HISTORY

20-year-old white man.

CHIEF COMPLAINT: Dyspnea and substernal pain with exertion, of one year duration.

PRESENT ILLNESS: At age 12, a murmur was heard, and at age 15, there was effort syncope.

FAMILY HISTORY: His mother died suddenly at age 40 and his brother has a murmur.

Question: What category of heart disease is suggested by this history?
**Answer:** Aortic outflow tract obstruction, which classically presents with effort angina, syncope, and later, congestive failure.

**PHYSICAL SIGNS**

a. **GENERAL APPEARANCE** - Normal 20-year-old white man.

b. **VENOUS PULSE** - The CVP is estimated to be 5 cm H$_2$O.

**Question:** What is the dominant wave in the venous pulse?
Answer: The “a” wave (arrow) due to atrial contraction is dominant in this normal venous pulse.

c. ARTERIAL PULSE - (BP = 120/80 mm Hg)

Question: What is abnormal about the arterial pulse?
**Answer:** Our patient has a bifid carotid arterial pulse. The upstroke is rapid, and there are two peaks in systole. These findings are consistent with subvalvular muscular obstruction and reflect the dynamic nature of the obstruction which develops in systole.

d. **PRECORDIAL MOVEMENT and**

e. **CARDIAC AUSCULTATION**

**Questions:**

1. The triple apical impulse is nearly diagnostic of what lesion?

2. How do you interpret the acoustic events at the mid-left sternal border and apex?
**Answers:**

1. A presystolic impulse (palpable pathologic fourth sound) and two systolic impulses are rarely if ever felt except in hypertrophic cardiomyopathy with obstruction. The presystolic impulse reflects the poorly compliant left ventricle, and the double systolic impulse reflects the development of systolic obstruction to outflow.

2. There is a crescendo-decrescendo, harsh systolic murmur heard best at the mid-left sternal edge that radiates poorly to the base. Its configuration is consistent with outflow obstruction and its location suggests that the obstruction is below the aortic valve.

There is a holosystolic, high frequency murmur best heard at the apex consistent with mitral regurgitation. Third and fourth sounds are also present, and reflect rapid deceleration of blood during filling due to poor left ventricular compliance.

**Proceed**
e. CARDIAC AUSCULTATION (continued)

**Question:** Why is the second sound split in expiration?
**Answer:** The second sound is paradoxically split due to a delay in aortic valve closure caused by left ventricular outflow tract obstruction. The second sounds fuse in inspiration when the usual prolongation of right ventricular ejection occurs.

**f. PULMONARY AUSCULTATION**

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

**Proceed**
Answer: In all lung fields, there are normal vesicular breath sounds.

**ELECTROCARDIOGRAM**

Question: How do you interpret this ECG?
**Answer:** The ECG shows increased QRS voltage associated with ST-T wave abnormalities, all consistent with left ventricular hypertrophy. There are also abnormal Q waves in leads reflecting the inferior and lateral walls. While such Q waves may be due to previous infarction, they are also a clue to the diagnosis of hypertrophic cardiomyopathy, in which case they are probably related to marked hypertrophy of the ventricular septum.

**Proceed**
Questions:

1. How do you interpret these chest X rays?

2. Based on the history, physical examination, ECG and chest X rays, what is your initial diagnostic impression and plan to further evaluate this patient?
**Answers:**

1. The chest X rays show mild left atrial enlargement (arrows). The absence of poststenotic dilation of the aortic root is a feature against the diagnosis of aortic stenosis at the valve level.

2. The history, physical examination, ECG and chest X rays are all consistent with an after-(pressure) loaded ventricle due to outflow obstruction, and on bedside examination, the murmur is best heard at the left sternal border and apex, suggesting that the obstruction is located below the valve, and is associated with mitral regurgitation.

