Dobutamine Myocardial Perfusion Imaging

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Dobutamine, a pharmacologic stressor, is useful for myocardial perfusion imaging in patients who cannot exercise. Patients with asthma or severe chronic obstructive pulmonary disease who are at risk for adverse effects from either dipyridamole or adenosine are prime candidates for dobutamine perfusion studies. Dobutamine is a predominant beta-1 agonist that increases heart rate, myocardial contractility and systolic blood pressure. The sensitivity and specificity of dobutamine myocardial perfusion imaging are comparable, for the most part, to those from perfusion studies using exercise, dipyridamole or adenosine.

Key Words: myocardial perfusion imaging; pharmacologic stress; dobutamine

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Although most patients undergo exercise stress testing to evaluate myocardial perfusion, the use of drugs that stress the heart have become important in certain patients, particularly those who cannot exercise adequately. There are three pharmacologic stressors used today in cardiovascular nuclear medicine: dipyridamole (*1*), adenosine (*2,3*) and dobutamine (*4*).

At Baylor College of Medicine/The Methodist Hospital in Houston, we performed 3970 myocardial perfusion studies in 1991 (Table 1) (*5*). Most patients were stressed by exercise, although more than 800 were stressed with adenosine and 42 with dipyridamole. (At most institutions, however, dipyridamole is used more often than adenosine because it is commercially available.) Comparing our use of pharmacologic stressors in 1991 with previous years, the real growth was in our use of dobutamine, which was used for 256 patients. Since dipyridamole and adenosine work well and were developed before dobutamine for this indication, one might ask why we need a third pharmacologic stress agent.

The patients selected for dobutamine studies were those who could not exercise and who were not good candidates for dipyridamole or adenosine because of a history of chronic obstructive pulmonary disease or asthma. These patients are prime candidates for dobutamine stress perfusion imaging.

Other candidates include patients who drank coffee or used medications containing theophylline (within 12 hr), before a scheduled dipyridamole or adenosine myocardial perfusion study. Patients who use oral dipyridamole could attain dangerously high adenosine levels if adenosine is administered intravenously as a pharmacologic stress; these patients are also candidates for dobutamine stress testing. In addition, patients with heart failure who are already receiving low-dose intravenous dobutamine for inotropic support are, at times, referred for stress perfusion imaging. In these patients, it may be more reasonable to perform a dobutamine stress study by simply increasing its dose rather than a dipyridamole or adenosine perfusion scan.

PROTOCOL

The protocol used in our laboratory (Fig. 1) begins with a low dose of dobutamine, 10 μg/kg/min for 3 min, and is increased to a maximum of 40 μg/kg/min every 3 min (*4*). Thallium-201 is injected 1 min after starting the first dose of dobutamine, with the infusion maintained for another 2 min. Technetium-99m-sestamibi or teboroxime may be used in place of ^{201}Tl. The infusion is stopped and planar or SPECT images are acquired, followed by delayed (or rest) image acquisition to determine radiotracer redistribution.

MECHANISM OF ACTION

Dobutamine is a predominant beta-1 agonist that increases heart rate and myocardial contractility; at sufficiently high doses, dobutamine also increases systolic blood pressure. The increases in these three parameters result in increased myocardial oxygen demand. Normal coronary arteries dilate to increase perfusion in order to meet the demand; stenotic arteries may not be able to increase blood flow to the same degree as normal vessels, creating a perfusion defect based on a similar physiologic response as that triggered by exercise stress.

Data from a series of 144 patients indicate that an increase in heart rate is the most consistent effect of dobutamine (*4*). Systolic blood pressure also increases, peaking around 20 μg/kg/min; diastolic blood pressure decreases due to the peripheral (beta-2) vasodilator effect of dobut-

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TABLE 1
Number of Myocardial Perfusion Imaging Studies Performed at the Nuclear Cardiology Laboratory, The Methodist Hospital/Baylor College of Medicine, Categorized by Exercise or Pharmacologic Stressor

	1987	1988	1989	1990	1991
Exercise	2280	2498	2595	2801	2840
Dipyridamole	220	215	214	39	42
Adenosine	0	62	430	800	832
Dobutamine	0	0	0	27	256
Total	2500	2775	3239	3667	3970

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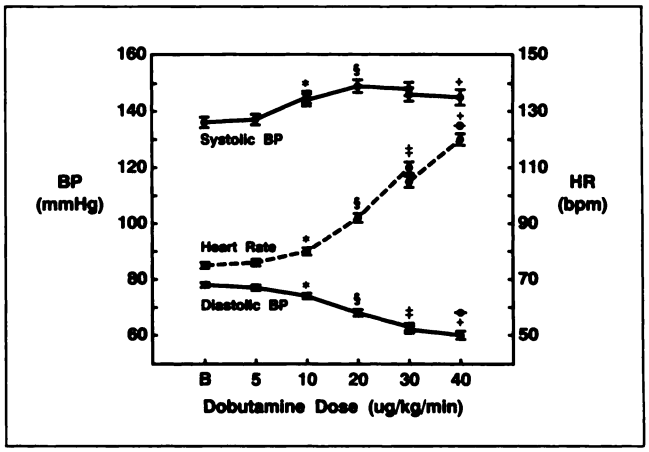

FIGURE 2. Heart rate (HR) and blood pressure (BP) changes during dobutamine infusion. Reprinted with permission from the American College of Cardiology (*Journal of the American College of Cardiology*, 1993;21:1583).

amine. These changes are similar to those seen in patients who undergo a submaximal exercise test (Fig. 2).

