Does This Patient Have Aortic Regurgitation?

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CLINICAL SCENARIO
You are asked to see a 59-year-old woman with liver cirrhosis who will be undergoing sclerotherapy for esophageal varices. When she was examined by her primary care physician, she had a pulse pressure of 70 mm Hg. The primary care physician is concerned about the possibility of aortic regurgitation (AR) and asks you whether endocarditis prophylaxis is necessary for sclerotherapy. You conduct a complete physical examination and hear no early diastolic murmur in the third or fourth intercostal spaces at the left-sternal border.

WHY IS THE CLINICAL EXAMINATION IMPORTANT IN EVALUATING FOR AR?
Aortic regurgitation is a potentially serious cardiac abnormality that may be caused by important underlying disorders. Patients with AR require careful clinical monitoring to identify the optimal time for surgical intervention. Asymptomatic patients with severe AR may benefit from vasodilator therapy. Endocarditis prophylaxis may be indicated for patients with AR who are undergoing various procedures.

The use of noninvasive cardiac testing, such as echocardiography, has increased in recent years. It is estimated that 2% of the general population undergoes noninvasive cardiac diagnostic evaluation annually. If a careful clinical examination can exclude the presence of AR, then there would be no need to proceed with further cardiac evaluation.

Anatomical and Physiological Origins of Diastolic Murmurs
The cardinal manifestation of AR is a diastolic murmur. Diastolic murmurs are important indicators of structural cardiac abnormalities or pathological states of increased flow (TABLE 1). As discussed in a previous article in this series, heart murmurs are produced when turbulent blood flow causes prolonged auditory vibrations of cardiac structures. The intensity of the murmur depends on many factors, including blood viscosity, blood flow velocity and turbulence, the distance between the vibrations and the stethoscope, the angle at which the vibrations meet the stethoscope, the transmission qualities of the tissue between the vibration and the stethoscope, and the auditory capabilities of the examiner.

How to Examine for AR
A complete clinical history and physical examination are essential in the evaluation of aortic regurgitation. The cardinal manifestation of AR is a diastolic murmur. Diastolic murmurs are important indicators of structural cardiac abnormalities or pathological states of increased flow (TABLE 1).

Objective To review evidence as to the precision and accuracy of clinical examination for aortic regurgitation (AR).

Methods We conducted a structured MEDLINE search of English-language articles (January 1966-July 1997), manually reviewed all reference lists of potentially relevant articles, and contacted authors of relevant studies for additional information. Each study (n = 16) was independently reviewed by both authors and graded for methodological quality.

Results Most studies assessed cardiologists as examiners. Cardiologists’ precision for detecting diastolic murmurs was moderate using audiotapes (κ = 0.51) and was good in the clinical setting (simple agreement, 94%). The most useful finding for ruling in AR is the presence of an early diastolic murmur (positive likelihood ratio [LR], 8.8-32.0 [95% confidence interval (CI), 2.8-32 to 16-63] for detecting mild or greater AR and 4.0-8.3 [95% CI, 2.5-6.9 to 6.2-11] for detecting moderate or greater AR) (2 grade A studies). The most useful finding for ruling out AR is the absence of early diastolic murmur (negative LR, 0.2-0.3 [95% CI, 0.1-0.3 to 0.2-0.4] for mild or greater AR and 0.1 [95% CI, 0.0-0.3] for moderate or greater AR) (2 grade A studies). Except for a test evaluating the response to transient arterial occlusion (positive LR, 8.4 [95% CI, 1.3-81.0]; negative LR, 0.3 [95% CI, 0.1-0.8]), most signs display poor sensitivity and specificity for AR.

Conclusion Clinical examination by cardiologists is accurate for detecting AR, but not enough is known about the examinations of less-expert clinicians.
evaluation of patients with a diastolic murmur. A diastolic murmur in a patient with renal failure and volume overload will have different significance than a diastolic murmur in a patient with a history of rheumatic fever and atrial fibrillation.

The examiner’s ability to detect a diastolic murmur can be undermined by environmental factors such as noisy rooms, examiner factors such as fatigue or haste, and patient factors such as dyspnea or tachycardia. If examining conditions are not optimal, the examination should be repeated when conditions improve.

The precision and accuracy of many individual components of the examination for AR, including all of the cardiac history and most of the physical examination, have not been adequately evaluated. This article will focus on aspects of the cardiac physical examination that have been sufficiently assessed for precision or accuracy.

