

Manual of Cardiovascular Diagnosis and Therapy

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Preface

The Manual of Cardiovascular Diagnosis and Therapy was conceived as an aid to harried physicians, house officers, and medical students involved in the daily care of patients with cardiovascular disease. The introductory chapters review salient features of the cardiovascular physical examination and the numerous noninvasive tests available for cardiovascular diagnosis. Following these initial chapters, common complications of patients with cardiac disease, such as arrhythmias, are reviewed. Finally, specific cardiovascular disease entities are dealt with in the longest section of the manual. Each chapter is written in outline form for easy scanning. Chapters on specific disease entities follow identical formats, dealing first with various aspects of diagnosis and second with approaches to medical and surgical management. A brief annotated bibliography is appended to each chapter.

We gratefully acknowledge the assistance and inspiration of the following colleagues, editors, artists, and secretaries: Priscilla T. Baggesen, Eugene Braunschweig, M.D., James E. Dalen, M.D., Charles I. Haffajee, M.D., Marc Hallett, M.D., Lois Liebman, Ruth K. Lyle, Kathleen O'Brien, Ira S. Ockene, M.D., Linda A. Pape, M.D., John A. Paraskos, M.D., Marilyn J. Parks, Lin Richter, Christine Wiggins.

The authors hope that this manual will be as functional as previous publications in this series.

J. S. A.
J. M. R.

Contents

Preface	v
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I	
Introduction to Cardiovascular System	

1	
Physical Examination of the Heart	3

2	
Noninvasive Examination of the Heart	13

3	
Arrhythmias	21

4	
Heart Failure	39

5	
Pulmonary Edema	57

6	
Shock	67

7	
Syncope	81

8	
Cardiac Arrest	89

9	
Exercise and the Cardiovascular System	109

10	
Psychological Aspects of Heart Disease	117

II	
Specific Disorders	

11	
Hypertension	129

12	
Hypertensive Crisis	149

13	
Ischemic Heart Disease	161

14	Valvular Heart Disease	191
15	Congenital Heart Disease	223
16	Cardiomyopathy, Myocarditis, and Rheumatic Fever	245
17	Pericardial Disease	265
18	Infectious Endocarditis	277
19	Cardiac Tumors	285
20	Pulmonary Embolism	291
21	Cor Pulmonale	299
22	Heart Block and Sick Sinus Syndrome	305
23	Cardiac Trauma	311
24	Pregnancy and Heart Disease	317
25	Noncardiac Surgery in Patients with Heart Disease	323
26	Diseases of the Aorta	327
27	Peripheral Vascular Disease	337
28	Central Nervous System Involvement in Cardiovascular Disease	345
	Appendix Cardiac Involvement in Other Medical Conditions	351
	Index	359

Notice

The indications and dosages of all drugs in this manual have been recommended in the medical literature and conform to the practices of the general medical community. The medications described do not necessarily have specific approval by the Food and Drug Administration for use in the diseases and dosages for which they are recommended. The package insert for each drug should be consulted for use and dosage as approved by the FDA. Because standards for usage change, it is advisable to keep abreast of revised recommendations, particularly those concerning new drugs.

Introduction to Cardiovascular System Physical Examination of the Heart

- I. Introduction.** Careful physical examination of the heart provides important information about the cardiovascular system. Together with a thorough history, the physical examination provides the initial data base and suggests further diagnostic tests and therapeutic maneuvers. In many conditions, careful physical examination can yield information as important as that obtained by more complex and costly procedures.

This chapter focuses on diagnostic aspects of physical examination of the heart and provides general guidelines for evaluating physical findings. Descriptions of the actual techniques of physical examination and theories concerning the origins of heart sounds are beyond the scope of this manual. Detailed descriptions of physical examination findings for various cardiac diseases are found in the chapter for each entity.

II. Observation, palpation, and percussion

- A. Jugular venous pulse (JVP).** Two types of information are obtained from the JVP: the quality of the wave form and the central venous pressure (CVP).

