Myocardial Perfusion and Function of the Systemic Right Ventricle in Patients After Atrial Switch Procedure for Complete Transposition: Long-Term Follow-up

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OBJECTIVES Our purpose was to assess the right ventricular (RV) function and identify patients with RV impairment long after the Mustard or Senning operation.

BACKGROUND Systemic ventricular failure can cause myocardial perfusion abnormalities in thallium scintigraphy correlating with hemodynamic deterioration.

METHODS Myocardial perfusion at rest and at peak exercise was assessed in 61 patients, aged 7 to 23 years in mean time 10.0 ± 2.9 years after surgery using technetium-99m methoxyisobutyl isonitrile single-photon emission computed tomography. Ventricular function was assessed by first-pass radionuclide angiography at rest. Exercise capacity was determined with a modified Bruce protocol.

RESULTS The mean RV ejection fraction was 36.1 ± 7.7%, and left ventricular (LV) ejection fraction was 52.1 ± 9.4%. Moderate or severe perfusion abnormalities on the rest scan were observed in 20 patients (33%). On exercise perfusion worsened in another 13 patients (21.3%). Patients with perfusion defects on stress scan had significantly lower RV and LV ejection fraction (33.2 vs. 39.4%; p = 0.002 and 49.2 vs. 55.5%; p = 0.01, respectively). They were also older (16.6 vs. 13.0 years; p = 0.002), operated on at an older age (4.0 vs. 2.4 years; p = 0.05) and had longer follow-up (12.5 vs. 10.5 years; p = 0.003).

CONCLUSIONS Myocardial perfusion defects are common findings in patients in long-term follow-up after atrial switch operation. Despite excellent exercise tolerance, the extent of myocardial perfusion abnormalities correlated well with impaired RV and LV function, and greater perfusion defects were seen more frequently in older patients with longer follow-up. It is likely that myocardial perfusion defects could be a sensitive predictor of systemic ventricular impairment. (J Am Coll Cardiol 2000;36:1365–70) © 2000 by the American College of Cardiology

Atrial correction for complete transposition (TGA) was the most popular operation for the past three decades. The procedure introduced by Senning in 1959 and Mustard in 1964 has dramatically improved the life expectancy of these patients although the long-term results are far from perfect (1–4). This approach corrects hemodynamic abnormalities of complete transposition by redirecting the venous return at atrial level leaving the anatomy unaltered. The late problems include arrhythmia, right ventricular (RV) failure and sudden death (3–9).

Frequency of RV dysfunction after atrial switch varies from 8% to 16% (3,10); however, there is a lack of well-defined predictors of RV failure.

In order to determine functional and clinical status of patients during long-term follow-up after atrial redirection procedure, we investigated myocardial perfusion and the prevalence of perfusion abnormalities at rest and during exercise, using myocardial perfusion single-photon emission computed tomography (SPECT). A secondary aim was to assess exercise capacity, RV and left ventricular (LV) contractility and significance of myocardial perfusion defects on myocardial scans as a factor affecting RV performance or possibly preceding RV failure.

METHODS

Study patients. The study group consisted of unselected patients with simple TGA who underwent atrial switch operation between 1982 and 1990. Patients with a moderate to large ventricular septal defect (VSD) were excluded. Those with TGA and small VSD (hemodynamically insignificant), LV outflow tract obstruction (LVOTO) or patent ductus arteriosus were included. Eligibility criteria for participation in
this study were as follows: age >7 years and no physical limitation precluding exercise testing. The study was approved by the Human Ethics Investigation Committee of our institution. Informed consent was obtained for each participant.

**Patient demographics.** Of the 80 patients who met eligibility requirements, 61 (76%) participated in this study. There were 49 patients after Senning and 22 after Mustard operation. Five patients had concomitant VSD not requiring patch closure, and mild or moderate LVOTO was present in eight patients at subvalvular level. Fifty-five patients before atrial switch operation underwent Rashkind procedure; one had Blalock-Taussig shunt. After palliative procedures, 54 patients (88.5%) had one cardiac catherization, 5 patients (8.2%) had two cardiac catherizations and 2 patients (3.2%) had three cardiac catherizations. All patients led a physically normal life.

The mean age at surgery was 3.2 ± 3.29 years. The mean follow-up time from the surgery to the study was 10.0 ± 2.9 years.