Cardiac Auscultation

During routine auscultation, the examiner attempts to detect a diastolic murmur. Diastole is the period that begins with the closure of the aortic and pulmonic valves (second heart sound \([S_2]\)) and ends with the closure of the mitral and tricuspid valves (first heart sound \([S_1]\)). A common maneuver used to identify diastole is to palpate the carotid artery pulse during auscultation; \(S_1\) is synchronous with the carotid artery pulsation while \(S_2\) follows the pulse. A diastolic murmur is a diastolic sound longer than a heart sound. Examiners should describe the grade, location of maximal intensity (FIGURE 1), timing (FIGURE 2), duration, pitch, and radiation of the murmur.

The Levine grading system, with slight modifications, was developed for auscultation but is heard after the examiner focuses for a few seconds. Grade 1 murmur is not heard immediately on auscultation, but is heard after the examiner focuses for a few seconds. Grade 2 murmurs are heard immediately on auscultation but are softer than the loud grade 3. Grade 4 murmurs are associated with a palpable precordial vibration called a thrill. (Grade 5 and 6 murmurs are also associated with a thrill. A grade 5 murmur is audible when only 1 edge of the stethoscope is on the chest, and a grade 6 murmur is audible with the entire stethoscope lifted off the chest.)

The typical murmur of AR is an early diastolic, decrescendo blowing sound (Figure 2), which may be accentuated with the patient sitting upright and leaning forward. In some cases, \(S_2\) can be obscured by the murmur. Most AR murmurs are high pitched and are best heard with the diaphragm of the stethoscope placed firmly on the chest wall. Some AR murmurs are low pitched and are better heard with the bell of the stethoscope placed lightly on the chest wall. For example, the AR murmur associated with endocarditis and a fenestrated aortic valve can be low pitched.

The examiner should apply the stethoscope to the chest wall in the third or

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**Table 1. Selected Causes of Diastolic Murmurs**

<table>
<thead>
<tr>
<th>Abnormal cardiac structure</th>
<th>Aortic regurgitation</th>
<th>Mitral stenosis</th>
<th>Pulmonic regurgitation</th>
<th>Tricuspid stenosis</th>
<th>Atrial myxoma</th>
<th>Ventricular septal defect*</th>
<th>Atrial septal defect*</th>
<th>Mitral regurgitation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal cardiac structure, increased flow</td>
<td>Renal failure with volume overload</td>
<td>Thyrotoxicosis</td>
<td>Anemia</td>
<td>Sepsis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Diastolic murmurs are caused by abnormally increased diastolic flow across the mitral or tricuspid valves.

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**Figure 1. Typical Location of Abnormal Diastolic Murmurs**

There are 3 important areas to auscultate for diastolic murmurs. Area 1 is the second and third intercostal spaces at the right-sternal border. Area 2 is the second and fourth intercostal spaces at the left-sternal border. Aortic regurgitation murmurs may be heard in both areas 1 and 2. If the murmur is loudest in area 1, then the underlying cause of aortic regurgitation may be an ascending aortic aneurysm or aortic dissection. Pulmonic regurgitation murmurs are loudest in the superior part of area 2, and may radiate downward. The murmur of mitral stenosis and the first murmur of aortic regurgitation are best heard at the apex (area 3).
fourth intercostal space at the left sternal border and listen while the patient stops his/her breath at end of expiration. The patient should not hold his/her breath because he/she may inadvertently do a Valsalva maneuver. If the murmur is louder at the second to third right intercostal space, the underlying cause of AR may be an ascending aortic aneurysm or aortic dissection.10

Aortic regurgitation also may be associated with a systolic murmur,11 which results from the flow of an abnormally large volume of blood through a nonstenotic aortic valve or a bicuspid aortic valve. The murmur is an early peaking, crescendo-decrescendo systolic sound that is best heard with the diaphragm of the stethoscope applied to the second-right intercostal space.

The Flint murmur is a low-pitched late-diastolic apical murmur, which is associated with AR. The murmur is likely produced when the regurgitant jet of blood collides with the left ventricular endocardium.12 The murmur may have a mid-diastolic component, but the original description by Flint referred only to “presystolic blubbering.”13 It is best heard with the diaphragm of the stethoscope placed at the apex soon after moving the patient into the left-lateral decubitus position. This will both bring the left ventricle closer to the chest wall and serve as a form of exercise, which will increase flow across the mitral valve and, therefore, increase the intensity of the murmur.10 The murmur of mitral stenosis may be inaudible in patients with low cardiac output. The S1 may be increased in intensity in mitral stenosis.14 A normal S1 is best appreciated near the apex where it should be louder than S2. The S1 is normally softer than S2 in the second-right and second-left intercostal spaces adjacent to the sternum. If S1 is as loud as or louder than the S2 in these areas, then the S1 is increased in intensity.