1. Technique of examination. The JVP is best observed in the right internal jugular vein. With normal central venous pressures, the JVP is assessed with the patient's trunk raised less than 30 degrees. With elevated CVP the patient's trunk must be raised higher, sometimes to as much as 90 degrees. The JVP is accentuated by turning the patient's head away from the examiner and shining a flashlight obliquely across the skin overlying the vein.

2. Wave form of the JVP. Two waves per heart beat are generally visible in the JVP: the A wave and the V wave. The A wave appears as a brief "flicker" and represents increased venous pressure resulting from atrial contraction. The V wave is a longer surge that follows the A wave and represents increased venous pressure transmitted during ventricular contraction. The drop in pressure following the A wave is called the X descent, and the fall in pressure after the V wave is denoted as the Y descent. The JVP waves should be timed with simultaneous palpation of the carotid artery. The A wave just precedes the carotid pulse; the V wave follows the pulse.

The diagnosis of a variety of pathological states is assisted by observation of abnormalities in the JVP wave forms (Table 1-1).

3. Determination of CVP. Central venous pressure is approximately equal to the vertical distance from the top of the V wave to the right atrium. In the individual with normal CVP, the V wave rises 1-2 cm above the sternal angle. When the V wave rises to more than halfway to the angle of the jaw in a patient who is not recumbent, elevated CVP is present. In some pathological conditions (e.g., cardiac tamponade, constrictive pericarditis), CVP may be so high that A and V waves are above the angle of the jaw. In this setting, exaggerated X and Y descents may suggest the diagnosis. As a rule of thumb, for a patient sitting upright,

Table 1-1. Clinical Information Derived from Abnormal Jugular Venous Pulsations

Finding	Comment/Significance
Markedly raised central venous pressure, accentuated X and Y descents	? Cardiac tamponade ? Constrictive pericarditis ? Endocardial fibroelastosis ? Severe right-heart failure
Large A waves	? Pulmonary valvular stenosis ? Hypertension ? Various arrhythmias where atria contract against closed atrioventricular valve (e.g., junctional rhythm, atrioventricular dissociation)
Absent A wave	Atrial fibrillation
Large V wave	Tricuspid regurgitation

JVP visible at the sternal angle represents a CVP of approximately 10 mm Hg.

- B. Arterial pressure pulse.** The central arterial pressure pulse is characterized by a rapid rise to a rounded-shoulder peak with a less rapid decline. Information about the adequacy of ventricular contraction and possible obstruction of the left ventricular outflow tract may be assessed by palpation of the carotid artery. By the time the pulse wave is transmitted to peripheral arteries, much of this initial information is lost. However, pulsus alternans is best evaluated in peripheral arteries.

A variety of pathological conditions alter the characteristics of the carotid pulse. These conditions, and the corresponding modifications of the carotid pulse, are listed in Table 1-2. In patients with unexplained hypertension, simultaneous palpation of radial and femoral arterial pulses helps to rule out coarctation of the aorta.

- C. Precordial palpation.** Information concerning the location and quality of the left ventricular impulse is available through precordial palpation. In addition, intensity of murmurs may be gauged by palpating associated thrills.

Palpation is best accomplished using the fingertips, with the patient either supine or in the left lateral decubitus position. Simultaneous auscultation can aid in the timing of events. A list of abnormalities detected by precordial palpation and their significance is found in Table 1-3.

III. Auscultation

- A. S_1 .** The first heart sound (S_1) occurs at the time of closure of the mitral and tricuspid valves. It is probably generated by the closure of the valves. S_1 is frequently split (with mitral closure preceding tricuspid), but this event is often hard to appreciate and of little clinical relevance. More important is variation in intensity of the first sound. S_1 varies with the P-R interval of the electrocardiogram. The shorter the P-R interval, the louder the S_1 . The best example of S_1 variation with P-R interval occurs in complete heart block, in which atrial and ventricular contractions are dissociated.