**Study protocol and testing.** Each patient underwent two-day comprehensive evaluation. On arrival to an outpatient clinic, an intravenous line was placed for administration of the myocardial imaging agent. After a period of time, which allowed the patients to calm down, the first dose of nuclear perfusion tracer was administered. On the same day, chest X-ray, echocardiogram and 12-lead electrocardiogram (ECG) were performed and 24-h ambulatory Holter monitoring was installed. On the following day, exercise treadmill test was done, during which the next dose of the tracer was given. After 45 to 90 min, peak exercise imaging was performed. Before discharge 24-h ambulatory Holter recordings were interpreted.

**Exercise testing.** Treadmill exercise testing was performed using a modified Bruce protocol with 12-lead ECG monitoring. The patients were exercised until 85% of the age-predicted maximum heart rate was achieved or the subject felt fatigued. All ECGs obtained before exercise, at each stage of exercise and during recovery were reviewed by one of us.

**Radionuclide angiography.** In all patients the function of both ventricles was assessed by the first-pass technique using technetium-99m methoxyisobutyl isonitrile (Tc-99m MIBI). Because Tc-99m MIBI has no significant “redistribution,” two injections of the radiopharmaceutical agent are necessary to obtain rest and peak exercise myocardial perfusion images (12, 13). The patients were given an injection of 0.3 mCi/kg of Tc-99m MIBI for the rest of the myocardial perfusion study. On the next day during exercise, a second dose of Tc-99m MIBI (0.3 mCi/kg) was given when the patient could no longer exercise. After this injection, the patients were encouraged to run for an additional 60 s.

Single photon emission computed tomography images were recorded using a Siemens Orbiter gamma camera 750 ZLC. The data were stored, reconstructed and displayed in microcomputer system (MaxDELTA 2000 Siemens). For each study data acquisition began 60 to 90 min after tracer injection. The parameters used for acquisition and reconstruction were those optimized for the LV studies with Tc-99m MIBI. The transverse reconstruction of the studies used a Butterworth filter of the seventh order and a cutoff frequency of 0.4 Nyquist. Transverse slices of the RV were rearranged into oblique slices—cross-sectional (perpendicular to the long-axis of the RV), oblique/sagittal slices—vertical long axis (parallel to the long axis of the RV and crossing the anterior, apical and inferior wall) and oblique/coronal slices—horizontal long axis (parallel to the long axis of the RV and crossing the septal, apical and free wall). Slice thickness was 0.64 cm. All sets of slices were studied by two observers trained in nuclear cardiology and were evaluated until agreement was reached. Tracer uptake in each image was graded as normal or mildly, moderately or severely (in four grade scale) decreased. The reviewers had no knowledge of the patient’s history, clinical status and other test results. Right ventricular cross-sectional, horizontal long-axis and vertical long-axis views were analyzed from both rest and exercise images. The so-called “bull’s eye” images were not estimated because the anatomy of the RV is nonspherical.

A moderate or severe lesion was defined as an area of reduced radioactivity occupying, in neighboring slices, at least 50% of all oblique slices or at least 50% of all oblique/coronal or at least 50% of all oblique/sagittal slices. Other areas of reduced radioactivity were classified as mild lesions (14). Data collection was completed in January 1998.

**Echocardiographic Study**

Standard transthoracic cross-sectional and color-coded Doppler echocardiography was performed in all patients in order to assess systemic and pulmonary venous inflow and tricuspid valve function. Tricuspid regurgitation was defined

### Abbreviations and Acronyms

- **ECG** = electrocardiogram
- **LVEF** = left ventricular ejection fraction
- **LV** = left ventricle or ventricular
- **LVOTO** = left ventricular outflow tract obstruction
- **RVEF** = right ventricular ejection fraction
- **RV** = right ventricle or ventricular
- **SD** = standard deviation
- **SPECT** = single-photon emission computed tomography
- **TGA** = complete transposition
- **VSD** = ventricular septal defect
- **Tc-99m MIBI** = technetium-99m methoxyisobutyl isonitrile
- **LV** = left ventricle or ventricular
- **RV** = right ventricle or ventricular
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[Abbreviations and Acronyms table]

The mean age at surgery was 3.2 ± 3.29 years. The mean follow-up time from the surgery to the study was 10.0 ± 2.9 years.
as mild, moderate or severe using a semiquantitative method from color-coded Doppler echocardiography.

