Assessment of Cardiac Stress Tests

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Objective: The goal of our study was to perform a quality assurance evaluation of our nuclear cardiology laboratory to ensure that patients who underwent exercise stress testing reached an adequate exercise level to accurately evaluate coronary blood flow with a nuclear cardiology perfusion scan.

Methods: We evaluated 282 outpatient cardiac stress test studies. A drug usage evaluation checklist was completed for each patient to determine what test to perform on the patient.

Results: Exercise stress tests were done on 180 of 282 patients (63.8%), and 102 of 282 (36.2%) had pharmacologic stress testing. Of exercise stress test patients, 145 of 180 (80.6%) met at least one of the criteria and the exercise was considered adequate. Of the 35 patients who did not meet any of the criteria, 26 (74.3%) were on calcium channel antagonists or beta blockers.

Conclusions: We concluded: (1) 80% of the exercise stress tests done in our laboratory are adequate by usual criteria; (2) reaching a heart rate ≥ 85% of maximum comprised the majority of the adequate tests (>80%); (3) ischemic endpoints (angina, positive ECG or both) at a lower heart rate occurred in < 20% of the adequate tests; (4) most patients with inadequate tests were on pharmacologic therapy; and (5) further DUE study is necessary to determine if the inadequate tests still provide adequate data for clinical decision making.

Key Words: drug usage evaluation; cardiac stress test; exercise stress test; pharmacologic stress test

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Our nuclear cardiology laboratory performs a high number of cardiac stress tests each month. During an average month, we do approximately 300–350 outpatient cardiac stress tests. It is important to ensure that patients undergoing a cardiac stress test are reaching an adequate level of stress in order to accurately evaluate coronary blood flow with a nuclear cardiology perfusion scan (*1,2*).

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To analyze the cardiac stress testing in our nuclear cardiology laboratory, a drug usage evaluation (DUE) checklist was completed by the attending nurse or physician. The checklist contained two basic sections: patient information and study information, which was subdivided into a pharmacologic stress testing section and an exercise stress testing section (Fig. 1). The purpose of this study was to determine if our patients were achieving an adequate work load to accurately assess coronary blood flow with a myocardial perfusion study.

MATERIALS AND METHODS

Completion of DUE Form

During our study, 282 outpatient cardiac stress studies were evaluated. The attending nurse or physician would complete the DUE sheet (Fig. 1) for each patient including the type of stress test ordered for the patient, i.e., exercise or pharmacologic stress test. If a pharmacologic stress test was requested, the drug used was also indicated, as well as the reason why the patient did not perform an exercise stress test.

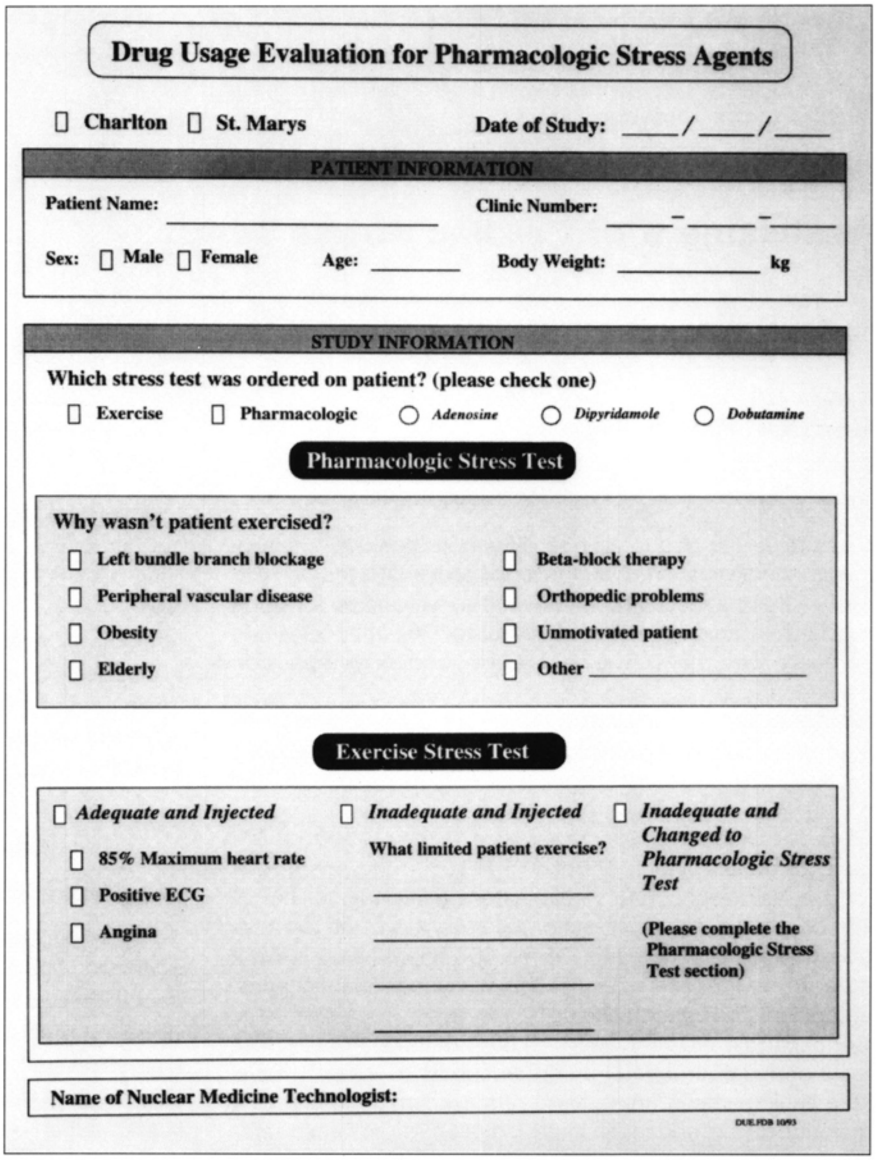
If an exercise stress test was performed, the test was considered adequate if: (1) the patient's peak heart rate was ≥ 85% of maximum, (2) the electrocardiogram (ECG) became abnormal or (3) the patient developed angina.