An OS is a high-frequency early diastolic sound that is associated with the opening of a stenotic mitral valve. It occurs 50 to 100 milliseconds after the aortic valve component (A2) of S2 and is best heard in the area from the left sternal border to the apex. Much like the murmur of mitral stenosis, it may be accentuated by listening to the patient in the left-lateral decubitus position shortly after the patient has performed exercise. The A2-OS interval shortens with increasing severity of mitral stenosis. The OS may be absent in the case of a heavily calcified immobile mitral valve. It is often difficult to differentiate an OS from the P2 of S2. The OS usually decreases in intensity with inspiration and S2-OS interval widens on standing. Conversely, P2 becomes louder with inspiration and the A2-P2 interval remains the same or narrows with standing.14 Additionally, P2 is not expected to be heard at the apex unless the patient has pulmonary hypertension.

Mitrval stenosis is associated with a mid-diastolic decrescendo low-frequency rumble, which, if the patient is in sinus rhythm, may be followed by late-diastolic (presystolic) crescendo that ends with the mitral component of S1 (Figure 2). It is best heard using the bell of the stethoscope placed at the apex soon after moving the patient into the left-lateral decubitus position. This will both bring the left ventricle closer to the chest wall and serve as a form of exercise, which will increase flow across the mitral valve and, therefore, increase the intensity of the murmur.10 The murmur of mitral stenosis may be inaudible in patients with low cardiac output.

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Maneuvers
Selective use of maneuvers can enhance the detection and interpretation of diastolic murmurs. There is no point in doing maneuvers if a loud AR murmur has been detected during routine auscultation. However, if the clinician is unsure about the presence of a faint diastolic murmur, then a maneuver that increases murmur intensity may clarify the situation. If the clinician has a heightened suspicion for AR (eg, after hearing an aortic ejection sound), or if examining conditions are not optimal, then a maneuver to augment murmur intensity might bring out an otherwise inaudible murmur. Finally, if the clinician is unsure whether a murmur represents PR or AR, then these maneuvers may help distinguish between the 2. In this latter situation, the clinician should listen where the murmur is just barely audible, so that it is easy to detect a decrease or increase in murmur intensity during the maneuver.

Quiet inspiration increases venous return and is intended to augment rightsided heart murmurs such as PR. To determine the effect of inspiration on the intensity of the murmur, the examiner should listen during quiet inspiration rather than asking the patient to breathe deeply, as the murmur may be obscured by breath sounds.

Transient arterial occlusion primarily increases systemic arterial resistance that results in an intensification of left-sided regurgitant lesions such as AR and may help distinguish the murmur from that of PR. To perform this maneuver, sphygmomanometers are placed around both of the patient’s arms and are inflated to 20 to 40 mm Hg above the previously recorded systolic blood pressure. Any changes in murmur intensity are noted 20 seconds after cuff inflation.16

Peripheral Hemodynamic Signs
There are a variety of peripheral hemodynamic signs traditionally associated with AR. Some of these signs have been adequately evaluated, including de Musset head bobbing sign,17 a wide pulse pressure,18 the brachial-popliteal pulse gradient (Hill sign),19 Duroziez femoral murmur,17 the femoral pistol shot murmur,19 and Corrigan water hammer pulse.20 The de Musset head bob-
bing sign consists of a forward shaking of the head with every heartbeat; it is best observed in patients who are sitting.  

Pulse pressure refers to the difference between systolic and diastolic blood pressures. A widened pulse pressure may be defined as greater than 50 mm Hg.21 Other definitions include a pulse pressure greater than 50% of the systolic pressure.22 Determination of the blood pressure has been described in another article in this series.22

The brachial-popliteal pulse gradient (Hill sign) can be defined as a systolic blood pressure in the lower extremities that is at least 20 mm Hg higher than that in the arms.21 To determine a popliteal blood pressure, an appropriately sized blood pressure cuff should be placed on the patient’s thigh14 with the artery marker over the popliteal artery; the cuff should be inflated and the systolic pressure can then be determined in the popliteal fossa either by palpation, as judged by the point where the pulse reappears as the cuff is deflated, or by auscultation, listening for Korotkoff sounds to appear. Both the brachial and popliteal blood pressures should be measured while the patient is supine. The average of repeated readings should be used, especially in patients with irregular heart rates, such as atrial fibrillation.