Recent PET studies using ^{13}N-ammonia showed changes in blood flow after administration of dobutamine: myocardial blood flow tripled with a 40 μg/kg/min dose of dobutamine (*6*). The increase in blood flow is significantly related to heart rate, indicating good correlation between increase in blood flow and oxygen demand. This result is expected because the primary cause of increased coronary flow with dobutamine is increased oxygen demand; the direct effect of coronary vasodilation produced by dobutamine is secondary. With dipyridamole and adenosine, on the other hand, myocardial perfusion increases primarily because of the drug's vasodilatory effect on the coronary arteries.

SAFETY AND ADVERSE EFFECTS

With dobutamine perfusion imaging, about 75% of patients will experience adverse effects; about 29% of these patients will have palpitations, and 31% will report chest pain (*4*). In general, the palpitations are simply the patient's awareness of increased heart rate and force of contraction, which may feel odd to patients when not caused by exercise. Some patients report headache, flushing, and dyspnea. The vast majority of these adverse effects are transient.

However, premature ventricular contractions are common, and dobutamine occasionally produces ventricular tachycardia (which is usually not sustained) or atrial fibrillation (*4*). Patients with underlying atrial fibrillation or flutter must be studied with extra caution because their heart rates may increase to extreme levels.

Dobutamine has a longer biologic half-life, about 2 min, than adenosine. Many of its adverse effects are similar to those reported with adenosine, and usually last only a few minutes. Rarely, a patient may require medication, such as a rapidly acting beta-blocker (e.g., esmolol), to neutralize the side-effects of dobutamine.

EFFICACY

Dobutamine perfusion images can be interpreted with the same criteria used to read exercise perfusion scans

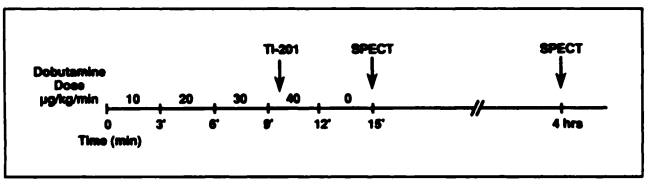

FIGURE 1. Protocol for administration of dobutamine during myocardial perfusion imaging with ^{201}Tl. Reprinted with permission from the American College of Cardiology (*Journal of the American College of Cardiology*, 1993;21:1583).

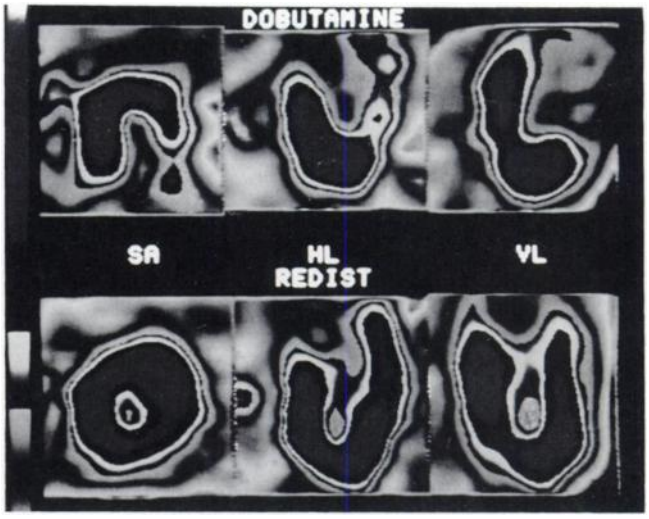

FIGURE 3. Dobutamine-thallium SPECT stress images (top row) and delayed redistribution images (bottom row). One mid-cavity slice is shown for the short-axis (SA), horizontal long-axis (HL) and vertical long-axis (VL). A defect is present in the inferior and posterolateral walls in the stress image, which fills in after redistribution. Reprinted with permission from the American College of Cardiology (*Journal of the American College of Cardiology*, 1993;21:1583).

(Fig. 3). With regard to quantification, it is important to develop a normal database for dobutamine, just as with exercise, dipyridamole and exercise.

In our own series, the overall sensitivity and specificity for dobutamine perfusion imaging are 86% and 90%, respectively, for detection of coronary artery disease (CAD) (*4*). These accuracy measurements are comparable to those reported from our institution for myocardial perfusion imaging with exercise (*7*), dipyridamole (*1*) or adenosine (*2,3*). Dobutamine perfusion imaging has a good sensitivity (78%) for detection of all severe (>70%) stenoses, whereas the sensitivity is lower (44%) for detection of moderate (50% to 70%) stenoses. Other investigators have recently reported similar accuracies (*8–10*).

Dobutamine perfusion imaging detects CAD with higher accuracy in patients with multivessel disease (100% in those with triple-vessel disease) than in patients with single-vessel disease (84%) (*4*). In our institution, the ability to detect CAD in individual vessels with dobutamine perfusion studies is comparable to that of myocardial imaging with exercise (*7*) or other pharmacologic stressors (*1–3*).

Another recent study using dobutamine-thallium SPECT in 50 patients reported a sensitivity of 97% and a specificity of 80% for detecting CAD (*8*). Two recent studies (*9,10*) using dobutamine-sestamibi imaging found sensitivities of 80% and 83% and specificities of 74% and 89%, respectively. The same studies reported sensitivities of 85% and 75%, respectively, for echocardiography with dobutamine.

CONCLUSION

Myocardial perfusion imaging with dobutamine-induced stress is a valuable tool for evaluating CAD, especially in patients who are not candidates for exercise, dipyridamole or adenosine imaging.

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