HISTORY

48-year-old man.

CHIEF COMPLAINT: Chest distress of two months duration.

PRESENT ILLNESS: His substernal chest pressure radiates into the jaw and arms. It occurs with heavy labor, sexual intercourse and emotional upset, and is relieved by rest in 5 minutes. Hypertension has been noted in the past, but not treated. He has smoked a package of cigarettes daily for years.

FAMILY HISTORY: His father had hypertension and died of a myocardial infarction at age 56. Several family members have diabetes.

Question: Given only this history, what is your diagnosis?
**Answer:** The history is typical of atherosclerotic heart disease with angina pectoris.

Angina occurs when myocardial oxygen demand exceeds the capacity of the diseased coronary vessels to deliver oxygen. Exertion and emotion are classic precipitating factors, as they increase systolic blood pressure, heart rate and contractility, the major determinants of oxygen consumption.

Several risk factors for the development of coronary artery disease are also present, including hypertension, smoking and a positive family history.
a. GENERAL APPEARANCE - Slightly obese 48-year-old white man.

b. VENOUS PULSE - The CVP is estimated to be 4 cm of H$_2$O.

**Question:** What is your interpretation of the venous pulse?
Answer: The venous pulse is normal in mean pressure and wave form.

c. ARTERIAL PULSE - (BP = 150/100 mm Hg)

Question: What is your interpretation of the arterial pulse?
**Answer:** The blood pressure is elevated and the arterial pulse contour is normal.

d. PRECordial MOVEMENT and
e. CARDiac AUSCULTATION

**Question:** What is the acoustic event shown by the arrow?
**Answer:** A fourth heart sound. Because of its intensity and low frequency, it is also palpable as the simultaneous “a” wave on the apexcardiogram. The fourth sound and associated presystolic movement indicate forceful left atrial contraction into a left ventricle with reduced compliance.

e. **CARDIAC AUSCULTATION (continued)**

**Question:** How do you interpret the acoustic events at the upper left sternal edge?
**Answer:** There is normal inspiratory splitting of the second sounds due to asynchronous aortic and pulmonic closure of .04 sec.

**f. CAROTID AUSCULTATION**

**Question:**

*How do you interpret the acoustic events over the carotid vessels?*

**Proceed**
**Answer:** There is a bruit over the upper left carotid vessel reflecting underlying atherosclerotic disease.

**g. PULMONARY AUSCULTATION**

**Question:** How do you interpret the acoustic events in the pulmonary lung fields?

**Proceed**
Answer: There are normal vesicular breath sounds in all lung fields.

**ELECTROCARDIOGRAM**

**Question:** How do you interpret this ECG and does it change your diagnosis?
**Answer:** The ECG is normal. It should in no way change your initial diagnostic impression. Patients with angina pectoris commonly have normal resting ECGs.

**CHEST X RAYS**

**Questions:**
1. How do you interpret the chest X rays?
2. Based on the history, physical examination, ECG and chest X rays, what is your diagnosis and plan to further evaluate this patient?
Answers:

1. The chest X rays are normal, a common observation in patients with angina pectoris.

2. Based on the history alone, the best diagnosis is angina pectoris due to atherosclerotic heart disease. Other less common causes of angina, e.g., left ventricular outflow obstruction, are virtually excluded by the physical examination, ECG and chest X rays.

   Evaluation for diabetes and hyperlipidemia will further characterize the patient’s coronary risk and will be helpful in his long-term management.

Proceed
### LABORATORY - FASTING BLOOD TESTS

<table>
<thead>
<tr>
<th>Test</th>
<th>mg %</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>140</td>
<td>60-110</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>300</td>
<td>&lt; 200* (Age related)</td>
</tr>
<tr>
<td>Low Density Lipoprotein</td>
<td>219</td>
<td>&lt; 100*</td>
</tr>
<tr>
<td>High Density Lipoprotein</td>
<td>33</td>
<td>&gt; 40 **</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>240</td>
<td>&lt; 150</td>
</tr>
</tbody>
</table>

* The lower, the better
** The higher, the better

**Question:** What noninvasive procedure would further help to evaluate this patient?
**Answer:** A graded treadmill exercise stress test.