**Question:** What non-invasive laboratory procedure is likely to further define the diagnosis?
Answer: Echocardiography

LABORATORY- TWO-DIMENSIONAL ECHOCARDIOGRAM

DIASTOLIC FRAME

- **VST** = ventricular septal thickness
- **PWT** = posterior wall thickness
- **LV** = left ventricle
- **RV** = right ventricle
- **MV** = mitral valve
- **LA** = left atrium
- **Ao** = aorta

Proceed to the M-Mode echocardiogram
ECHOCARDIOGRAM (continued)

M-Mode Echocardiogram

**Question:** What are the diagnostic features of the patient’s M-Mode and two-dimensional echocardiograms?

**NORMAL**

- LVOT
- CHEST WALL
- ANTERIOR MYOCARDIUM
- INTERVENTRICULAR SEPTUM
- ANTERIOR MITRAL VALVE
- POSTERIOR MYOCARDIUM

**PATIENT**

- LVOT
- SAM

**Definitions:**

- LVOT = left ventricular outflow tract
- SAM = systolic anterior motion
**Answer:** The echocardiograms show marked asymmetrical septal hypertrophy (ASH), a narrowed left ventricular outflow tract (LVOT) and abnormal systolic anterior movement (SAM) of the mitral valve. Normally, there is only a very slight and gradual movement of this valve towards the septum. When the ratio of septal to posterior free wall thickness is greater than 1.3, the diagnosis of ASH is confirmed. These findings are typical of hypertrophic cardiomyopathy.

This is one of the few lesions where M-Mode echocardiography is of value, as it is a sensitive method to detect SAM.

A Doppler echocardiogram in this patient localizes the obstruction to the subvalvular level and estimates the gradient to be severe.

**Question:** Is catheterization necessary in this patient?
Answer: No. The diagnosis has been very well defined at the bedside and by noninvasive procedures. While catheterization is not necessary, a typical study follows. The tracing was obtained by placing a catheter in the left ventricle and pulling it back into the aorta.

**LABORATORY**
*(continued)*

**Question:** How do you identify the level of the gradient?
**Answer:** The fact that the systolic pressure drop occurs when the diastolic pressure is still low means that the gradient of approximately 100 mm Hg is in the ventricle and not at the level of the aortic valve.

Analysis of the post-ventricular premature contraction (VPC) arterial pulse pressure response is a useful diagnostic test for hypertrophic cardiomyopathy. A typical tracing follows.
**Question:** What is the diagnostic feature of this tracing?
**Answer:** The pulse pressure of the post-VPC (B) is less than the pulse pressure of the control beat (A). This is the result of several hemodynamic changes that occur in the post-VPC beat:

1. an increase in contractility due to the VPC per se, and to the greater ventricular volume resulting from the long diastole;
2. a decrease in afterload due to the long diastole that results in reduced outflow tract distending pressure;
3. an increase in ventricular volume due to the long diastole that tends to increase outflow tract distending pressure.

In hypertrophic cardiomyopathy with obstruction, the first two effects are dominant and, therefore, the obstruction and the murmur increase and the pulse pressure decreases during the post-VPC beat in most cases.

In most normal patients and in those with valvular obstruction, the pulse pressure of the post-VPC is greater than normal. Note that the systolic gradient is approximately 20 mm Hg (arrow), reflecting the dynamic and variable nature of the muscular obstruction.

To better identify the anatomy of the obstruction, a left ventricular angiogram may be performed as follows:

**Proceed**
Questions:

1. The arrows in this angiogram point to what two lesions?

2. How would you treat this patient?
Answers:

1. The top arrow points out mitral regurgitation into the left atrium, and the bottom arrow points out a thickened papillary muscle associated with an angiographic deformity that may be seen in hypertrophic cardiomyopathy.

2. Beta-adrenergic and/or calcium channel blocking agents are the primary medical therapy. They act by decreasing heart rate and contractility. Heart rate reduction results in greater diastolic filling (increased pre-load) and hence, decreases the degree of apposition of the ventricular walls in systole. This in turn reduces the degree of obstruction. Reducing contractility also decreases the degree of muscular narrowing of the outflow tract. Calcium channel blockers may also favorably alter diastolic compliance.

Proceed
Other therapeutic approaches include: 1) dual chamber pacemakers programmed with short A-V delays, 2) other drugs with negative inotropic action, 3) antiarrhythmic agents such as amiodarone, 4) septal ablation by alcohol infusion into septal arteries, and 5) implantable cardiac devices. For those patients with persistent obstructive symptoms on medical therapy, surgical resection of a wedge of septum (surgical myomectomy) is recommended.