Duroziez double intermittent femoral bruit is elicited by first gently compressing the femoral artery with the diaphragm of the stethoscope. This will yield a systolic bruit in all patients. As increasing pressure is applied to the diaphragm, an early diastolic bruit will become audible in patients with AR. While listening to the diastolic bruit, the stethoscope should then be tilted such that the distal rim (closest to the patient’s feet) is compressing the femoral artery. If the bruit becomes louder with this maneuver then the diastolic bruit is due to the retrograde flow of blood toward the heart in AR. The diaphragm should then be tilted such that the proximal rim (closest to the patient’s head) is compressing the femoral artery. If the diastolic bruit becomes softer, this can be taken as supportive evidence of the presence of retrograde blood flow. If, however, the bruit becomes louder with proximal pressure (and softer with distal pressure), then this sign should not be used as evidence of AR but may indicate the presence of a high-flow state such as renal failure with volume overload.23

Femoral pistol shot sounds are elicited by auscultating with the diaphragm of the stethoscope over the femoral arteries. A high-pitched pistol shot sound may be heard in AR. Corrigan water hammer pulse refers to an increased volume and rate of rise of the radial pulse when the wrist is elevated perpendicular to the body of a supine patient. The radial pulse should first be assessed while the patient is lying supine with his/her arms resting at the sides. Sufficient pressure should be applied to obliterate the pulse. While maintaining this pressure, the patient’s arm should be elevated such that it is perpendicular to the plane of the body. In AR, the pulse will become palpable despite applying an equivalent amount of pressure as when the arm was at the patient’s side.

Other peripheral hemodynamic signs, such as Mayne sign (a decrease in diastolic blood pressure of 15 mm Hg when the arm is held above the head compared with when the arm is held at the level of the heart),24 Quincke capillary pulsation, Muller pulsatile uvula, and Rosenbach liver pulsation, have not been adequately evaluated for precision or accuracy.

METHODS

To identify articles pertaining to the precision and accuracy of the physical examination for AR, we used standard methods for conducting research overviews.25 Our data collection strategy involved 3 steps and was deliberately broad to reduce the possibility of overlooking important articles. First, we searched MEDLINE for English-language articles from 1966 through July 1997 using a structured search strategy (available on request from the authors). Second, we manually reviewed potentially relevant articles and their reference lists. Third, we contacted the authors of relevant studies for additional information. Studies were excluded if they were review articles, involved patients younger than 18 years, or were of low quality (author’s opinion).

Studies were independently reviewed for the presence of the physical examination findings of interest. Studies were independently reviewed for the presence of the physical examination findings of interest. Studies were independently reviewed for the presence of the physical examination findings of interest. Studies were independently reviewed for the presence of the physical examination findings of interest.
different physicians (interobserver) or between multiple assessments by the same physician (intraobserver). The precision of the clinical examination for diastolic murmurs has been evaluated in usual clinical situations by auscultating patients or in controlled nonclinical circumstances by listening to recorded audiotapes (Table 2).29

There have been 4 studies that address the interobserver precision of cardiac auscultation to detect diastolic murmurs (Table 2). While simple agreement is high in these studies, the 1 study for which it was possible to calculate agreement adjusted for chance (κ) showed only moderate agreement. The experience of observers likely affects precision. The 1 study29 that compared cardiologists with noncardiologists found a higher simple agreement for cardiologists.

The interobserver agreement between examiners on the intensity of heart sounds is excellent (92%).30 In this study, examiners progressively inserted 0.5-mm-thick paper disks between the patient’s chest and the stethoscope. The total thickness of the disks was used as a measure of heart sound intensity. Murmur intensity was also assessed using this technique (Table 2).

**The Bottom Line for Precision**

The interobserver precision of cardiologists examining for any diastolic murmur is moderate using audiotapes (κ = 0.51) and good in the clinical setting (simple agreement, 94%). Noncardiologists may be less precise than cardiologists. The precision of examining for the intensity of murmurs and heart sounds using a standardized series of paper disks to assess intensity is good (simple agreement, 92%-96%).

**Accuracy of the Examination for AR**

We consider Doppler echocardiography and cardiac catheterization to be acceptable reference standards for AR (Table 3). In 1 study, the reference standard was open-heart surgery. Some studies explicitly graded the severity of AR detected by the reference standard (for example, on the basis of the absolute height of the regurgitant jet or the ratio of the height of the jet to the height of the left ventricular outflow tract on Doppler echocardiography), which allowed us to calculate LRs for detecting both mild (or worse) and moderate (or worse) AR.