S_1 may be loud and "snapping" in quality in mitral stenosis, indicating both that the valve is pliable and that it remains wide open at the beginning of isovolumic contraction. Conversely, a diminished or absent S_1 in mitral stenosis suggests a rigidly calcified valve that has become incapable of "snapping" shut.

Other situations in which S_1 may be diminished include mitral regurgitation, slow heart rates (long P-R interval), poor sound conduction through

Table 1-2. Clinical Information Derived from Abnormalities in Carotid Pulse

Finding	Comment/Significance
Pulsus bisferiens (2 systolic peaks)	Found in aortic regurgitation and idiopathic hypertrophic subaortic stenosis
Pulsus parvus (small, weak pulse)	Any condition causing diminished left ventricular stroke volume or narrow pulse pressure (hypovolemia, mitral valve stenosis, restrictive pericarditis, recent myocardial infarction)
Pulsus tardus (delayed systolic peak of pulse)	Aortic outflow obstruction
Pulsus paradoxus (larger than normal decrease in systolic arterial pressure during inspiration)	Pericardial tamponade, airway obstruction, superior vena caval obstruction
Pulsus alternans (consistent alteration in pulse pressure amplitude despite regular rhythm)	Severe left ventricular decompensation for any reason; following paroxysmal tachycardia; for several beats following a premature beat

Table 1-3. Clinical Significance of Abnormalities in Precordial Palpation

Finding	Comment/Significance
Left ventricular thrust	Left ventricular hypertrophy
Displacement of left ventricular impulse downward and to the left	Left ventricular dilatation; left ventricular failure; volume overload (aortic regurgitation)
Presystolic impulse	Pressure overloaded states (hypertension, aortic stenosis)
Double systolic impulse	Idiopathic hypertrophic subaortic stenosis
Systolic bulge	Coronary artery disease; recent myocardial infarction (most commonly felt above and medial to the point of maximal impulse)
Parasternal lift	Mitral regurgitation (occurs after the left ventricular apical impulse); right ventricular dilatation (mitral stenosis, pulmonary embolism)
Thrills	Aortic stenosis; pulmonic stenosis; ventricular septal defect

Table 1-4. Clinical Information Derived from Abnormalities in S_1

Finding	Comment/Significance
Loud S_1	Short P-R interval
Loud "snapping" S_1	Mitral stenosis (pliable valve)
Variation in intensity of S_1	Complete heart block
Diminished intensity of S_1	Mitral regurgitation, slow heart rate (long P-R interval), poor conduction of sound through chest wall, slow rise of left ventricular pressure, mitral stenosis (rigidly calcific valve)

the chest wall, and a slow rise of left ventricular pressure. A summary of clinical information derived from variations in S_1 is found in Table 1-4.

- B. S_2 .** In contrast to S_1 , in which splitting is less important than changes in intensity, S_2 reveals variations in both splitting and intensity that provide important clinical information.

The second heart sound (S_2) occurs at the time of closure of the aortic and pulmonic valves. In normal circumstances, aortic closure precedes pulmonic closure (A_2 followed by P_2). Under normal circumstances, the split in S_2 is maximal at the end of *inspiration* and minimal at the end of *expiration*. This phenomenon reflects an underlying movement of P_2 with respect to a relatively constant A_2 . During inspiration, right ventricular filling increases and P_2 is delayed, causing the widely split S_2 . During expiration, less right ventricular filling occurs and P_2 "closes" toward A_2 , causing a diminished split in S_2 . This "normal splitting" of S_2 is invariably present in individuals under 30 years of age, provided heart rates are not markedly accelerated. It is best appreciated over the "pulmonic area" and can be heard with either the bell or the diaphragm.