**LABORATORY- (continued)**

**TREADMILL EXERCISE STRESS TEST**

![Heart rate charts showing different time periods: Resting lead V5, 10 minutes of exercise, 1 minute after exercise, and 2 minutes after exercise.]

**Question:** What is your interpretation of the stress test?
Answer: The treadmill test is positive with greater than 1 mm (0.1 mv) of “ischemic” (horizontal or downsloping) ST segment depression, lasting more than .08 seconds past the “J” point (the junction of the QRS and ST segment).

Even if it were negative, the diagnosis of angina would still be tenable, as the overall sensitivity of this study is less than 75%. In addition, in patients with chest pain, at least 10% of male patients and a higher percentage of female patients have false positive stress tests. In asymptomatic patients, the percentage of false positive results is even higher.

Proceed
Answer (continued): Nonetheless, exercise stress testing can be both diagnostically and prognostically important. Almost all patients who have positive stress tests at low levels of exercise (e.g., heart rates of < 120/min.) have significant coronary artery disease, especially those who develop typical angina during the test. A significant percentage of such patients have three vessel disease or narrowing of the left main coronary artery.

Proceed
**Answer (continued):** Greater than 2 mm (0.2 mv.) of “ischemic” ST segment depression with exercise, the absence of a systolic blood pressure rise with exercise, and persistence of ST segment changes for more than five minutes after exercise also help to identify those patients with more severe disease.

In contrast, patients who exercise for long durations and achieve higher heart rates with either negative or indeterminate ST segment responses have a low incidence of severe disease and a better prognosis.

**Question:** What additional noninvasive study could increase the accuracy of the diagnosis?
Answer: Rest and stress (exercise or pharmacologic) imaging of the myocardium using radionuclide or echocardiographic techniques.

Our patient underwent a symptom-limited radionuclide exercise study. The regional distribution of the isotope in the myocardium reflects blood flow. The agent was injected intravenously during maximum exercise, followed by prompt scanning. A second dose of the isotope was given, and the scan was repeated four hours later to assess perfusion at rest.

Proceed
Our patient had a positive myocardial perfusion imaging study. At peak exercise, there was decreased perfusion in the anterior wall. The resting scan was normal.

Only one type of stress imaging is ordinarily selected. The choice depends upon many factors, including the patient’s resting electrocardiogram, ability to exercise and body habitus. In addition, available facilities and professional experience will influence the choice of procedure. All appear to have a similar degree of sensitivity and specificity.

**Question:** What major cardiovascular parameters can be assessed by radionuclide techniques?
Answer: Radioisotope techniques are most commonly used to:

(1) evaluate myocardial perfusion,
(2) measure left ventricular wall motion and function, and
(3) assess myocardial viability.

Proceed
Answer (continued): The use of a radionuclide technique for myocardial perfusion imaging has been described in this patient. It complements electrocardiography for the identification of exercise induced myocardial ischemia or myocardial infarction. Perfusion imaging isotopes can be used to delineate areas of normally perfused myocardium. An area of ischemia or infarction will then appear as a region of decreased activity. The anatomic location of ischemia or infarction, as well as an estimate of its magnitude can be determined.

Another type of myocardial perfusion imaging identifies acutely infarcted myocardium by its uptake of radioisotopes. Technetium-99m pyrophosphate detects acute infarcts for 7 to 10 days; with optimal sensitivity between 24 and 48 hours post infarction.

The radionuclide evaluation of left ventricular wall motion and function involves blood pool labeling with a radioisotope followed either by “gated” or “first pass” cardiac blood pool imaging.

Proceed
Answer (continued): With “gated” studies, the QRS complex of the ECG triggers multiple scintiphotos (gates) in both systole and diastole. By analyzing these images, wall motion and ventricular size and function can be assessed.

“First pass” studies involve the computerized calculation of various parameters of ventricular function as the bolus of radioactive isotope initially circulates. Both techniques can assess ventricular function at rest and with exercise.

Myocardial viability can also be evaluated by Positron Emission Tomography (PET). Radioactive metabolic substrates are used to assess myocardial cell viability.

Question: How would you treat this patient?
Answer: The treatment of angina pectoris is directed at improving symptoms and prognosis. In an effort to improve prognosis, the patient was instructed to begin lifestyle modifications including smoking cessation, as well as medical therapy for his risk factors of hypertension, diabetes and dyslipidemia. This latter risk factor is especially important in this patient because he had both high LDL and low HDL cholesterol levels, each an independent predictor of cardiovascular risk.