Cardiologists conducted the clinical examinations in most studies. Too few studies, using few patients, allow for reasonable estimates of the accuracy of noncardiologists, although noncardiologists are likely less adept at detecting the diastolic murmur of AR. Approximately 20% of residents and medical students correctly identified the murmur of AR on high-fidelity digitized audiotapes, while 46% of internal medicine residents correctly identified an AR murmur using a patient simulator.33

The best-studied physical finding is the typical early diastolic murmur of AR.44-47 If an examiner does not hear a typical AR murmur then the likelihood that the patient has moderate or greater AR is significantly reduced (negative LR, 0.1 for grade A studies); the likelihood of mild or greater AR is also significantly reduced (negative LR, 0.2-0.3 for grade A studies).44,45

If an examiner hears the typical AR murmur, the likelihood that the patient has moderate or greater AR is increased (positive LR, 4.0-8.3 for grade A studies); the likelihood of mild or greater AR is also significantly increased (positive LR, 8.8-32.0 for grade A studies).44,45

The intensity of the murmur correlates with the severity of echocardiographic AR. Desjardins et al29 studied 40 patients with echocardiographic AR, including 17 with severe AR. A grade 3 diastolic murmur had an LR of 4.5 (95% CI, 1.6-14.0) for distinguishing severe AR from less severe AR, while a grade 2 murmur had an LR of 1.1 (95% CI, 0.5-2.4), a grade 1 murmur had an LR of 0.0 (95% CI, 0.0-0.9), and absence of a diastolic murmur had an LR of 0.0 (95% CI, 0.0-1.1).48

Two grade C studies of the Flint murmur and some peripheral hemodynamic findings are reported in Table 3. Grade C studies tend to overestimate diagnostic test accuracy. Despite this tendency, 1 study found that absence of a Flint murmur did not rule out AR (negative LR, 0.5-0.8).49 Another study of patients with mild-to-severe AR only found that a wide pulse pressure or peripheral hemodynamic sign (Duroziez bruit, femoral pistol shots, and Corrigan pulses) was not helpful for distinguishing mild AR from moderate or severe AR.21

One small study (grade C) evaluated peripheral hemodynamic signs in patients exclusively with proven AR of varying severity defined by aortography or surgery. These studies provide an estimate of the sensitivity of the peripheral hemodynamic signs. The de Musset head bobbing sign was seen in only 1 of 20 patients (sensitivity, 5%) and Duroziez femoral bruit was observed in 8 of 12 patients (sensitivity, 67%).17

**The Bottom Line for AR**

When a cardiologist hears the typical murmur of AR, the likelihood of mild or greater AR is increased significantly (2 grade A studies). The absence of a typical diastolic murmur significantly reduces the likelihood of AR (2 grade A studies). Noncardiologists may be less proficient than cardiologists at detecting the murmur of AR.
Mitral Stenosis and PR
In 1 grade A study of 529 unselected nursing home residents (31 with mitral stenosis), a cardiologist detected a mid-diastolic murmur in all cases of mitral stenosis, with no false-positive or negative examinations (W. A. Aronow, MD, written communication, 1997).50 Only 1 patient had an audible OS.

Noncardiologists may be less proficient at detecting the physical findings of mitral stenosis. Less than 10% of residents and medical students correctly identified a mid-diastolic murmur of mitral stenosis on a high-fidelity digitized audiotape,32 while 43% of medical residents identified a mid-diastolic murmur of mitral stenosis using a patient simulator. In the latter study, only 21% identified the OS of mitral stenosis.33

The only evaluated element of the clinical examination for PR is the presence of a typical diastolic decrescendo murmur best audible in the second intercostal space at the left-upper sternal border, which may increase in intensity with quiet inspiration. All studies used cardiologists as examiners and were of poor methodologic quality (grade C).