We calculated 85% maximum heart rate as follows: (220 − patient's age) × 0.85 = 85% maximum heart rate. Our basic criteria for a positive ECG was at least 1-mm horizontal or down-sloping ST depression 80 msec past the J point, in the absence of baseline ST abnormalities.

If an exercise stress test was done on the patient, one of three boxes was checked: i.e., adequate and injected; inadequate and injected; or inadequate and changed to a pharmacologic stress test. If the test was changed to a pharmacologic stress test, that section was then completed. If a patient was injected without meeting at least one of the three criteria to be considered adequate, the attending physician or nurse gave a brief explanation as to what limited the patient's exercise.

Imaging Protocol

SPECT imaging using either ^{99m}Tc-sestamibi or ^{201}Tl-thallous chloride was completed on all the cardiac stress patients.



Drug Usage Evaluation for Pharmacologic Stress Agents

☐ Charlton ☐ St. Marys   Date of Study: ____/____/____

PATIENT INFORMATION

Patient Name: ____________   Clinic Number: ____-____-____

Sex: ☐ Male ☐ Female   Age: ______   Body Weight: __________ kg

STUDY INFORMATION

Which stress test was ordered on patient? (please check one)

☐ Exercise ☐ Pharmacologic ○ *Adenosine* ○ *Dipyridamole* ○ *Dobutamine*

Pharmacologic Stress Test

Why wasn't patient exercised?

☐ Left bundle branch blockage
☐ Peripheral vascular disease
☐ Obesity
☐ Elderly
☐ Beta-block therapy
☐ Orthopedic problems
☐ Unmotivated patient
☐ Other ____________

Exercise Stress Test

☐ *Adequate and Injected*
☐ 85% Maximum heart rate
☐ Positive ECG
☐ Angina

☐ *Inadequate and Injected*
What limited patient exercise?
____
____
____
____

☐ *Inadequate and Changed to Pharmacologic Stress Test*
(Please complete the Pharmacologic Stress Test section)

Name of Nuclear Medicine Technologist:

DUE.FDB 10/93

FIGURE 1. Drug usage evaluation worksheet.

A 3-mCi (111-MBq) ^{201}Tl injection was given during exercise stress. A postexercise planar anterior view of one million counts was performed 7–15 min after exercise followed by a SPECT scan over 180° (45° RAO to 135° LPO) with 30 images at 40 sec per image. A 64 × 64-word mode matrix was used with a Hanning prefilter cutoff at 0.7 Nyquist. A 1-mCi (37-MBq) ^{201}Tl re-injection at 3.5–4 hr poststress was given several minutes prior to the redistribution scan, which followed a similar acquisition protocol. Patients with very difficult veins received 4 mCi (148 MBq) during the stress study with no reinjection prior to their redistribution scan.

