This program will demonstrate:

1. how a careful cardiovascular evaluation can accurately assess pathology and physiology at the bedside, and

2. the importance of integrating this information with selected laboratory procedures.

In order to become skillful at the bedside examination, one must first have a basic knowledge of cardiac anatomy and understand the events of the cardiac cycle.

Proceed
Coronal section with pulmonary outflow tract, anterior ventricles and aorta cut away.

Proceed
THE CARDIAC CYCLE

Left ventricular systole begins with S1, that occurs when the pressure in the left ventricle rises above that of the left atrium (red arrow), closing the mitral valve. Systole ends and diastole begins with S2, that occurs when left ventricular pressure falls below that of the aortic root (blue arrow) closing the aortic valve.

Analogous events of the cardiac cycle occur in the right heart, but at a lower pressure.
Blood flow is greatest early in systole and diastole. Approximately two-thirds of the blood ejected (stroke volume) leaves the ventricle in the first one-third of systole, and two-thirds of the blood filling the ventricle enters during the first one-third of diastole. This information is useful when analyzing the significance of certain auscultatory events.

Proceed
When performing a cardiovascular evaluation, one should use an orderly method, such as the five finger approach advocated by Dr. W. Procter Harvey.

THE FIVE FINGERS OF CLINICAL DIAGNOSIS

PHYSICAL SIGNS

ECG

X RAY

DIAGNOSTIC LABORATORY

HISTORY

We shall follow this outline in a case-oriented, problem solving format, beginning with the history.

Proceed
HISTORY

50-year-old man.

CHIEF COMPLAINT: Although asymptomatic, his wife insisted he have a cardiac evaluation because her best friend’s husband recently had a heart attack.

**Question:** What five key symptoms must be reviewed during a comprehensive cardiovascular history?
Answer:

1. Chest pain or discomfort
   e.g., ischemic cardiac pain or angina pectoris

2. Shortness of breath (dyspnea) at rest or with exertion
   e.g., as in left heart failure

3. Awareness of the heart beat (palpitations)
   e.g., tachyarrhythmia

4. Dizziness, lightheadedness or fainting
   e.g., syncope

5. Ankle swelling (edema)
   e.g., as in right heart failure

Question: What additional general categories of the history should also be reviewed?
Answer:

1. Family history
   e.g., premature coronary artery disease, sudden death

2. Past history
   e.g., hypertension, diabetes, lipid abnormalities, murmurs

3. Social history
   e.g., smoking, alcohol, drug abuse

The physical examination can also be approached in a systematic manner as follows.
While auscultation is relegated to the last finger, this by no means diminishes its importance. Acoustic events are best interpreted in the context of the other bedside findings.

We shall begin the physical examination with the general appearance.

Proceed
PHYSICAL SIGNS

a. GENERAL APPEARANCE - The patient is normally developed and well nourished. He is comfortable, appears his stated age, and is neither acutely nor chronically ill.

Question: How does the general appearance aid in evaluating a patient’s cardiac status?
Answer: The patient’s appearance can reflect both the state of the circulation and the presence of systemic disease that may also involve the heart.

Examples of the state of circulation include:

- cold, clammy skin and mental confusion as seen in cardiogenic shock
- cyanosis and clubbing (shown below) as seen in a congenital right-to-left intracardiac shunt.
Answer (continued):

Examples of systemic diseases include:

- Marfan’s syndrome associated with aortic dissection.
- Down’s syndrome (shown below) associated with an intracardiac shunt.

![Image of a child with Down's syndrome]

Proceed
b. VENOUS PULSE - The next step in the physical examination is the evaluation of the venous pulse. Information that may be obtained includes:

- the central venous pressure (CVP)
- the wave form

The venous pulse is evaluated by inspection of the transmitted internal jugular venous pulsations that directly reflect right atrial hemodynamics. They are observed (not palpated) as they undulate at the inferolateral aspect of the sternocleidomastoid muscle.

Proceed
A tangential light source can be used to better visualize the venous pulsations. Simultaneous palpation of the carotid artery will identify systole.

Proceed
b. VENOUS PULSE (continued) - CENTRAL VENOUS PRESSURE

The mean CVP is determined by measuring the vertical height of the venous pulsations above the mid right atrium, as the latter is the zero reference pressure. The patient should be examined in the semi-recumbent position at whatever angle the veins are best visualized. The sternal angle is used as a bedside reference point. It is 5 cm above the mid right atrium, and this relationship does not change significantly from the supine to the sitting position.