When a cardiologist hears the murmur of PR, the likelihood of PR increases (positive LR, 17 in both studies), but absence of a PR murmur was not helpful for ruling out PR (LR, 0.9 in both studies).37,43

Table 3. Accuracy of the Physical Examination for Detecting Aortic Regurgitation*

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient Population</th>
<th>Reference Standard</th>
<th>No. of Patients With AR</th>
<th>Positive Likelihood Ratio (95% CI)†</th>
<th>Negative Likelihood Ratio (95% CI)‡</th>
<th>Quality Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aronow and Kronzon,34 1989</td>
<td>Elderly patients</td>
<td>Echocardiography (n = 450)</td>
<td>Mild or greater AR</td>
<td>131 32 (16-63)</td>
<td>0.2 (0.1-0.3)</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>74 8.3 (6.2-11)</td>
<td>0.1 (0.0-0.2)</td>
<td></td>
</tr>
<tr>
<td>Grayburn et al,35 1986</td>
<td>Referred for catheterization</td>
<td>Catheterization (n = 106)</td>
<td>Mild or greater AR</td>
<td>82 8.8 (2.8-32)</td>
<td>0.3 (0.2-0.4)</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>57 4.0 (2.5-6.9)</td>
<td>0.1 (0.1-0.3)</td>
<td></td>
</tr>
<tr>
<td>Roldan et al,36 1996</td>
<td>Asymptomatic connective tissue disease and controls</td>
<td>Echocardiography (n = 143)</td>
<td>Mild or greater AR</td>
<td>10 80 (14-470)</td>
<td>0.4 (0.2-0.7)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>5 69 (18-270)</td>
<td>0.0 (0.0-0.6)</td>
<td></td>
</tr>
<tr>
<td>Rahko,37 1989</td>
<td>Referred for echocardiogram</td>
<td>Echocardiography (n = 403)</td>
<td>Mild or greater AR</td>
<td>134 27 (13-60)</td>
<td>0.4 (0.3-0.5)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>82 12 (8.1-19)</td>
<td>0.2 (0.1-0.3)</td>
<td></td>
</tr>
<tr>
<td>Cohn et al,38 1967</td>
<td>Mitral valve repair</td>
<td>Open-heart surgery (n = 156)</td>
<td>Mild or greater AR</td>
<td>50 5.2 (3.3-8.4)</td>
<td>0.3 (0.2-0.4)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>37 3.9 (2.6-5.7)</td>
<td>0.2 (0.1-0.4)</td>
<td></td>
</tr>
<tr>
<td>Meyers et al,39 1982</td>
<td>Referred for aortography</td>
<td>Catheterization (n = 75)</td>
<td>Mild or greater AR</td>
<td>66 3.3 (1.3-12)</td>
<td>0.4 (0.2-0.7)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>39 1.6 (1.2-2.4)</td>
<td>0.4 (0.2-0.7)</td>
<td></td>
</tr>
<tr>
<td>Dittmann et al,40 1987</td>
<td>Valvular heart disease</td>
<td>Catheterization (n = 55)</td>
<td>Mild or greater AR</td>
<td>42 16 (2.1-155)</td>
<td>0.4 (0.3-0.6)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Severe AR</td>
<td>19 3.6 (2.1-6.6)</td>
<td>0.1 (0.0-0.4)</td>
<td></td>
</tr>
<tr>
<td>Meyers et al,41 1985</td>
<td>Valvular heart disease</td>
<td>Catheterization (n = 20)</td>
<td>Mild or greater AR</td>
<td>11 9.8 (1.3-96)</td>
<td>0.5 (0.2-0.9)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>3 5.7 (1.4-14)</td>
<td>0.0 (0.0-0.9)</td>
<td></td>
</tr>
<tr>
<td>Linhart,42 1971</td>
<td>Mitral stenosis</td>
<td>Catheterization (n = 28)</td>
<td>Mild or greater AR</td>
<td>11 6.2 (1.9-23)</td>
<td>0.3 (0.1-0.7)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>7 7.0 (2.5-20)</td>
<td>0.0 (0.0-1.3)</td>
<td></td>
</tr>
<tr>
<td>Comer et al,43 1986</td>
<td>Mitral valve prolapse, plus patients with systolic flow murmurs</td>
<td>Echocardiography (n = 165)</td>
<td>Mild or greater AR</td>
<td>7 90 (8-982)</td>
<td>0.7 (0.4-0.9)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate or greater AR</td>
<td>32 33 (9.4-120)</td>
<td>0.2 (0.1-0.3)</td>
<td>C</td>
</tr>
<tr>
<td>Nienaber et al,44 1993</td>
<td>Clinically suspected aortic dissection</td>
<td>Echocardiography (n = 110)</td>
<td>Mild or greater AR</td>
<td>49 13 (2.9-75)</td>
<td>0.2 (0.1-0.3)</td>
<td>C</td>
</tr>
<tr>
<td>Ward et al,45 1977</td>
<td>Clinically suspected aortic dissection</td>
<td>Catheterization (n = 65)</td>
<td>Mild or greater AR</td>
<td>24 12 (2.4-67)</td>
<td>0.4 (0.3-0.7)</td>
<td>C</td>
</tr>
<tr>
<td>Esper,46 1982</td>
<td>AR and other heart disease</td>
<td>Echocardiography (n = 43)</td>
<td>Mild or greater AR</td>
<td>35 8.0 (1.9-45)</td>
<td>0.2 (0.1-0.4)</td>
<td>C</td>
</tr>
</tbody>
</table>