Technetium-99m-sestamibi patients followed a two-day rest/stress format. On the first day a 30-mCi (1,110-MBq) ^{99m}Tc-sestamibi resting first-pass acquisition was performed. A SPECT scan 30–90 min postinjection using 30 images over 180° at 25 or 40 sec per stop, depending on the patient's weight. A 64 × 64-word mode matrix was used with a Hanning prefilter cutoff at 0.7 Nyquist. Women over 80 kg and men over 100 kg used a 40-sec stop. The stress ^{99m}Tc-sestamibi study included a 15-mCi (555-MBq) injection 1.5 min prior to the completion of the exercise followed by the SPECT scan 30–60 min postinjection.

Image Interpretation

The 282 cardiac perfusion scans were read jointly by a nuclear cardiologist and a nuclear medicine physician. Short-axis images were divided into 14 segments and a five-point scoring system was used to assess each segment on both the postexercise and delayed or rest images (4 = normal, 0 = no perfusion). An abnormal segment was considered ischemic if perfusion improved one or more grades from the poststress to the delayed or rest images (*3*).

RESULTS

Adequate Exercise Stress Tests

Outpatient cardiac stress tests were evaluated on 282 studies. Exercise stress perfusion studies, mainly Bruce protocol,

TABLE 1
Results of Cardiac Stress Tests and Positive Scan Rate

Cardiac stress test	Number of patients	Percent of total studies (%)	Number of positive scans	Group positive scan rate (%)*	Percent of positive scans (%)†
All cardiac stress tests	282	100	137	48.6	100
Pharmacologic stress test	102	36.2	52	51.0	38.0
Exercise stress test	180	63.8	85	47.2	62.0

*Group positive scan rate (%) = (number of positive scans/number of patients meeting the criteria) × 100%
†Percent of positive scans (%) = (number of group positive scans/total number of positive scans) × 100%

were performed on 180 (63.8%) of the patients studied with the remaining 102 (36.2%) having pharmacologic stress tests (Table 1). Of 180 exercise stress patients, 145 (80.6%) met at least one of our criteria for the exercise to be considered adequate (Table 2). Of the 145, 118 (81.4%) achieved a heart rate ≥ 85% of maximum. Sixteen (11.0%) had a positive ECG as the only criterion met. Only 4 (2.8%) of the patients had angina as the only criterion met, and 7 (4.8%) had both a positive ECG and angina. Of the 35 patients that exercised and did not meet any of the criteria, 26 (74.3%) were on calcium or beta blocker therapy.

Pharmacologic Stress Tests

Pharmacologic stress tests accounted for 102 of the 282 patients (36.2%) (Table 1). When pharmacologic stress testing was used, reversible ischemia was demonstrated on 52 (51%) of the studies. Dipyridamole resulted in positive scans in 46 of 92 (50.0%) patients. Dobutamine resulted in positive scans in 5 of 8 (62.5%) patients. Adenosine was used in only 2 patients during this study, and 1 was positive. Our supply of adenosine was limited during this study.

Myocardial Perfusion Scans

Overall, 137 of the 282 (48.6%) cardiac stress perfusion scans, both exercise and pharmacologic, showed reversible ischemia (Table 1). Pharmacologic stress test patients showed reversible ischemia 51.0% of the time, whereas 47.2% of the exercise stress test patients had a myocardial perfusion scan showing reversible ischemia.

Sixty-six (45.4%) of 145 patients with adequate exercise tests had a scan with reversible ischemia. These made up 48.2% of the total ischemic scans (Table 2). Somewhat surprisingly 19 of 35 (54.3%) of the inadequate exercise stress test patients also had a perfusion scan with reversible ischemia.

Evaluating the exercise stress test results in relation to the criteria met for adequate exercise showed that those patients that exercised to a heart rate ≥ 85% of maximum had a group ischemic scan rate of 39.0% (46/118) and comprised 33.6% (46/137) of the total ischemic perfusion scans. Patients with a positive ECG had reversible ischemia 81.3% (13/16) of the time and made up 9.5% of the total perfusion scans with reversible ischemia. If angina was the only criteria met, only 25% (1/4) of patients had reversible ischemia and comprised 0.7% of the total perfusion scans with reversible ischemia. If patients had both angina and a positive ECG, 85.7% (6/7) had reversible ischemia. This group comprised 4.4% of the total perfusion scans with reversible ischemia.