**Arrhythmia assessment.** Serial standard 12-lead ECGs were used to assess rhythm and conduction. Patients in slow junctional rhythm on ECG or on Holter monitoring were classified as having junctional rhythm even if at a later time or during exercise they exhibited sinus rhythm. All 24-h ambulatory ECG recordings were interpreted by a single reviewer.

**Statistical analysis.** The data are presented as mean value ± SD or median and range. Student t test for paired observation, analysis of variance and univariate logistic regression were used for statistical analysis of the data. The relationship between our variables was assessed by chi-square test. Variables for values that were statistically significant by univariate analysis were evaluated by multivariate analysis using multiple logistic regression.

All statistical analyses were performed using SAS statistical software. Statistical significance was assessed with a cut-off p value <0.05.

**RESULTS**

**Clinical data.** The age of patients in the study ranged from 7 to 23 years (mean 13.3 ± 4.6 years). One patient underwent reoperation five years earlier because of superior caval vein obstruction at the atrial level. Two others underwent reoperation because of an important shunt at atrial level, respectively, one and two years before the study. The New York Heart Association functional class was judged to be class I in 56 patients and class II in five patients. Clinical examination revealed no signs of heart failure. The cardiothoracic ratio on chest X-ray ranged from 0.39 to 0.59 (mean 0.48 ± 0.04). Pulmonary vascular markings were normal in all cases.

Preoperatively, all patients were in sinus rhythm. Junctional rhythm on serial ECG or on Holter monitoring was noticed in 16 patients (26%) during follow-up; 3 patients (4.9%) were in paced rhythm (pacemaker implanted because of sinus arrest and atrial flutter); 6 patients (9.8%) had recurrent atrial flutter (including those with paced rhythm); the rest of the patients were in uninterrupted sinus rhythm.

On standard 12-lead ECG, 6 patients had right bundle branch block, 21 patients (34.4%) had ST-T changes (strain pattern).

**Echocardiographic studies.** Doppler echocardiography disclosed mild tricuspid regurgitation in 28 patients, moderate in 8 and severe in 3 patients. The investigation of systemic and pulmonary venous inflow revealed no significant obstruction (mean maximal gradient of 2.9 ± 1.4 mm Hg [range from 0.9 to 6.3 mm Hg]) and mitral inflow of 3.91 ± 1.69 (range from 1.4 to 8.9 mm Hg). Flow velocity showed acceleration in LV outflow tract exceeding 1.5 m/s in 14 patients. Seven patients had LVOTO gradient higher than 20 mm Hg (gradient ranged from 20 to 65 mm Hg).

**Radionuclide angiography.** Mean RVEF was 36.1 ± 7.7% (range from 20 to 53%), median 35%. Patients with RVEF <33% (> 2 SD below normal) were considered as having significantly impaired systolic ventricular function. There were 16 patients with RVEF <33% (mean 27.4 ± 3.2%) and 39 patients with RVEF ≥33% (mean 39.5 ± 5.9%). The mean LVEF was 52.1 ± 9.4% (range from 31 to 75%).

**Treadmill exercise stress tests.** Exercise time ranged in all patients from 5.1 to 19.5 min (mean 14.8 ± 3.0 min). Exercise test in three patients ended prematurely because two of them refused to continue after 5.1 min and 7 min, respectively, and the third had a cough at the peak of exercise. For all patients, the maximal heart rate at peak exercise ranged from 111 to 196 beats/min (mean 167 ± 83). With exercise, heart rates increased to 80 ± 8.7% of the age-predicted maximum heart rate.

Mean attained effort was 10.6 METs ± 2.35 METs (range from 5 to 14.4 METs).

**Myocardial perfusion scans.** Myocardial imaging showed the RV when the LV uptake of Tc-99m MIBI was very poor. The LV was visible only in three patients: one who underwent surgery at the age of 17 and two with LVOTO gradient of 47 and 65 mm Hg.

**Studies at rest.** Normal RV perfusion (Fig. 1) was found in 29 patients (47.5%), perfusion defects assessed as mild in 12 patients (19.6%), and 20 patients (32.7%) had moderate or severe perfusion abnormalities. Table 1 presents data comparing patients with and without perfusion defects at rest.