*Typical Murmur Without AR Severity Specified (May Include Trivial AR)

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient Population</th>
<th>Reference Standard</th>
<th>No. of Patients With AR</th>
<th>Positive Likelihood Ratio (95% CI)†</th>
<th>Negative Likelihood Ratio (95% CI)‡</th>
<th>Quality Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comer et al,43 1986</td>
<td>Mitral valve prolapse, plus patients with systolic flow murmurs</td>
<td>Echocardiography (n = 165)</td>
<td>Mild or greater AR</td>
<td>7 90 (8-982)</td>
<td>0.7 (0.4-0.9)</td>
<td>C</td>
</tr>
<tr>
<td>Nienaber et al,44 1993</td>
<td>Clinically suspected aortic dissection</td>
<td>Echocardiography (n = 110)</td>
<td>Mild or greater AR</td>
<td>32 33 (9.4-120)</td>
<td>0.2 (0.1-0.3)</td>
<td>C</td>
</tr>
<tr>
<td>Ward et al,45 1977</td>
<td>Clinically suspected aortic dissection</td>
<td>Catheterization (n = 65)</td>
<td>Mild or greater AR</td>
<td>49 13 (2.9-75)</td>
<td>0.2 (0.1-0.3)</td>
<td>C</td>
</tr>
<tr>
<td>Esper,46 1982</td>
<td>AR and other heart disease</td>
<td>Echocardiography (n = 43)</td>
<td>Mild or greater AR</td>
<td>24 12 (2.4-67)</td>
<td>0.4 (0.3-0.7)</td>
<td>C</td>
</tr>
<tr>
<td>Saal et al,47 1985</td>
<td>Mitral stenosis</td>
<td>Catheterization (n = 45)</td>
<td>Mild or greater AR</td>
<td>35 8.0 (1.9-45)</td>
<td>0.2 (0.1-0.4)</td>
<td>C</td>
</tr>
</tbody>
</table>
The Bottom Line for Mitral Stenosis and PR

Presence of a mid-diastolic murmur significantly increases the likelihood of mitral stenosis, while absence of a mid-diastolic murmur significantly reduces the likelihood of mitral stenosis (1 grade A study). When a cardiologist hears a typical PR murmur, the likelihood of PR increases significantly. Absence of a typical murmur does not alter the likelihood of PR (2 grade C studies). Non-cardiologists may be less proficient at detecting the mid-diastolic murmur of mitral stenosis.

Diastolic Murmurs in Patients With Renal Failure

Diastolic murmurs due to abnormal flow states, rather than abnormal cardiac structure, may be associated with a variety of conditions. Renal failure with volume overload is the only abnormal flow state associated with diastolic murmurs that has been evaluated.

Up to 9% of patients with end-stage renal disease have diastolic murmurs, particularly when these patients also have volume overload, anemia, and hypertension. These murmurs typically disappear after the treatment of volume overload, as was demonstrated in 2 small studies (grade C). These murmurs are probably due to transient pulmonary hypertension and dilation of the pulmonary artery root, leading to PR.

The Bottom Line for Diastolic Murmurs in Patients With Renal Failure

Although there is an insufficient amount of data on which to make rigorous recommendations, if an early diastolic murmur is heard in a dialysis patient with volume overload, the patient should be reexamined after treatment because the murmur may disappear.

When to Examine for AR

There are no evaluative data on which to base a recommendation regarding when to examine for AR. Undetected AR may be common in elderly persons: 13% (n = 552) of asymptomatic elderly Finnish persons had moderate or severe echocardiographic AR. Unfortunately, that study does not indicate how many of these patients had audible diastolic murmurs. Audible diastolic murmurs may be relatively uncommon findings in asymptomatic persons. In 1 study only 1% (n = 103) of elderly asymptomatic nursing home residents had an audible diastolic murmur.