Proceed
b. VENOUS PULSE *(continued)* - The CVP in our patient is estimated to be 3 cm H$_2$O.

The sternal angle is 5 cm above the mid right atrium. Since our patient’s neck veins undulate 2 cm below the sternal angle, his estimated CVP is 3 cm H$_2$O.

**Proceed**
Neck veins normally do not pulsate to a level exceeding 2 cm above the sternal angle, i.e., the normal mean CVP is less than 7 cm.

The most common cause of an elevated mean central venous pressure is an elevated right ventricular diastolic pressure, such as occurs with right ventricular heart failure.

Proceed
b. VENOUS PULSE (continued) - WAVE FORM

**Question:** How do you interpret the jugular venous wave form?
**Answer:** The venous wave form is normal. The normal venous waves include:

- The “a” wave due to right atrial contraction
- The “x” descent due to right atrial relaxation and systolic descent of the tricuspid valve
- The “c” wave (more often recorded than seen), in part transmitted from the carotid artery
- The “v” wave due to passive filling of the right atrium
- The “y” descent due to emptying of the right atrium after the tricuspid valve opens

**Proceed**
There are several variations in the venous wave form that may provide important diagnostic information at the bedside. An example follows:

An abnormally prominent or giant “a” wave is due to enhanced right atrial contraction against an increased resistance. This is most often due to right ventricular hypertrophy, e.g., as in pulmonic stenosis or pulmonary hypertension.

Proceed
c. **ARTERIAL PULSE** - The next step in the physical examination is the evaluation of the arterial pulses. This includes the measurement of heart rate and blood pressure, as well as the assessment of the peripheral pulses.

The initial blood pressure should be taken in each arm using an appropriate size cuff that is tightly fitted. The cuff is inflated above systolic pressure and then slowly deflated. The level at which the first Korotkoff sound is heard is the systolic pressure. The level at which the Korotkoff sounds disappear is the diastolic pressure.

Proceed
c. ARTERIAL PULSE (continued) - Our patient’s heart rate is 60 and his blood pressure is 120/80 mm Hg.

**Question:** How do you interpret the patient’s blood pressure?

*Place the stethoscope diaphragm over the brachial artery and inflate the cuff.*
Answer: The blood pressure is normal.

In the adult, repeated resting blood pressures between 120/80 and 139/89 mm Hg are defined as “pre-hypertension.” As long as the patient has no symptoms, the lower the blood pressure the better.

Proceed
c. ARTERIAL PULSE  (continued) - CAROTID ARTERY

**Question:** How do you interpret the carotid arterial pulse?
**Answer:** The carotid arterial pulse is normal.

The carotid artery is examined by placing the finger high in the neck between the trachea and the sternocleidomastoid muscle. Light pressure should be used to best evaluate the contour and to avoid cerebral ischemia.
The carotid artery is assessed by evaluating:

- rate of rise, e.g., normal, rapid or delayed
- pulse volume, e.g., normal, large or small
- contour, e.g., single or double

Most commonly, the peripheral pulses mirror the carotid pulses. In patients, it is important to compare the pulses in all four extremities to rule out vascular abnormalities, e.g., coarctation of the aorta, wherein the pulse volume beyond the obstruction may be reduced.

Proceed
A comparison of the normal pulse to an abnormal carotid arterial pulse is shown in the following graphic.

The abnormal pulse is small in amplitude and slow in upstroke (hypokinetic). It is due to a decreased stroke volume, as may be seen with severe left ventricular failure.
d. PRECORDIAL MOVEMENT - The next step in the bedside examination is a systematic assessment of precordial (chest wall) movements. First, inspect the general configuration of the thorax looking for obvious asymmetry or musculoskeletal abnormalities. Next observe the entire precordium for movement.

The palm of the hand is best suited for locating impulses and detecting vibrations. The fingertips are best for evaluating the size and contour of the impulse. Determine if the impulse is systolic or diastolic by simultaneously palpating the carotid artery or by listening to the heart sounds.