Proceed
**Answer (continued):** The frequency of anginal attacks may be reduced by nitrates, beta-adrenergic blockers and/or calcium-channel blockers. The mechanisms by which these agents act are shown below.

<table>
<thead>
<tr>
<th>Determinants of Oxygen Consumption</th>
<th>Nitrates</th>
<th>Beta-Blockers</th>
<th>Calcium-Channel Blockers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contractility</strong></td>
<td>Reflex ↑</td>
<td>Direct ↓</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Heart Rate</strong></td>
<td>Reflex ↑</td>
<td>Direct ↓</td>
<td>Direct ↓, Reflex ↑</td>
</tr>
<tr>
<td><strong>Preload (ventricular diameter)</strong></td>
<td>↓ by venous pooling</td>
<td>↑ by reduced heart rate</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Afterload (systemic pressure)</strong></td>
<td>↓ by peripheral arterial dilatation</td>
<td>Direct ↓</td>
<td>Direct ↓</td>
</tr>
</tbody>
</table>

In addition, the direct dilating effect of nitrates and calcium-channel blockers on the coronary arteries may result in greater oxygen delivery to the myocardium.

**Proceed**
Answer (continued): The patient was started on nitrates and a beta blocker. He also took sublingual nitroglycerin as needed for angina. There was a favorable initial response, including classic relief of angina by nitroglycerin in less than three minutes.

Subsequently, his symptoms worsened despite the addition of a calcium-channel blocker. His risk factors were controlled and low dose aspirin therapy was started for its antiplatelet effect.

The quality of his life was poor, even though his medication was pushed to maximum tolerated doses.

In addition, he complained of occasional isolated palpitations, although his ECG showed no arrhythmia.

**Question:** What procedure should be performed to further assess the patient’s palpitations?
Answer: A 24-hour continuous electrocardiographic Holter monitor recording. While being monitored, the patient had several isolated episodes of “palpitations” lasting a few seconds. His rhythm strip, shown below, reflects both the frequency and character of his arrhythmia.

![Rhythm strip image]

Question:
1. How do you interpret this rhythm strip?
2. Should antiarrhythmic therapy be given at this time?
Answers:

1. The rhythm strip shows two unifocal ventricular premature beats (VPBs).

2. No antiarrhythmic therapy is indicated, as these VPBs do not have the characteristics of more complex forms of ventricular ectopy that may be associated with a poor prognosis.

A rhythm strip from a continuous monitor taken from another patient with coronary artery disease is shown below.

*Question:* How do you interpret this arrhythmia and what is its significance?
**Answer:** VPBs are seen from two foci with a couplet and a triplet. This type of ventricular ectopy is associated with a high risk of sudden death.

Certain types of VPBs in patients with coronary artery disease are powerful independent predictors of the risk of sudden death due to ventricular fibrillation. Such advanced or malignant forms include those that are frequent, multifocal, repetitive and occur early in the cardiac cycle (R on T phenomenon). These types of VPBs are commonly seen associated with reduced ventricular function and extensive coronary artery disease.

Since the patient continued to have significant angina in spite of medical treatment, coronary revascularization had to be considered. Angiographic study to define the exact anatomy of the coronary arteries was indicated. The patient’s study follows.
The right coronary and left ventricular angiograms were normal, as were the intracardiac pressures and cardiac output.

**Question:** What is your interpretation of this study and your plan for further therapy?
**Answer:** Injection of dye into the left main coronary artery shows 90% obstruction of the left anterior descending branch distal to the first septal perforator (arrow).

The major clinical indication for revascularization is refractory angina. Revascularization can be accomplished by percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) surgery (including vein grafting and/or internal mammary artery grafting).

PCI is a non-surgical catheter technique for reducing coronary stenoses in coronary arteries. This technique requires cardiac catheterization and placement of a small balloon-tipped catheter within the stenosis and inflation of the balloon to dilate the narrowed arterial segment. The use of drug eluting stents markedly decreases the incidence of coronary restenosis.