Our patient was started on a beta-adrenergic blocking agent. The dose was gradually increased and he has become asymptomatic.

Proceed for Summary
SUMMARY

Hypertrophic cardiomyopathy is a primary abnormality of the myocardium that exhibits myocyte disarray and unprovoked hypertrophy often affecting the septum disproportionately. Obstruction below the valve may be significant and may include abnormal systolic anterior movement of the mitral valve into the outflow tract.

The disorder is often inherited and transmitted in an autosomal dominant pattern that has been linked to a number of genetic abnormalities involving sarcomere proteins. While the pathophysiology and natural history of familial hypertrophic cardiomyopathy are variable, certain mutations have a greater association with sudden death. First degree relatives with hypertrophic cardiomyopathy should be evaluated.

Hypertrophic cardiomyopathy is the most common cardiac abnormality found in young athletes who die suddenly during vigorous physical exertion. The typical gross pathology follows.
LA = Left Atrium
MV = Anterior Mitral Valve Leaflet
VS = Thickened Ventricular Septum
LV = Left Ventricle

Proceed for Case Review
To Review This Case of Hypertrophic Cardiomyopathy with Obstruction:

The **HISTORY** is classic, including the early appearance of a murmur, effort syncope, angina, and familial features.

**PHYSICAL SIGNS:**

a. The **GENERAL APPEARANCE** is that of a normal young man. His young age is consistent with a congenital etiology.

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

c. The **ARTERIAL PULSE** shows a carotid impulse that is rapid rising and bifid.

Proceed
d. The PRECORDIAL MOVEMENT is virtually diagnostic, with a presystolic impulse and two systolic impulses.

e. CARDIAC AUSCULTATION reveals paradoxic splitting of the second sound due to prolonged left ventricular ejection.

Filling sounds (S3 and S4) are prominent at the apex.

A crescendo-decrescendo systolic murmur is heard at the left sternal edge consistent with subvalvular obstruction. A holosystolic murmur is heard at the apex and is consistent with mitral regurgitation.

No ejection sound or diastolic murmur is heard as might be the case in valvular aortic stenosis.

Proceed
e. **CARDIAC AUSCULTATION** *(continued)* Factors that affect preload, afterload, and contractility may affect the gradient, and hence, the murmur. For example:

The Valsalva maneuver or standing decreases preload (filling), allowing the ventricular walls to appose more readily, and increases the murmur. Squatting increases afterload (pressure) and preload, distending the outflow tract and reducing wall apposition, hence decreasing the murmur.

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

**Proceed**
The **ELECTROCARDIOGRAM** shows left ventricular hypertrophy and characteristic ST-T wave abnormalities along with prominent Q waves which likely reflect depolarization of the hypertrophic ventricular septum. Electrocardiographic features of the W-P-W Syndrome may also be seen in hypertrophic cardiomyopathy, though not present in this case.

The **CHEST X RAY** shows mild left atrial enlargement without significant left ventricular enlargement, as is so typical of afterloaded thick left ventricles which are often not dilated.

**Proceed**
LABORATORY STUDIES include the non-invasive echo-cardiogram which shows marked asymmetric septal hypertrophy, systolic anterior movement of the anterior mitral leaflet associated with a subvalvular gradient by Doppler within the left ventricular outflow tract.

While cardiac catheterization and angiography were not necessary in this case, a typical study is shown which demonstrates a 100 mm Hg gradient below the valve. This gradient is dynamic and may vary considerably in an individual patient, or may even be absent. The brachial artery tracing shows a diagnostic post-VPC reduction in pulse pressure.

The angiogram also demonstrates mild mitral regurgitation which is frequently associated with hypertrophic cardiomyopathy with obstruction.

TREATMENT is medical with beta-adrenergic blocking agents. Digitalis and nitroglycerin are relatively contraindicated, as they may enhance the obstruction. If medical therapy fails, surgical myomectomy is possible.