Proceed
The precordial impulse should be assessed by analyzing:

- Location
- Size
- Contour

Palpation should be carried out in the areas shown on the diagram that follows.
d. PRECORDIAL MOVEMENT (continued)

- **a** = PULMONARY AREA (upper left sternal edge)
- **b** = RIGHT VENTRICULAR AREA (mid and lower left sternal edge)
- **c** = APICAL = LEFT VENTRICULAR AREA (midclavicular line [MCL] 5th intercostal space [ICS])
- **d** = DISPLACED APICAL AREA (anterior axillary line [AAL] 6th and 7th ICS)

Proceed
d. PRECordial MOVEMENT *(continued)*

The only palpable impulse in this patient is at the apex.

**Question:** How do you interpret the apical impulse?
Answer: The apical impulse is normal. It is located in the fifth intercostal space, midclavicular line and is brief in duration, occurring immediately after S1. Such normal impulses are small (dime size). The apical impulse may be felt best with the patient in the left lateral decubitus position.

Proceed
e. APICAL IMPULSE - In patients with left ventricular dilatation due to volume overload, e.g., aortic or mitral regurgitation, the apical impulse may be displaced inferolaterally and its size enlarged.

Note the abnormal impulse is located in the anterior axillary line (inferolaterally displaced). It occupies the 6th and 7th ICS (enlarged) and is sustained throughout systole (abnormal contour).

Proceed
Precordial movements may occur in diastole as well as systole.

5th ICS MCL

In the abnormal tracing, there is a palpable presystolic impulse preceding the normal short systolic impulse. It reflects enhanced atrial contraction against a stiff or poorly compliant left ventricle. This impulse is common in patients with ischemic heart disease.

Proceed
The final step in the physical examination is auscultation. One must systematically listen in each of the classic acoustic areas shown below to evaluate the heart sounds and assess any murmur that might be present.

- **a** = Aortic Area (Upper Right Sternal Edge)
- **b** = Pulmonary Area (Upper Left Sternal Edge)
- **c** = Tricuspid Area (Lower Left Sternal Edge)
- **d** = Mitral Area (Apex)
- **e** = Mitral radiation (Posterolateral to Apex)
- **f** = Aortic or pulmonary radiation (Upper Chest)
- **g** = Carotids

Proceed
We shall begin auscultation at the aortic area and move sequentially to the pulmonary, tricuspid and mitral areas. The diaphragm of the stethoscope is best for hearing high frequency sounds, and the bell is best for low frequency sounds.

In each area, one should first listen selectively for the first and second heart sounds (S1 and S2), as these sounds respectively identify the beginning of systole and diastole. It is also helpful to palpate simultaneously the carotid artery to time the acoustic events. Both S1 and S2 are relatively high frequency and are, therefore, best heard with the diaphragm.

Most important, the events of the cardiac cycle should be kept in mind when interpreting acoustic events at the bedside.

Proceed
In these left heart pressure tracings, S1 indicates the beginning of systole and coincides with closure of the mitral valve. S2 indicates the end of systole (and the beginning of diastole) and coincides with closure of the aortic valve.
e. CARDIAC AUSCULTATION

**Question:** How do you interpret the acoustic events at the upper right sternal edge?
Answer: S1 is softer than S2. Both are single and normal in intensity.

In this area, S1 is related to mitral valve closure and S2 to aortic valve closure. Both sounds are due to vibrations of the valve apparatus and surrounding cardiac structures and blood (“cardiohemic column”) that result from valve closure and the ensuing deceleration of blood flow.

S2 is normally louder than S1 in the aortic area because the stethoscope is closer to the aortic valve than it is to the mitral valve. The relative intensities of the heart sounds may be clues to pathology. For example, a loud aortic closure (A2) may be seen in some patients with hypertension.
Question: How do you interpret the acoustic events at the upper left sternal edge?
Answer: There is normal inspiratory (physiologic) splitting of S2 due to asynchronous aortic and pulmonic closure of .04 seconds. A2 (aortic valve closure) is slightly more intense than P2 (pulmonic valve closure), as the aortic valve closes under a much higher pressure than the pulmonic valve.

Inspiration causes a drop in intrathoracic pressure with greater venous return to the right ventricle and less return to the left ventricle. The increase in right ventricular volume prolongs right-sided ejection time, and the decrease in left ventricular volume reduces left-sided ejection time. In addition, inspiration allows the pulmonary arteries to receive a greater volume of blood, contributing further to a delay in P2. The net effect is a later P2 and an earlier A2.