DISCUSSION

Nuclear cardiology perfusion scanning has been shown to be an accurate method to assess coronary blood flow, especially if an adequate heart rate is achieved (*2*) or a pharmacologic stress test is performed (*1*). Valuable information about the

TABLE 2
Results of Cardiac Stress Test and Positive Scan Rates

Group and criteria	Number of patients	Percent of exercise stress test (%)	Adequate test rate (%)	Number of positive scans	Group positive scan rate (%)*	Percent of positive scans (%)†
Inadequate	35	19.2	—	19	54.3	13.9
Adequate	145	80.6	—	66	45.5	48.2
85% maximum heart rate	118	64.8	81.4	46	39.0	33.6
Positive ECG	16	8.8	11.0	13	81.3	9.5
Angina	4	2.2	2.8	1	25.0	0.7
Positive ECG and angina	7	3.8	4.8	6	85.7	4.4

*Group positive scan rate (%) = (number of positive scans/number of patients meeting the criteria) × 100%
†Percent of positive scans(%) = (number of group positive scans/total number of positive scans) × 100%

patient is gained during exercise testing even if the patient does not reach 85% of predicted maximal heart rate, which is often the case in patients on certain cardiac medications. Our goal was to evaluate if patients undergoing a myocardial perfusion scan were achieving an adequate heart rate during exercise (*4*). We were also interested in evaluating the results of the nuclear cardiac perfusion study in patients who did not meet any of our criteria for adequate exercise stress tests.

We found the DUE form a helpful way to evaluate the cardiac stress perfusion tests in our nuclear cardiology laboratory. We achieved adequate exercise stress levels in over 80% of our exercise stress patients (Table 2). Ischemic endpoints (i.e., a positive ECG, angina or both) only occurred in less than 15% of all exercise stress patients. Most patients who did not reach an adequate heart rate were taking calcium channel antagonists or beta blockers.

When one considers the number of ischemic scans within each patient group in relation to the total number of ischemic perfusion scans, the percent of total ischemic scans reveals a more representative picture of the true ischemic scan rate. As shown in Table 2, patients with an adequate exercise stress test accounted for approximately four times the number of ischemic scans when compared to the inadequate exercise stress group (i.e., 48.2% versus 13.9%). Among the adequate exercise stress patient group, the criteria of 85% maximum heart rate demonstrated the highest overall percent of reversible ischemic scans (33.6%), followed by positive ECG group (9.5%), and positive ECG and angina patients (4.4%). The angina only patient group had the lowest overall percent of ischemic scans (0.7%).

In the patient group that received pharmacologic stress testing, we achieved a slightly higher ischemic scan rate compared to exercise stress, 51.0% versus 47.2% (Table 1). This was expected due to patient selection in this group, including patients with diabetes, claudication and other cardiac risk factors that make exercise difficult and increase the chance of heart disease. In addition, maximal coronary dilatation is also consistently achieved with pharmacologic stress agents (*5*).

This also brings up the issues of whether all patients that do not exercise to an adequate level should be changed to a pharmacologic stress test and should patients be taken off drug therapy prior to having a cardiac stress test. Switching all inadequate stress test patients to a pharmacologic test depends greatly on the patient flow in each nuclear cardiology laboratory. Changing them all may disrupt patient flow too drastically to be practical. Changing tests will depend greatly on patient numbers, facility size, flexibility of camera time and the clinical reason for performing the stress test.

Stopping patients' drug therapy prior to doing their cardiac perfusion study can be impractical for patients from out of town, which is the case for a large portion of our patients. It can also be dangerous to remove drug therapy from certain patients, especially those on therapy for irregular heart rhythms. In some patients, the actual clinical goal is to assess whether the patient's current drug therapy is indeed influencing cardiac perfusion and removing the therapy would defeat the purpose of the test.

In our laboratory the nuclear medicine technologist is responsible for explaining the tests to the patient, hooking up a twelve-lead ECG and starting an intravenous line for infusions of the radiopharmaceutical. These technologists also monitor the ECG during the stress tests and are responsible for the changes in the speed and grade of the treadmill.

It is important for the nuclear medicine technologist to explain the test completely to the patient. This decreases the patient's fears and improves their effort on the treadmill. Helping to evaluate the patient's physical abilities prior to walking on the treadmill can help in choosing the correct protocol for each patient. Demonstrating how to walk on the treadmill and encouraging the patient during walking can also ensure an adequate test is achieved.

Ensuring that patients exercise to an adequate level, or changing their test to a pharmacologic stress test when appropriate, is a very important factor in increasing the sensitivity of the nuclear cardiology perfusion scan. We found the DUE form a helpful aid in monitoring the stress tests done in our nuclear cardiology laboratory.

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