**Studies on peak exercise.** Normal RV perfusion was observed in 19 patients (31.1%), and mild perfusion defects were observed in 9 patients (14.7%). Extensive perfusion abnormalities (Fig. 2) on exercise scans (assessed as moderate or severe) were found in 33 patients (54%). Moderate

![Figure 1. Myocardial scan obtained with technetium 99m MIBI in a patient with normal perfusion: right ventricle, pairs of slices at stress (upper panels) and rest; (a) vertical long axis view, (b) horizontal long axis view, (c) cross-sectional view.](image-url)
observed that by using the counts ratio of thallium-201 in for the assessment of RV overload. Rabinovich et al. (17) suggested (6). We now report significant myocardial perfusion defects in patients after atrial redirection procedure. The structure of the RV myocardium (15,16). A mismatch for complete transposition leaving the anatomy unaltered with RV function (p = 0.009).

**DISCUSSION**

**Myocardial perfusion scans.** Atrial redirection procedure for complete transposition leaving the anatomy unaltered carries the potential risk of later development of RV failure. The mechanism of failure is unclear, but it may result from the structure of the RV myocardium (15,16). A mismatch between RV blood supply and demand had also been suggested (6). We now report significant myocardial perfusion defect in patients after atrial redirection procedure.

Thallium-201 myocardial imaging is known to be useful for the assessment of RV overload. Rabinovich et al. (17) observed that by using the counts ratio of thallium-201 in

or severe perfusion defects were found more often in the inferior and anterior wall of the RV. Extensive perfusion defects of the inferior wall were found in 22 patients (66.6%); 14 patients (42.4%) had anterior wall defects; 13 (39.4%) had free wall; and 11 patients (33.3%) had septum perfusion defects. Table 2 presents the data of patients with normal or nearly normal perfusion at peak exercise and with moderate and severe perfusion defects. Extensive perfusion abnormalities were found statistically more often in patients who were older at the time of surgery and with longer follow-up. They were associated with significantly lower RVEF and LVEF.

Multivariate logistic analysis did not reveal any influence of variables as: VSD closure, LVOTO, type of operation (Mustard or Senning procedure) on RV function and on perfusion defects. A close correlation was revealed of the variable of rhythm disturbances (nodal rhythm, paced rhythm, atrial flutter) with RV function (p = 0.009).

**Table 1.** Myocardial Perfusion at Rest

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal or Nearly Normal Perfusion</th>
<th>Abnormal Perfusion</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 41 Patients</td>
<td></td>
<td>n = 20 Patients</td>
<td></td>
</tr>
<tr>
<td>RVEF</td>
<td>37.6 ± 7.2%</td>
<td>32.5 ± 7.8%</td>
<td>0.02</td>
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<tr>
<td>LVEF</td>
<td>54.3 ± 8.5%</td>
<td>47.2 ± 9.6%</td>
<td>0.009</td>
</tr>
<tr>
<td>Age at operation</td>
<td>2.9 ± 3.2 yr</td>
<td>4.1 ± 3.5 yr</td>
<td>0.2 (NS)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>11.3 ± 2.4 yr</td>
<td>12.1 ± 3.0 yr</td>
<td>0.2 (NS)</td>
</tr>
<tr>
<td>Age at the study</td>
<td>14.3 ± 4.2 yr</td>
<td>16.3 ± 4.9 yr</td>
<td>0.1 (NS)</td>
</tr>
<tr>
<td>CTR</td>
<td>0.47 ± 0.03</td>
<td>0.49 ± 0.05</td>
<td>0.06 (NS)</td>
</tr>
<tr>
<td>TR mod. or severe</td>
<td>9.8%</td>
<td>9.8%</td>
<td>NS</td>
</tr>
<tr>
<td>Exercise tolerance</td>
<td>10.0 ± 2.3 MET</td>
<td>11.5 ± 2.0 MET</td>
<td>0.03</td>
</tr>
</tbody>
</table>

CTR = cardiothoracic ratio on chest X-ray; LVEF = left ventricular ejection fraction; mod. = moderate; RVEF = right ventricular ejection fraction; TR = tricuspid regurgitation.