- 1. Fixed splitting of S_2 .** The most common abnormality of S_2 is failure of splitting to close at the end of expiration. This "fixed splitting" occurs for either of two reasons: Either P_2 is delayed, or A_2 is early. A split of S_2 on expiration may also represent a normal variant. However, in the latter setting, some difference in the degree of split should occur between inspiration and expiration.

Fixed splitting of S_2 due to delayed P_2 is found in four clinical settings: (a) acute right-heart pressure overload (e.g., pulmonary embolism), (b) right bundle branch block, (c) atrial septal defect (ASD), (d) pulmonic stenosis.

- 2. Paradoxical splitting of S_2 .** Paradoxical splitting of S_2 is said to be present when S_2 splits on expiration and becomes singular on inspiration. While fixed splitting denotes delay in normal closure of the pulmonic valve, paradoxical splitting denotes delayed closure of the aortic valve. It is an important clinical sign that never occurs in the absence of cardiac disease. The most common states in which paradoxical splitting is encountered are aortic stenosis and left bundle branch block. Paradoxical splitting takes place in about 25% of individuals with these conditions.

Paradoxical splitting may occur in patients with coronary artery disease or hypertension or both. In these individuals a closely split S_2 may be observed to close to a single sound at mid inspiration. A similar finding is often made in early stages of aortic stenosis or in incomplete left bundle branch block.

Alterations in the intensity of S_2 can also yield important clinical information. A_2 is frequently decreased in aortic stenosis. The presence of

Table 1-5. Clinical Information Derived from Abnormalities in S_2

Finding	Comment/Significance
Abnormalities in Timing	
Fixed splitting	Acute right-heart overload (e.g., pulmonary embolism) Right bundle branch block Atrial septal defect Pulmonic stenosis
Paradoxical splitting	Aortic stenosis Left bundle branch block
Closely split with closure at mid inspiration (variant of paradoxical splitting)	Coronary artery disease Hypertension
Abnormalities in Intensity	
Increased A_2	Hypertension Aortic dilatation
Increased P_2	Pulmonary hypertension Normal finding in thin-chested individual
Decreased A_2	Aortic stenosis
Decreased P_2	Pulmonic stenosis

a normal A_2 when aortic stenosis is clinically suspected raises the question of outflow obstruction at a site other than the valve. P_2 may be augmented in pulmonary hypertension and diminished in pulmonic stenosis. Finally, P_2 may appear unusually loud in thin-chested individuals without cardiac disease.

A summary of clinical information derived from alterations in S_2 is found in Table 1-5.

- C. S_3 . The third heart sound (S_3) or ventricular gallop is low-pitched and best heard at the apex with the stethoscope bell. The S_3 is probably the result of rapid filling and stretching of an abnormal left ventricle. The cadence of the S_3 has been compared to the y in *Kentucky*. An S_3 may be heard in any condition resulting in rapid ventricular filling. It is frequently an early sign of left ventricular failure. Third heart sounds may also be present in atrial septal defect, mitral or aortic insufficiency, ventricular septal defect, and patent ductus arteriosus. An S_3 can also be a normal variant, particularly in young adults. A loud, early diastolic sound is often heard in constrictive pericarditis. This "pericardial knock" may be mistaken for an S_3 .
- D. S_4 . The fourth heart sound (S_4 , atrial gallop, presystolic gallop) is also the result of altered ventricular compliance. Its cadence has been compared to the soft a sound of *appendix*. It is a low-pitched sound, best heard with the stethoscope bell. It is loudest at the apex and may be accentuated by placing the patient in the left lateral decubitus position. The presence of an S_4 implies effective atrial contraction; it is never heard in atrial fibrillation. An S_4 may be heard in any condition causing reduced ventricular compliance: aortic stenosis, systemic or pulmonary hypertension, coronary artery disease, hypertrophic cardiomyopathy, acute mitral regurgitation, and myocardial infarction.

