Disease, Peripheral Vascular Disease (both upper and lower extremities), and Diseases of the Pulmonary Artery.

This chapter provides a brief overview of principles of cardiovascular assessment. The most recently published guidelines from the American Heart Association and the American College of Cardiology are the primary references used in this chapter. The reader is also encouraged to review other publications from the American Medical Association.[1] Additionally, a brief discussion will be provided on the use of contemporary diagnostic testing, including the use of specific laboratory data such as B-type natriuretic peptide (BNP) and use of myocardial imaging.

4.1 Principles of Assessment

Substantial transformation is apparent throughout this edition of the AMA *Guides*. The reader must read Chapters 1 and 2 in their entirety and must understand the key concepts and philosophy of the *Guides* before attempting to use this chapter. The functional impairment classes have been standardized, and each cardiovascular disease entity will include its own functional impairment table, maintaining a standard format. A new concept, "Burden of Treatment," has been introduced in the Sixth Edition and relates well to impairment ratings from cardiovascular disease. As the data shows, the incidence of death due to coronary artery disease (CAD) is declining; however, secondary to the survival success, the incidence of heart failure (HF) continues to increase. Please note that *heart failure* is the recommended term, as there are many causes of HF, not all of which are congestive. Most disease survivors are therefore receiving treatment and lead productive lives, but absent treatment they would have limited function, leading to greater impairment.

The New York Heart Association (NYHA) functional classification remains a mainstay reference for functional impairment (Table 4-1). It is noteworthy that a more recent, albeit similar, classification has been published by the Canadian Cardiovascular Society for grading of angina pectoris, which can be useful in the angina table.[2]

TABLE 4-1

NYHA Functional Classification of Cardiac Disease[a]

Class	Function of Patients
I	Patients with no limitation of activities; they suffer no symptoms from ordinary activities
II	Patients with slight, mild limitation of activity; they are comfortable with rest or with mild exertion
III	Patients with marked limitation of activity; they are comfortable with rest or with mild exertion
IV	Patients who should be at complete rest, confined to bed or chair; any physical activity brings on discomfort and symptoms occur at rest

[a] A functional and therapeutic classification of physical activity for cardiac patients.

Source: New York Heart Association. Heart Failure Society of America

4.1a Exercise Testing

Functional capacity is objectively determined and should be used for impairment ratings. There are several standard exercise protocols, which estimate energy expenditure (METs). Table 4-2 outlines the usual treadmill protocols. Although METs may be estimated from treadmill testing, it is preferable to measure energy expenditure using a metabolic system that employs protocols such as bicycle ergometry (Table 4-3). In addition to functional capacity based on exercise protocols, most stress testing is combined with myocardial imaging. Myocardial perfusion imaging uses nuclear isotopes to evaluate perfusion defects in the myocardium, representing previous infarction or current myocardial ischemia. Myocardial perfusion imaging when used with stress testing provides additional evidence for the degree of myocardial damage or ischemia.[3,4] Stress echocardiography is also an objective measure that could be used as an alternative.[2-4] Stress testing is preferably accomplished by exercise, but when needed, pharmacologic-induced testing can be employed.

4.1b Left Ventricular Function Evaluation

Left ventricular function is an important component in assessing impairment in an individual with virtually any form of cardiac assessment. It is equally important to recognize that both systolic and diastolic dysfunction can lead to HF. Both systolic and diastolic dysfunction may be measured and quantified by standard echocardiography.[5]

Left ventricular ejection fraction (LVEF), a measure of systolic function, is the percentage of blood contained in the ventricle at end diastole that is ejected in systole. Ejection fraction (EF) may be measured by echocardiography, radionuclide angiography (multiple gated acquisition, or MUGA), left ventriculography during diagnostic left-sided heart catheterization, computed tomography (CT), and cardiac magnetic resonance imaging (MRI). An EF is considered normal if it is greater than 50%. Ejection fraction values can be described as mild dysfunction of 41% to 50%, moderate dysfunction of 30% to 40%, and severe dysfunction of less than 30%.