Proceed
Abnormal splitting of the second heart sound occurs in many pathologic conditions. An example follows:

![Diagram showing heart sounds](image)

Expiration

Inspiration

The second heart sound is widely split in both inspiration and expiration, i.e., “fixed splitting.” Fixed splitting is characteristic of a large atrial septal defect. Normal variation of S2 splitting does not occur in this situation because blood continuously flows left-to-right through the shunt thereby counterbalancing respiratory effects. This results in constant, increased right ventricular flow.

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

**Question:** How do you interpret the acoustic events at the lower left sternal edge?
Answer: S1 is louder than S2, as the atrioventricular valves are closer to the stethoscope in this area than are the semilunar valves. There is normal splitting of S1 (.03 seconds) due to asynchronous closure of the mitral (M) and tricuspid (T) valves.

In normal patients, the first heart sound may be single or split. Splitting of S1, if present, is best heard at the tricuspid area because the normally softer tricuspid component is best heard at this area.

Proceed
Question: How do you interpret the acoustic events at the apex?
**Answer:** The heart sounds are normal. S1 and S2 are single and S1 is louder than S2.

Other heart sounds may be heard at the apex. Most important are diastolic filling sounds, the third and fourth sounds (S3 and S4).
These low frequency diastolic filling sounds are best heard with the bell of the stethoscope. The S3 is related to the acceleration and deceleration of blood during early passive filling of the ventricle. It can be normal in children and young adults (enhanced acceleration during filling) but may also be present in heart failure (enhanced deceleration during filling). The S4 is related to atrial contraction filling a stiff or poorly compliant ventricle.

Proceed
There are other heart sounds that may help to accurately define the diagnosis and severity of cardiac lesions. Examples include:

An ejection sound (ES) may be heard in congenital aortic stenosis associated with doming of a bicuspid valve.

An opening snap of the mitral valve (OS) may be heard in mitral stenosis.

Mid systolic clicks (C) may be heard in mitral valve prolapse due to tensing of the valve as it everts into the left atrium.

**Proceed**
In some patients a murmur may be heard. A murmur is a sustained series of audible vibrations due to turbulent blood flow. Murmurs may occur in systole or diastole. They may also be continuous, i.e. continue through the second heart sound as in patent ductus arteriosus. An example of a very common systolic murmur follows.
THE INNOCENT MURMUR

This is a typical “innocent” murmur, often heard in youngsters. It is heard in early systole when the majority of blood leaves the ventricle, and is related to the normal turbulence of flow across the pulmonary outflow tract. Note there is also normal splitting of S2 during inspiration.

Proceed
Murmurs may be characterized by some or all of the following descriptors:

1. **Timing**
   - phase of cardiac cycle - systolic, diastolic, continuous
   - location in systole/diastole - early, mid or late
   - duration in systole/diastole - short, long or throughout

2. **Contour (shape)**
   - crescendo
   - decrescendo
   - crescendo-decrescendo
   - plateau

3. **Frequency (pitch)**
   - high
   - medium
   - low

Proceed
MURMUR DESCRIPTORS (continued)

4. Quality
   blowing, harsh, rumbling, musical

5. Grade (loudness)
   I through VI

6. Location of maximal intensity

7. Radiation

8. Response of murmur to intervention
   respiration, changes in body position, Valsalva, etc.

Proceed
Using these guidelines, the innocent murmur could be more fully described as short, early systolic, medium frequency, grade 2, crescendo-decrescendo and best heard at the upper left sternal edge.

**THE INNOCENT MURMUR**

![Diagram of the innocent murmur]

**UPPER LEFT STERNAL EDGE**

**S1**

**Inspiration**

Proceed
There are four classic murmurs that reflect pathology of the left heart valves. One must recall that during left ventricular systole the aortic valve is normally open and the mitral valve is shut, whereas in diastole the reverse is true.

