previous studies. Patients with complete LBBB demonstrate severely reduced 18F-FDG uptake, but preserved septal uptake of the long-chain fatty acid analog 18F-fluoro-6-thia-heptadecanoate and 11C-acetate. Altehoefer et al. reported 1 patient with 3-vessel disease, a history of previous anterior myocardial infarction, and LBBB who showed severely reduced 18F-FDG uptake but preserved septal uptake of 18F-fluoro-6-thia-heptadecanoic acid in the interventricular septum and septal portions of the anterior and posterior walls. Zanco et al. described a patient with insulin-dependent diabetes who had significant left anterior descending artery stenosis, thrombolysed myocardial infarction, and complete LBBB, despite severe damage on 18F-FDG.

### TABLE 3. Wall Characteristics in Patients With Mild to Moderate Perfusion

|         | LBBB | Control | $\chi^2$ | $P$  | Odds Ratio |
|---------|------|---------|----------|------|------------|
| Septum, n |      |         |          |      |            |
| Match    | 2 (10.0) | 11 (29.7) | 1.725    | 0.189 |            |
| Mismatch | 6 (30.0) | 25 (67.6) | 7.386    | 0.007 | 0.206      |
| Reverse mismatch | 12 (60.0) | 1 (2.7) | 24.8 | <0.001 | 55.5    |
| Lateral, n |      |         |          |      |            |
| Match    | 3 (37.5) | 16 (35.6) | 0.000    | >0.99 |            |
| Mismatch | 5 (62.5) | 27 (60.0) | 0.000    | >0.99 |            |
| Reverse mismatch | 2 (4.4) |         |          | >0.99 |          |
| Anterior, n |      |         |          |      |            |
| Match    | 10 (29.4) | 14 (43.75) | 1.465   | 0.226 |            |
| Mismatch | 19 (55.9) | 17 (53.125) | 0.051  | 0.822 |            |
| Reverse mismatch | 5 (14.7) | 1 (3.125) | 2.012 | 0.156 |          |
| Inferior, n |      |         |          |      |            |
| Match    | 5 (33.3) | 7 (25.0) | 0.337   | 0.561 |            |
| Mismatch | 10 (66.7) | 21 (75.0) | 0.337   | 0.561 |            |
| Reverse mismatch |         |         |          |      |            |
| Apex, n  |      |         |          |      |            |
| Match    | 2 (25.0) | 8 (44.4) |         | 0.420 |            |
| Mismatch | 4 (50.0) | 10 (55.6) |         | >0.99 |            |
| Reverse Mismatch | 2 (25.0) |         |         | 0.086 |          |

LBBB = left bundle branch block.

11 (32%) did not. In our study, the overall incidence of myocardial flow metabolism reverse mismatching was 56.9% in the septum, 18.5% in the anterior segment, and 21.5% in the apex, similar to the findings of the previous studies. Patients with complete LBBB demonstrate severely reduced 18F-FDG uptake, but preserved septal uptake of the long-chain fatty acid analog 18F-fluoro-6-thia-heptadecanoate and 11C-acetate. Altehoefer et al. reported 1 patient with 3-vessel disease, a history of previous anterior myocardial infarction, and LBBB who showed severely reduced 18F-FDG uptake but preserved septal uptake of 18F-fluoro-6-thia-heptadecanoic acid in the interventricular septum and septal portions of the anterior and posterior walls. Zanco et al. described a patient with insulin-dependent diabetes who had significant left anterior descending artery stenosis, thrombolysed myocardial infarction, and complete LBBB, despite severe damage on 18F-FDG.

### TABLE 4. Wall Characteristics in Patients With Severe Perfusion Defects

|         | LBBB | Control | $\chi^2$ | $P$  |
|---------|------|---------|----------|------|
| Septum, n |      |         |          |      |
| Match    | 10 (62.5) | 13 (54.2) | 0.273 | 0.601 |
| Mismatch | 5 (31.25) | 9 (37.5) | 0.165 | 0.685 |
| Reverse mismatch | 1 (6.25) | 2 (8.3) | 0.000 | >0.99 |
| Lateral, n |      |         |          |      |
| Match    | 1 (50.0) | 0.286 |         |      |
| Mismatch | 1 (50.0) | 5 (100.0) | 0.286 |      |
| Anterior, n |      |         |          |      |
| Match    | 10 (58.8) | 18 (58.1) | 0.003 | 0.959 |
| Mismatch | 6 (35.3) | 13 (41.9) | 0.202 | 0.653 |
| Reverse mismatch | 1 (5.9) |         | 0.354 |      |
| Inferior, n |      |         |          |      |
| Match    | 9 (31.0) | 9 (28.1) | 0.062 | 0.804 |
| Mismatch | 20 (69.0) | 23 (71.9) | 0.062 | 0.804 |
| Apex, n  |      |         |          |      |
| Match    | 19 (50.0) | 25 (53.2) | 0.086 | 0.770 |
| Mismatch | 17 (44.7) | 22 (46.8) | 0.036 | 0.849 |
| Reverse mismatch | 2 (5.3) |         | 0.197 |      |

LBBB = left bundle branch block.
The Correlation of the QRS Interval and Myocardial Perfusion and Reverse Mismatch Score

Few studies have found correlations among the QRS interval, 18F-FDG uptake, and 99mTc-MIBI myocardial perfusion. Castro et al. reported that in patients with LBBB and non-ischemic heart failure, global heterogeneity in 18F-FDG uptake was highly correlated with QRS length ($r = 0.62$, $P = 0.002$); no correlation was found between 18F-FDG uptake standard deviation and LVEF ($r = 0.12$; $P = 0.57$). In our study of patients with CAD, the septum reverse mismatch scores were significantly correlated with the QRS interval ($r = -0.276$, $P = 0.026$).