**Table 2.** Myocardial Perfusion at Peak Exercise

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal or Nearly Normal Perfusion</th>
<th>Abnormal Perfusion</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 28 Patients</td>
<td></td>
<td>n = 33 Patients</td>
<td></td>
</tr>
<tr>
<td>RVEF</td>
<td>39.4 ± 7.9%</td>
<td>33.2 ± 6.4%</td>
<td>0.002</td>
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<tr>
<td>LVEF</td>
<td>55.5 ± 7.7%</td>
<td>49.2 ± 9.8%</td>
<td>0.01</td>
</tr>
<tr>
<td>Age at operation</td>
<td>2.4 ± 2.3 yr</td>
<td>4.0 ± 3.8 yr</td>
<td>0.05</td>
</tr>
<tr>
<td>Follow-up</td>
<td>10.5 ± 1.8 yr</td>
<td>12.5 ± 2.9 yr</td>
<td>0.003</td>
</tr>
<tr>
<td>Age at the study</td>
<td>13.03 ± 3.2 yr</td>
<td>16.6 ± 4.8 yr</td>
<td>0.002</td>
</tr>
<tr>
<td>CTR</td>
<td>0.47 ± 0.04</td>
<td>0.49 ± 0.05</td>
<td>0.1 (NS)</td>
</tr>
<tr>
<td>TR mod. or severe</td>
<td>3.2%</td>
<td>14.7%</td>
<td>0.05</td>
</tr>
<tr>
<td>Exercise tolerance</td>
<td>10.2 ± 2.2 MET</td>
<td>10.8 ± 2.4 MET</td>
<td>0.3 (NS)</td>
</tr>
</tbody>
</table>

CTR = cardiothoracic ratio on chest X-ray; LVEF = left ventricular ejection fraction; mod. = moderate; RVEF = right ventricular ejection fraction; TR = tricuspid regurgitation.

patients with pressure overloaded RV in congenital heart defects, RV counts were of equal or greater intensity as those of the LV. In our group of patients, SPECT study showed myocardial uptake predominantly in the RV, with very poor uptake by the LV (14). As expected, the RV at systemic pressure was hypertrophied, and its myocardial mass had to be greater than the low pressured LV. Ono and coworkers (18), using thallium-201 in patients with complete transposition, stated that the scintigraphic image correlated with the systolic pressure in the RV.

Searching for methods predicting early systemic ventricular impairment, which could precede its diminished ejection fraction and predict long-term outcome in this group of patients, we tried to assess perfusion distribution of the RV. In our experience, we observed that, in patients with mildly impaired LV function in idiopathic dilated cardiomyopathy, despite the presence of angiographically normal coronary arteries, perfusion scan was abnormal correlating with the degree of systemic ventricular failure and diminishing when systolic function was improved (19).

We used technetium-99m MIBI as a tracer because it produces excellent myocardial perfusion images at lower radiation dosage than that of thallium-201 (20,21).

Our study revealed that, in patients after Mustard or Senning operation, abnormalities of RV myocardial perfusion scans as assessed by SPECT were extremely common both at rest and on peak exercise. The most common location of perfusion scan abnormalities was the inferior wall of the RV. The group with normal perfusion or mild perfusion defects at rest compared with patients with persistent myocardial perfusion defects (abnormal rest
scans) had significantly higher RVEF and LVEF (Table 1). There was no difference between both groups in age at operation and during the study and in duration of follow-up. The heart silhouette was smaller in the group with normal or mild perfusion defects; however, statistical significance was not noted. The relevance of these perfusion scan defects is not clear, especially in view of excellent clinical outcomes and otherwise normal noninvasive findings. The myocardial perfusion defects in our patients tended to deteriorate with exercise similarly as in coronary artery disease or in patients with heart failure.

When comparing the groups with pronounced perfusion defects on peak exercise and those with normal perfusion scans or mild transient defects (Table 2), it became apparent that patients without perfusion defects underwent surgery at a younger age. Patients with perfusion defects were significantly older at the time of the operation; their mean age was 4.0 ± 3.8 years (p < 0.05). There was a greater difference in RVEF, follow-up time and age at the study between both groups (Table 2). Moderate or severe tricuspid regurgitation was significantly more frequent in the group with abnormal perfusion.

Myocardial perfusion abnormalities in patients with idiopathic dilated cardiomyopathy have been reported and assessed as a possible prognostic factor (22,23). Exercise causes an increase in systemic ventricular stress, which might alter myocardial perfusion and reduce thallium-201 uptake (24,25). On exercise thallium-201 tomography, neither the presence nor the reversibility of stress myocardial perfusion abnormalities can predict improvement of LVEF in dilated cardiomyopathy. However, regression of dilated cardiomyopathy is accompanied by a reduction of stress myocardial perfusion abnormalities (26). In our patients’ stress perfusion defects correlated better with RVEF than in the group with fixed defects and was more common in older patients with longer follow-up.