**Proceed**
The following graphic demonstrates the general principles of PCI.

In this patient, because of his favorable anatomy, angioplasty and placement of an intracoronary stent were elected. The patient responded well with amelioration of his symptoms. Follow-up studies were negative for ischemia.
With coronary artery bypass graft surgery, angina is significantly improved in the great majority of cases, with a very low mortality rate. Occlusion occurs, however, in a significant percentage of patients with the vein graft technique. Long term graft patency is markedly improved with the use of the internal mammary artery.

Age, gender and the patient’s clinical status have the most important influence in peri-operative and long-term survival.

In addition to anatomical obstruction, coronary artery spasm is another mechanism that can cause angina. Drug therapy rather than surgical intervention is more effective if spasm is the main etiology of the patient’s angina.
Coronary atherosclerosis begins in the vascular endothelium and subendothelium area with the lipid-filled “fatty streak.” Monocytes take up lipids, and endothelial injury results in adherence of platelets. This process results in an atherosclerotic plaque. The acute ischemic syndromes occur as a result of the disruption of a stable plaque with platelet and thrombus formation.

Coronary artery disease is the leading cause of death in the United States. Angina pectoris is a common presentation. Other manifestations include myocardial infarction, congestive heart failure, and sudden cardiac death. However, ischemia may be silent.

Many risk factors for atherosclerotic heart disease have been identified. These include a positive family history, hypertension, dyslipidemia, diabetes, cigarette smoking, obesity, and increasing age. More recently identified risk factors include markers of inflammation (e.g., highly sensitive CRP) and Lipoprotein a.
The angiographic estimate of the number of diseased vessels, left ventricular function, and ventricular ectopy all have important prognostic significance in patients with coronary artery disease.

The typical pathology follows.
The basic pathology is the lipid rich atherosclerotic plaque. Shown below is a section through the left anterior descending coronary artery of a man with angina pectoris who died suddenly. An atherosclerotic plaque fills the vessel. The small lumen (arrow) is obstructed by thrombus.

The gross pathology of myocardial infarction follows.
The infarction includes the anterior free wall and part of the septum (white solid arrows), and is in the distribution of the left anterior descending coronary artery. There is also a rupture of the anterior wall adjacent to the septum (broken white arrow), an uncommon complication of acute myocardial infarction.
To Review This Case of Atherosclerotic Heart Disease with Angina Pectoris:

The **HISTORY** is classic for angina pectoris. Risk factors include a positive family history, heavy smoking, and hypertension.

**PHYSICAL SIGNS:**

a. The **GENERAL APPEARANCE** is that of a moderately obese man.

b. The **JUGULAR VENOUS PULSE** is normal in mean pressure and wave form.

c. The **CAROTID ARTERIAL PULSE** is normal and the blood pressure is moderately elevated.

d. **PRECORDIAL MOVEMENT** reveals a palpable fourth sound followed by a normal left ventricular apical impulse.

e. **CARDIAC AUSCULTATION** confirms the fourth sound. Note also normal splitting of the second sound at the upper left sternal edge.

Proceed
f. **CAROTID AUSCULTATION** reveals a bruit over the upper left carotid vessel reflecting underlying atherosclerotic disease.

g. **PULMONARY AUSCULTATION** reveals normal vesicular breath sounds in all lung fields.

The resting **ELECTROCARDIOGRAM** and **CHEST X RAYS** are normal.

**LABORATORY STUDIES** reveal additional risk factors including diabetes and hyperlipidemia. The treadmill exercise stress test is positive with >1 mm of “ischemic” ST depression. A radionuclide study reveals a significant defect during exercise in the distribution of the left anterior descending coronary artery. Holter monitoring shows only isolated unifocal VPBs corresponding to the patient’s “palpitations.” Coronary angiography reveals a high grade proximal left anterior descending obstruction.

**Proceed**
TREATMENT consists of risk factor modification and the reduction of myocardial oxygen consumption with nitrates, beta-blockers and calcium-channel blockers. Because of the patient’s poor response to this therapy, coronary arteriography was performed to precisely define the anatomy. Such study also provides important prognostic information.

The patient was successfully treated with PCI with placement of an intracoronary stent.

After successful revascularization, lifestyle modification and treatment of risk factors, including drug therapy when indicated, must continue.