Correlation Between Wall Motion Scores of Echocardiography and Reverse Mismatch Score

A previous study demonstrated paradoxical septal wall motion in 33% of patients with LBBB, and wall thickening abnormalities were observed in 49% of those patients. However, no differences in wall motion or wall thickening abnormalities were observed between LBBB patients with and without CAD. Regional findings in LBBB patients reflect delayed conduction and asynchronous contraction of the septal and lateral walls, as demonstrated by echocardiography; without a correlation between the reverse mismatch and wall motion scores.

The Mechanism of Myocardial Perfusion and Metabolism

The mechanism of myocardial perfusion and metabolism mismatching remains unclear, but several hypotheses exist regarding the mechanism of abnormal septal perfusion and metabolism. Ho et al. showed that LBBB may be caused by functional ischemia due to asynchronous septal contraction.

| TABLE 5. Comparison of Wall Characteristics Among Patients With Coronary Artery Disease and Left Branch Bundle Block (LBBB), Depending on Perfusion Defect Severity |
|-----------------------------------------------|
| Mild to Moderate | Severe to Defect | $\chi^2$ | $P$ | Odds Ratio |
|-------------------|------------------|---------|-----|------------|
| Septum, n         |                  |         |     |            |
| Match             | 2 (10.0)         | 10 (62.5) | 8.789 | 0.003 | 0.067 |
| Mismatch          | 6 (30.0)         | 5 (31.25)  | 0.000 | $>0.99$ |
| Reverse mismatch  | 12 (60.0)        | 1 (6.25)  | 9.554 | 0.002 | 24.000 |
| Lateral, n        |                  |         |     |            |
| Match             | 3 (37.5)         | 1 (50.0)  | 0.000 | $>0.99$ |
| Mismatch          | 5 (62.5)         | 1 (50.0)  | 0.000 | $>0.99$ |
| Anterior, n       |                  |         |     |            |
| Match             | 10 (29.4)        | 10 (58.8) | 4.113 | 0.043 | 0.292 |
| Mismatch          | 19 (55.9)        | 6 (35.3)  | 1.922 | 0.166 |
| Reverse mismatch  | 5 (14.7)         | 1 (5.9)   | 0.213 | 0.645 |
| Inferior, n       |                  |         |     |            |
| Match             | 5 (33.3)         | 9 (31.0)  | 0.024 | 0.877 |
| Mismatch          | 10 (66.7)        | 20 (69.0) | 0.024 | 0.877 |
| Apex, n           |                  |         |     |            |
| Match             | 2 (25.0)         | 19 (50.0) | 0.810 | 0.368 |
| Mismatch          | 4 (50.0)         | 17 (44.7) | 0.000 | $>0.99$ |
| Reverse mismatch  | 2 (25.0)         | 2 (5.3)   | 1.233 | 0.267 |

TABLE 6. Correlation of the Reverse Mismatch Score With the QRS Interval and Wall Motion Scores in Patients With Coronary Artery Disease and Left Branch Bundle Block

|                         | q    | P     |
|-------------------------|------|-------|
| QRS length and reverse mismatch score |     |       |
| Septum                  | -0.276 | 0.026* |
| Anterior                | -0.154 | 0.221 |
| Apex                    | -0.079 | 0.532 |
| Lateral                 | -0.186 | 0.138 |
| Inferior                | -0.086 | 0.495 |
| Reverse mismatch score and wall motion score |     |       |
| Septum                  | 0.083 | 0.509 |
| Anterior                | 0.004 | 0.973 |
| Apex                    | 0.176 | 0.160 |
| Lateral                 | -0.051 | 0.687 |
| Inferior                | 0.093 | 0.463 |

QRS = ??.
Ono et al. suggested that it is probable that the increased septal IMP (Intramycardial Pressure) during the Tp1 (The Tp phase included the major component of LAD flow and was mainly diastolic) phase of the LBBB pattern caused a compression of the septal vessels and increased the coronary vessel resistance, thereby resulting in the reduced myocardial perfusion in the septum, and with impaired thickening during LBBB induced parallel reduction of myocardial glucose uptake in the septum. Impaired septal \(^{18}\)F-FDG uptake that is not paralleled by a concordant reduction of flow to the myocardial septum must be the result of impaired transmembranous transport and/or phosphorylation kinetics.\(^{23}\)

**Clinical Importance**

LBBB induces inhomogeneous activation and deformation of the ventricles, leading to inefficient contraction. This regional workload redistribution is associated with important changes in glucose utilization, which is lowest in the septum and highest in the lateral wall region. Higgins et al. suggested that abnormal septal wall motion and impaired wall thickening, in conjunction with perfusion defects, are more likely false-positive findings, whereas normal wall motion and normal wall thickening with septal perfusion abnormalities are indicative of CAD in patients with LBBB.\(^{24}\)

**Limitations**

This study was limited by the semi-quantitative, rather than quantitative, nature of the myocardial perfusion and the myocardial metabolism scores. Further, the study was limited by the relatively small number of patients, despite involving 1 of the largest patient populations reported for this type of study.

**CONCLUSIONS**

In this study, CAD patients with LBBB were found to frequently demonstrate septal and anterior wall reverse mismatches in myocardial perfusion and metabolism, even in the presence of reduced myocardial perfusion. Furthermore, the septal reverse mismatch score was found to negatively correlate with the QRS interval. To further validate the correlation between myocardial perfusion and myocardial metabolism in CAD patients with LBBB, an investigation involving larger groups of similar patients is warranted.

**ACKNOWLEDGMENTS**

This work was partially supported by grants from the Natural Science Foundation of China (81320108014, 30970849) and the National Science & Technology Pillar Program in the 12th Five-year Plan Period, China (2011BA11B02).

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