Using technetium-99m sestamibi for qualitative assessment of myocardial perfusion after arterial switch operation, Hayes et al. (27) hypothesized that open heart surgery itself may lead to myocardial damage. The authors thus speculated that microinfarction due to embolism during surgery may be a potential explanation for their findings. In this study perfusion defects were not correlated with the type of operation, with period of bypass time, duration of operation or redo surgery; thus, the likelihood of surgery related myocardial damage. Ventricular function. Normal values for systemic RV are not available so that laboratory norms for the high pressure LV cannot be transferred directly to the high pressure RV. Right ventricular end-diastolic volume is larger than the left and is not reduced in the presence of increased afterload. Thus, normal stroke volume can be maintained at a comparatively lower ejection fraction than that of the systemic LV and, thus, does not imply abnormal function (15,28,29).

Despite good functional capacity, the majority of our patients had diminished RVEF estimated by first-pass radionuclide angiography. Similar findings were reported by Peterson et al. (30) during exercise both in patients after Mustard or Senning operation for complete TGA and in a group with congenitally corrected transposition. In both groups systemic ventricular function was impaired and failed to increase during exercise (30).

Graham et al. (15) observed that, in patients with congenitally corrected transposition, the systemic ventricular function deteriorated with age, suggesting limited capacity of the morphologically RV while coping with systemic circulation. Furthermore, heart failure in this group of patients tends to occur very late in life or not at all. This does not explain the absence of heart failure in the majority of patients after Mustard or Senning repair, being limited to about 10% (4,6,9).

The relationship between RV function and tricuspid regurgitation is not well defined (6,9,31–33). The question is raised whether tricuspid incompetence leads to RV dysfunction or is its consequence. In our study mild tricuspid regurgitation was frequently seen on echocardiography while moderate tricuspid regurgitation was found in eight patients and severe in three. Its frequency correlated with impaired RV function. It is likely that decreased contractility and dilation of the RV is followed by annular dilation that, in turn, exacerbates the degree of tricuspid regurgitation. Our results are in agreement with the Prieto report (34) of congenitally corrected transposition.

Less concern has been focused on the functioning of the anatomic LV as the pulmonary ventricle in patients after atrial correction. In the group LV function was also significantly diminished. It implied complex mechanism of systolic and diastolic ventricular interaction as well as anatomy of the LV, which is not ideally suited to function in a low-pressure pulmonary circulation (16,30,35–37).

Long-lasting and severe preoperative hypoxemia may also influence the ventricular function. It is likely that this factor was important in our patients. Their average age at surgery was much higher than in recent surgical practice, so prolonged preoperative hypoxemia might have worsened heart function.

Exercise tolerance. Many authors describe excellent exercise capacity in patients after Mustard or Senning operation (3,4,9,32). Our data confirm good exercise tolerance in the group. Although not all patients have exercised up to their maximal heart rate predicted for age, each patient presented a significant increase in heart rate with exercise. All patients had exercise capacity within normal limits. The maximal heart rate and the increase in heart rate with exercise prove that these patients were adequately stressed and that the stress loading was greater than their daily maximal activity. This is supported by the significant difference between the maximal heart rate recorded during 24-h ambulatory ECG monitoring (138 ± 21 beats/min) and during exercise testing (167 ± 18.3 beats/min, p = 0.001).

In heart failure several approaches have been introduced to improve the hemodynamic status and to prolong life...
expectancy. The need for noninvasive parameters to objectively assess the benefit of therapy as well as the appropriate combination of drugs is widely recognized. Perfusion defects found in patients after atrial repair for complete TGA could perhaps identify patients at risk for overt heart failure who may benefit from early treatment.

Conclusions. Myocardial perfusion defects are a common finding in patients in long-term follow-up after atrial switch procedure for complete transposition.

Despite excellent exercise tolerance, the extent of myocardial perfusion abnormalities correlated well with impaired RV and LV function and was seen more frequently in older patients with longer follow-up. It is likely that myocardial perfusion defects found in patients with TGA after Mustard or Senning operation is a sensitive predictor of systemic ventricular impairment.

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REFERENCES