Both diastolic and systolic dysfunction can result in significant difficulties, which may range from mild dyspnea to pulmonary edema. Quantifying the degree of diastolic dysfunction can be problematic; however, it is manifest clinically as symptoms of HF in the face of normal systolic function and no significant valvular disease. Standard imaging protocols utilizing both 2-dimensional and Doppler imaging can now identify diastolic dysfunction with clear criteria.[6,7]

TABLE 4-2

Relationship of METs and Functional Class According to 5 Treadmill Protocols[a]

METS	1.6	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TREADMILL TESTS																
Ellestad																
Miles per hour					1.7	3.0				4.0						5.0
% grade					10	10				10						10
Bruce																
Miles per hour					1.7		2.5			3.4				4.2		
% grade					10		12			14				16		
Balke																
Miles per hour				3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
% grade				2	4	6	8	10	12	14	16	18	20	22	24	26
Balke																
Miles per hour			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0				
% grade			0	2.5	5	7.5	10	12.5	15	17.5	20	22.5				
Naughton																
Miles per hour	1.0	2.0	2.0	2.0	2.0	2.0	2.0									
% grade	0	0	3.5	7	10.5	14	17.5									
METS	**1.6**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
CLINICAL STATUS																
Symptomatic patients	←						→									
Diseased, recovered		←					→									
Sedentary healthy				←						→						
Physically active					←											→
Functional class	IV	←	III	→	←	II →	←				I and Normal					→

[a] Adapted from: Fox SM III, Naughton JP, Haskell WL. Physical activity and the prevention of coronary heart disease. *Ann Clin Res*. 1971;3:404–432.

TABLE 4-3

Energy Expenditure in METs During Bicycle Ergometry[a]

Body Weight		Work Rate on Bicycle Ergometer, kg m min^{-1} (W)												
kg	(lb)	75	150	300	450	600	750	900	1050	1200	1350	1500	1650	1800
(12)	(25)	(50)	(75)	(100)	(125)	(150)	(175)	(200)	(225)	(250)	(275)	(300)		
20	(44)	4.0	6.0	10.0	14.0	18.0	22.0							
30	(66)	3.4	4.7	7.3	10.0	12.7	15.3	17.9	20.7	23.3				
40	(88)	3.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0		
50	(110)	2.8	3.6	5.2	6.8	8.4	10.0	11.5	13.2	14.8	16.3	18.0	19.6	21.1
60	(132)	2.7	3.3	4.7	6.0	7.3	8.7	10.0	11.3	12.7	14.0	15.3	16.7	18.0
70	(154)	2.6	3.1	4.3	5.4	6.6	7.7	8.8	10.0	11.1	12.2	13.4	14.0	15.7
80	(176)	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0
90	(198)	2.4	2.9	3.8	4.7	5.6	6.4	7.3	8.2	9.1	10.0	10.9	11.8	12.6
100	(220)	2.4	2.8	3.6	4.4	5.2	6.0	6.8	7.6	8.4	9.2	10.0	10.8	11.6
110	(242)	2.4	2.7	3.4	4.2	4.9	5.6	6.3	7.1	7.8	8.5	9.3	10.0	10.7
120	(264)	2.3	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0	8.7	9.3	10.0

[a] Source: American College of Sports Medicine. *Guidelines for Graded Exercise Testing and Exercise Prescription*. Philadelphia, Pa: Lea & Febiger; 1975:17.

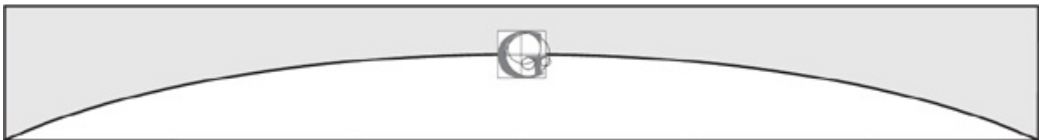
A recent laboratory test has been developed that is useful for determining the presence or absence of HF. B-type natriuretic peptide or the closely related N-terminal pro-B-type natriuretic peptide (NT-proBNP) is released when ventricular wall tension is increased. Clinically, the value is used to determine whether shortness of breath is, in fact, due to actual congestive HF (CHF) or to other processes.[8-10] Assays for BNP vary for each laboratory. The BNP also varies by age, sex, and body size. The degree of elevation needs to be assessed in the context of the normal values for each particular laboratory. The BNP level is now included in the impairment tables as an objective measure of active HF.

Methodology for Determining the Grade in an Impairment Class

This chapter employs impairment grids for use in determining the appropriate impairment class (class) and severity grade (grade) in a class for the condition or conditions being rated at *Maximum Medical Improvement (MMI)*. As was stated in Chapter 1, the decision regarding which key factor is the primary determinant of impairment will be clearly stated for each organ system impairment grid selected. The examiner will use this key factor to determine the appropriate class. Once the class has been determined, based on this key factor, the final impairment grade in that class must then be determined by non-key factors, and it is not possible to move upward or downward between classes based on these non-key factors. For most impairment rating scenarios, the middle grade (integer) in a class will serve as the initial (default) rating (Table 4-4).