E. Snaps, clicks, and other adventitious sounds

1. **Opening snap (OS).** An opening snap of the mitral valve is frequently heard in mitral stenosis. The opening snap arises from the stiff

mitral valve's snapping into the left ventricle in early diastole. The opening snap is best heard in the fourth intercostal space halfway between the apex and the left sternal border. The interval between S_2 and the OS is related to the severity of mitral stenosis. The more severe the stenosis, the shorter the S_2 -OS interval.

2. **Ejection clicks.** Ejection clicks are high-pitched sounds occurring in early systole. They are associated with stenosis of either the aortic or the pulmonic valve, with hypertension or dilatation of either the aorta or the pulmonary artery, or both. Aortic clicks are best heard at the apex, while pulmonic clicks are most audible at the left upper sternal border. Pulmonic clicks vary with respiration and are best heard during expiration. Aortic clicks do not vary with respiration.
3. **Mid-systolic (nonejection) clicks.** Mid-systolic clicks, often accompanied by a late systolic murmur occur in patients with prolapse of the posterior leaflet of the mitral valve. The clicks may result from sudden tensing of the chordae tendineae or snapping of the prolapsing leaflet. The clicks may be single or multiple and may occur at any time during systole, although they generally come later than ejection clicks.

F. Systolic murmurs. Systolic murmurs are classified according to their time of occurrence, sound quality, and duration. The most fundamental distinction is between systolic ejection murmurs and pansystolic murmurs. Ejection murmurs ordinarily occur in mid-systole. Early and late systolic murmurs also occur and should be distinguished from ejection murmurs. Ejection murmurs begin after S_1 and are usually crescendo-decrescendo ("diamond-shaped"), ending before S_2 . Pansystolic murmurs begin with S_1 , extend throughout systole, and are characteristically uniform in intensity. Systolic ejection murmurs have been compared to the chug of a steam engine laboring up a hill, while pansystolic murmurs have been likened to the high-pitched wail of the engine's whistle.

1. **Systolic ejection murmurs (SEMs).** SEMs begin after the semilunar (aortic and pulmonic) valves open at the end of isovolumic systole. Their intensity parallels the amount of blood being ejected through the stenosis, peaking in mid-systole. SEMs arise in the following settings: (a) aortic or pulmonic stenosis, (b) dilatation of the aorta or pulmonary artery distal to the valve, (c) increased rate of ventricular ejection (heart block, fever, anemia, exercise, thyrotoxicosis), and (d) normal individuals.
2. **Pansystolic murmurs.** Pansystolic murmurs occur when blood flows through a ventricular septal defect, or retrograde through the mitral or tricuspid valve. The even intensity and long duration of these murmurs reflect the large pressure difference across the orifice where the sound originates. The murmur continues as long as pressure in the chamber of origin exceeds that in the recipient chamber.
3. **Early and late systolic murmurs.** Early systolic murmurs begin with or shortly after S_1 and end by mid-systole. They have been reported in (a) mitral stenosis (etiology unclear, either coexistent mitral regurgitation or distortion of the mitral valve apparatus), (b) small ventricular septal defects, and (c) individuals without cardiac disease.
Late systolic murmurs begin in mid-systole and extend to or through S_2 . They may be heard in (a) mitral valve prolapse (frequently accompanied by mid-systolic clicks) or (b) coarctation of the aorta.
4. **Summary.** Figure 1-1 summarizes systolic murmurs. Systolic murmurs arising from the right side of the heart generally increase with inspiration while those originating on the left side decrease. Many systolic murmurs are totally innocent (as in pregnant women, growing children, and individuals with abnormal chest configuration).