Proceed
FOUR CLASSIC HEART MURMURS

Aortic Stenosis
Aortic valve not fully open in systole

Mitral Regurgitation
Mitral valve not fully closed in systole

Aortic Regurgitation
Aortic valve not fully closed in diastole

Mitral Stenosis
Mitral valve not fully open in diastole

SYSTOLE      DIASTOLE
S1

Proceed
f. PULMONARY AUSCULTATION

Pulmonary auscultation is also an important step in the physical examination. One must systematically listen in each of the lung fields shown below to evaluate the lung sounds and assess any abnormalities that might be present.

**Pulmonary Auscultation:**
- a = Right upper
- b = Right inferoposterior
- c = Right Inferoanterior
- d = Left upper
- e = Left inferoanterior
- f = Left inferoposterior

**Respiration:**
- g = Abdominal breathing is simulated

**Question:** How do you interpret the acoustic events in the pulmonary lung fields?
Our patient’s history was unremarkable, as was the assessment of his general appearance, venous pulse, arterial pulses, precordial movements and auscultation.

Therefore, based on the history and physical examination, this patient’s cardiovascular assessment is normal. The bedside assessment is frequently complemented by low cost, high yield laboratory procedures such as blood work, ECGs and X rays.

Our patient’s routine screening blood work was normal, including his blood sugar and lipids.

**Answer:**

In all lung fields, there are normal vesicular breath sounds.

**Proceed**
The electrocardiogram is a recording of the electrical signal passing from the atria to the ventricles. The relationship of the electrocardiogram to the cardiac cycle and the heart sounds is shown.

**LABORATORY - ELECTROCARDIOGRAM**

*p* = atrial depolarization  
**QRS** = ventricular depolarization  
*T* = ventricular repolarization

**Proceed**
This patient’s ECG shown above, is normal. Information that can be obtained from the ECG includes rhythm and conduction disturbances, chamber hypertrophy and myocardial ischemia and/or infarction.
This patient’s chest X rays are normal. PA and lateral chest X rays show the location and size of the heart and great vessels within the thorax. The X ray may also demonstrate disease of the lungs, the mediastinum and bony structures.

Proceed
ECHOCARDIOGRAM
While not indicated in this case, echocardiography is a noninvasive procedure that accurately defines cardiac anatomy and function. When combined with the Doppler technique, hemodynamic abnormalities may be quantitated. The following is a normal study.
SUMMARY

This patient’s cardiovascular status is normal. This conclusion is based on a simple but orderly approach to bedside diagnosis.

The cardiovascular examination consists of a complete history and a careful examination, including assessment of the general appearance, the jugular venous pulse mean pressure and wave form, arterial pulses, precordial movements and auscultation. Laboratory studies, including blood work, ECGs and chest X rays are commonly included. In an individual patient, more sophisticated procedures may be required.

Skillful performance of the physical examination requires continued practice, as well as knowledge of cardiac anatomy and physiology.

Proceed
Examples of other noninvasive procedures that may also be indicated in an individual patient include echocardiography, ambulatory monitoring of the electrocardiogram and blood pressure, stress testing, radionuclide studies, MRI, etc.

Cardiac catheterization and angiography are invasive studies that assess intracardiac pressures and flow, ventricular function, valve structure and function, and coronary anatomy.
To Review This Normal Patient

The **HISTORY** is negative in this asymptomatic patient.

**PHYSICAL SIGNS:**

a. The **GENERAL APPEARANCE** is that of a well developed, well nourished 50-year-old white man in no distress.

b. The **JUGULAR VENOUS PULSE** mean venous pressure is normal at 3 cm H$_2$O, with a normally dominant “a” wave.

c. The **CAROTID ARTERIAL PULSE** is normal in upstroke, peak and downstroke.

Proceed
d. **PRECORDIAL MOVEMENT** reveals a normal brief apical impulse in the fifth intercostal space at the midclavicular line, occurring at the time of the first heart sound.

e. **CARDIAC AUSCULTATION** reveals normal first and second heart sounds. The first sounds are normally dominant at the tricuspid and mitral areas, while the second heart sounds are normally dominant at the aortic and pulmonic areas. There is normal (.03 sec.) splitting of the first sound at the tricuspid area, and normal (.04 sec.) inspiratory splitting of the second sound at the pulmonic area.

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

Proceed
The **ELECTROCARDIOGRAM** and **CHEST X RAYS** are normal, as is the routine blood work.

No other **LABORATORY STUDIES** are necessary.

No **TREATMENT** is required.