Despite the lack of evaluative data, we think that a prudent clinician will examine for AR in most clinical settings. Aortic regurgitation is a serious cardiac abnormality, which may be caused by underlying disorders and may be asymptomatic. The clinician’s suspicion for AR may be heightened by evidence of systemic disease, such as ankylosing spondylitis, a peripheral hemodynamic finding (although these are by no means indicative of underlying AR), or an abnormality detected during routine auscultation (such as an aortic ejection sound). Other findings may suggest different cardiac abnormalities associated with diastolic murmurs, such as evidence of pulmonary hypertension (for PR), a wide-fixed split S₂ (for atrial-septal defect), or a holo-

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### Table 3. Accuracy of the Physical Examination for Detecting Aortic Regurgitation* (cont)

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient Population</th>
<th>Reference Standard</th>
<th>Maneuver</th>
<th>No. of Patients With AR</th>
<th>Positive Likelihood Ratio (95% CI)†</th>
<th>Negative Likelihood Ratio (95% CI)‡</th>
<th>Quality Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>8.4 (1.3-81)</strong></td>
<td><strong>0.3 (0.1-0.8)</strong></td>
<td><strong>C</strong></td>
</tr>
<tr>
<td>With transient arterial occlusion murmur increases in intensity**</td>
<td>Patients with AR, mitral stenosis, and pulmonic regurgitation</td>
<td>Catheterization or echocardiography (n = 16)</td>
<td><strong>10</strong></td>
<td><strong>8.4 (1.3-81)</strong></td>
<td><strong>0.3 (0.1-0.8)</strong></td>
<td><strong>C</strong></td>
<td></td>
</tr>
<tr>
<td>Flint murmur**</td>
<td>Isolated AR and controls</td>
<td>Echocardiography (n = 36)</td>
<td><strong>Mild or greater AR</strong></td>
<td><strong>8 (0.5-40)</strong></td>
<td><strong>0.8 (0.6-1.3)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any systolic murmur**</td>
<td>Isolated AR and controls</td>
<td>Echocardiography (n = 36)</td>
<td><strong>Mild or greater AR</strong></td>
<td><strong>1.3 (0.9-2.7)</strong></td>
<td><strong>0.5 (0.2-1.6)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popliteal-brachial gradient &gt;20 mm Hg**</td>
<td>Mild to severe AR</td>
<td>Catheterization (n = 33)</td>
<td><strong>Mild or greater AR</strong></td>
<td><strong>1.5 (1.0-2.1)</strong></td>
<td><strong>0.0 (0.0-1.0)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral hemodynamic signs†‡§</td>
<td>Mild to severe AR</td>
<td>Catheterization (n = 34)</td>
<td><strong>Mild or greater AR</strong></td>
<td><strong>2.1 (0.3-22)</strong></td>
<td><strong>0.8 (0.7-1.7)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse pressure &gt;50 mm Hg**</td>
<td>Mild to severe AR</td>
<td>Catheterization (n = 33)</td>
<td><strong>Mild or greater AR</strong></td>
<td><strong>1.0 (0.7-2.2)</strong></td>
<td><strong>0.9 (0.2-5.5)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*AR indicates aortic regurgitation; CI, confidence interval.
†The applicable likelihood ratio when the finding is present.
‡The applicable likelihood ratio when the finding is absent.
§Grade B study except catheterization results not interpreted independently of clinical findings.
∥Grade B study except echocardiogram not interpreted independently of clinical findings.
¶Included Duroziez bruit, femoral pistol shots, and Corrigan pulses.
systolic apical murmur (for mitral regurgitation).

**Recommendations for Further Research**

Most studies used cardiologists to conduct clinical examinations. There are some data that suggest that noncardiologists may be less accurate than cardiologists, so studies evaluating techniques to improve the skills of noncardiologists are needed. There are also no studies defining the optimal examination technique for detecting the AR murmur.

**SCENARIO RESOLUTION**

Your patient, who will be undergoing sclerotherapy for esophageal varices, has a wide pulse pressure but no typical early diastolic murmur. The likelihood of mild or moderate AR is significantly reduced by the absence of a typical early diastolic murmur (negative LR, 0.1-0.3; 2 grade A studies). You perform transient arterial occlusion and no diastolic murmur appears, which enhances your confidence (negative LR, 0.3). You are confident in your assessment because it was conducted in a quiet room with a comfortable and cooperative patient. You can advise the primary care physician that AR is unlikely and echocardiography is not necessary.

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**Disclaimer:** The views expressed in this article are those of the authors and do not reflect those of any sponsoring or supporting agency.

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**REFERENCES**