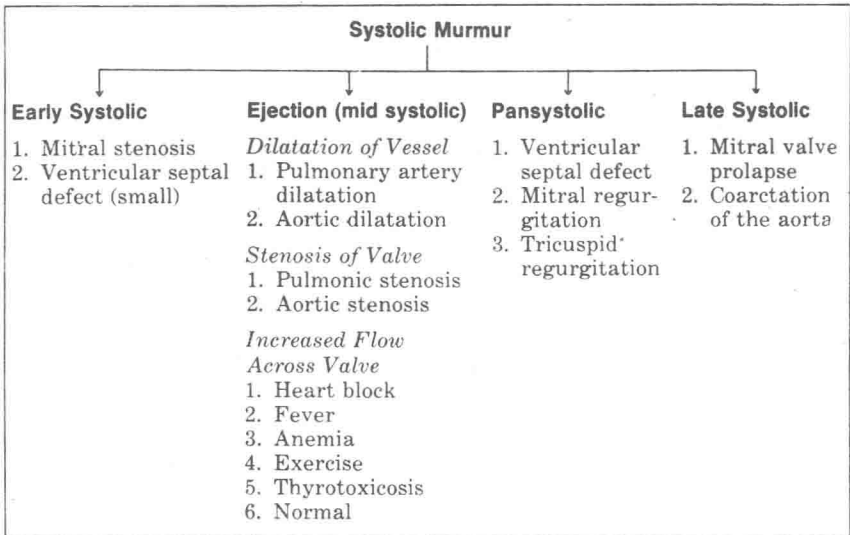


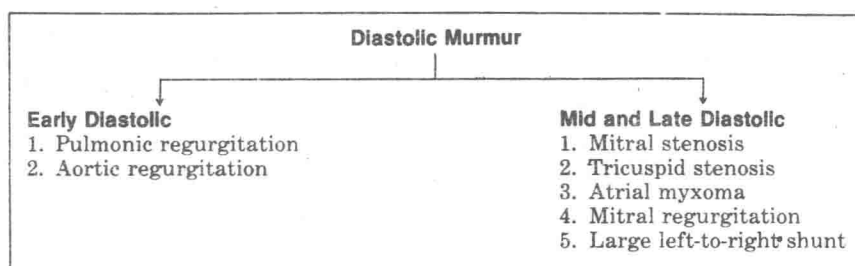
Figure 1-1. Differential diagnosis of systolic murmurs

G. Diastolic murmurs. Diastolic murmurs are classified according to their position in diastole as early, mid, or late. An alternative classification emphasizes etiology: regurgitant murmurs from semilunar insufficiency versus ventricular filling murmurs. Regurgitant murmurs are generally early diastolic whereas ventricular filling murmurs occur in mid and late diastole.

- 1. Early diastolic murmurs.** Early murmurs begin immediately after S_2 . The most common causes are aortic or pulmonic valve regurgitation. The murmur is usually high-pitched and blowing in quality with a decrescendo configuration. The intensity of the murmur reflects the size of the valvular leak, the acoustic properties of the chest, and the pressure difference across the valve. The distinction between pulmonic and aortic regurgitation may be extremely hard to make and may require catheterization for definitive determination.
- 2. Mid and late diastolic murmurs.** Mid and late diastolic murmurs are produced by forward flow of blood through the atrioventricular (mitral and tricuspid) valves. They arise from either augmented blood flow or a stenosed valve. As a rule the murmur is low-pitched and rumbling in quality. It does not begin until the valve from which it originates opens (sometimes with an audible snap) and ventricular pressure has fallen below atrial pressure in early diastole. Conditions in which mid or late diastolic murmurs may arise include (a) mitral or tricuspid stenosis, (b) left atrial myxoma, (c) mitral regurgitation (increased flow), and (d) large left-to-right shunts (increased flow).

A summary of murmurs that may occur in diastole is found in Figure 1-2.

H. Continuous murmurs. Murmurs are considered continuous when they are audible throughout all phases of the cardiac cycle. They generally arise when a continuous pressure differential allows blood to flow constantly from a high to a low pressure area, as may occur in a variety of congenital defects, most commonly patent ductus arteriosus.

**Figure 1-2.** Differential diagnosis of diastolic murmurs**Table 1-6.** Manipulation of Heart Sounds and Murmurs

Maneuver	Physiological Consequence	Comment
Physiological maneuvers		
Respiration	Inspiration: right-heart filling increased, left-heart filling decreased	Right-heart murmurs increased; left-heart murmurs decreased
Rapid changes in position (e.g., elevation of legs, standing, squatting)	Mechanical changes; changes in right ventricular filling (RV filling increased by lying, leg elevation, or squatting; venous return decreased by standing)	Gallop sounds, murmurs of pulmonic and aortic stenosis, all increased by lying, leg elevation, or squatting; IHSS murmur increased by standing
Valsalva maneuver	Initially causes sharp rise in blood pressure (phase I), then impairs venous return and blood pressure drops (phase II)	During phase II, murmurs of pulmonic and aortic stenosis and mitral regurgitation diminish while murmurs of IHSS increase
Pharmacological maneuvers		
Phenylephrine	Raised systemic arterial pressure	Murmur of aortic regurgitation and mitral regurgitation increased
Isoproterenol	Increased myocardial contraction	Murmur of IHSS increased
Amyl nitrite	Potent vasodilator; decreased systolic pressure; reflex increase in heart rate	Murmurs of aortic and mitral regurgitation decreased; all ejection murmurs increased; VSD murmur decreased

Table 1-7. Maneuvers for Analysis of Heart Sounds and Murmurs

Condition	Maneuver
Aortic stenosis	Valvular: mid-systolic murmur louder with sudden squatting, leg raising, or amyl nitrite; fades during Valsalva maneuver Hypertrophic subvalvular: systolic murmur louder with sitting or squatting, during Valsalva maneuver, or with amyl nitrite; softens with sudden squatting or leg elevation
Aortic regurgitation	Blowing diastolic murmur increases with sudden squatting, fades with amyl nitrite Austin Flint murmur fades with amyl nitrite
Mitral stenosis	Diastolic murmur made louder with tachycardia, exercise, left lateral position, coughing, or amyl nitrite
Mitral regurgitation	Rheumatic: systolic murmur louder with sudden squatting, softer with amyl nitrite Mid to late systolic mitral valve prolapse: late systolic murmur becomes mid or holosystolic with upright position, with amyl nitrite, and during Valsalva maneuver; mid-systolic click occurs earlier with these maneuvers; murmur fades with lying flat
Pulmonic stenosis	Mid-systolic murmur increases with amyl nitrite, except with marked right ventricular hypertrophy; also may increase with first few beats after Valsalva release
Pulmonic regurgitation	Congenital: early or mid-diastolic murmur (harsh, low-pitched) increases on inspiration and with amyl nitrite Pulmonary hypertensive: high-frequency early diastolic blowing murmur not influenced by respiration; inconstant response to amyl nitrite
Tricuspid stenosis	Mid-diastolic and presystolic murmurs increase during inspiration and with amyl nitrite
Tricuspid regurgitation	Systolic murmur increases during inspiration and with amyl nitrite
Ventricular septal defect	Small defect without pulmonary hypertension: murmur fades with amyl nitrite Large defect with hyperkinetic pulmonary hypertension: murmur louder with amyl nitrite Large defect with severe pulmonary vascular disease: little change with above agents
Gallop rhythm	Ventricular filling sounds: ventricular gallop and atrial gallop are accentuated by lying flat with passive leg raising; decreased by sitting or standing; right-sided gallop sounds usually increased during inspiration, left-sided during expiration Summation gallop may separate into ventricular gallop (S ₃) and atrial gallop (S ₄) sounds when heart rate slowed by carotid sinus massage
Ejection sounds	Ejection sound in pulmonic stenosis fades and occurs closer to S ₁ during inspiration

Source: Adapted from Dohan MC, Criscitiello MG: Physiological and pharmacological manipulations of heart sounds and murmurs. *Mod Concepts Cardiovasc Dis* 39:121, 1970, with permission of the author and the American Heart Association.