In many situations, the examiner will then use the non-key factors to determine the grade as being either a higher or lower severity than the default. For each impairment rating grid in this chapter, classes 1 through 4 will include 5 potential grades.

TABLE 4-4 Methodology for Determining the Grade in an Impairment Class



IMPAIRMENT CLASS	CLASS 0	CLASS 1	CLASS 2	CLASS 3	CLASS 4
SEVERITY GRADE (%)		1 2 3 4 5 (A B C D E) ↑ Class 1 Default	6 7 8 9 10 (A B C D E) ↑ Class 2 Default	11 12 13 14 15 (A B C D E) ↑ Class 3 Default	16 17 18 19 20 (A B C D E) ↑ Class 4 Default

In order to consistently determine the appropriate impairment grade for a given class, the following procedure is recommended:

1. Determine the impairment class (IC) first, according to the "key factor" for that particular impairment grid.
2. Default to the middle ("C") grade position for that IC.

3. For the first remaining (non-key) factor, determine the most appropriate IC position and record the number difference to the key factor IC.
4. Repeat step 3 for each remaining (non-key) factor.
5. Summate the IC column differences and add or subtract the final number from the default identified in step 1 to determine the final impairment grade.

To illustrate, if the key factor identifies IC 3 (default to 3C), and non-key factors identify IC 1 and 4, this would produce differences of -2 and +1, respectively. These summate to -1. Subtracting 1 grade from IC/grade 3C gives a final IC/grade of 3B.

In this example, if the non-key factors both identified IC 1, you would summate the diffrerences to -4. Since this procedure does not allow jumping from one IC to a lower (or higher) IC, you would subtract the maximum allowable 2 grades, for a final IC/grade of 3A.

If the key factor indicated class 4C, and both non-key factors were also IC 4, the differences would summate to zero, and IC/grade 4D or 4E would not be possible. In order to correct this deficiency, if the key factor identifies IC 4C, automatically add +1 difference to the value of each non-key factor. For example, if the key factor identifies IC 4, and the first non-key factor was IC 3, the second was IC 4, the differences are -1 and zero. Adding +1 to each of these yields zero and +1, which summates to +1. Consequently, the final IC/grade is 4D.

The process of assigning impairment according to the generic template is as follows:

1. The examiner should note that throughout this chapter the objective test results are used as the primary, or key factor in the impairment rating for the condition, as well-validated functional test measures exist for the cardiovascular system. Using the key impairment factor (objective test results), the patient is assigned an impairment class, with the median as the default position.
2. Each impairment class has a corresponding range of available impairment grades. The examiner should consider the range in each class as divisible into 5 subsections. The first is the lowest impairment rating that could be assigned for the class; the fifth is the highest.
3. The NYHA class is the primary basis for history. For the sake of simplicity and consistency, the authors have elected to use the NYHA classification throughout the various tables. However, it must be recognized that there are other validated functional instruments for cardiovascular disorders, such as the Canadian Cardiovascular Society classification system for angina pectoris,[2] Seattle Angina Questionnaire,[11] and the Minnesota Living With Heart Failure Questionnaire.[12] If examiners opt to use any other assessment tool, they must justify their decision explicitly.
4. When secondary factors such as history, physical exam, or ADLs are reviewed, they move the impairment rating up or down within the same class only if they are

from a different class. The grade level may be moved to reflect the impact of each secondary factor. The impairment rating will never move out of the class to which it was initially assigned by the objective key factor.

For example, a patient has an echocardiogram that places his or her heart disease in class 2. The default, median (midposition) value is 17%. The range of impairment grades is 11% to 23%, with this range being defined by the specific integers of 11, 14, 17, 20, 23. The patient in our hypothetical example has a NYHA class of II. This is in the same class as the objective factor, so there is no change in the rating. The physical examination shows no minimal changes, consistent with a class 1 examination. This examination, being from a lower class than the original objective test, moves the impairment rating down 1 grade, in this case to 14%. The final impairment rating will come from 1 of these 5 integers (they are not an open range of numbers), but the examiner must specifically identify 1 impairment number.

4.2 Valvular Heart Disease

4.2a Criteria for Rating Impairment due to Valvular Heart Disease

Causes of valvular heart disease include calcific or age-related changes, congenital disease, rheumatic disease, and infectious endocarditis. Trauma is rarely a factor. Valvular heart disease may be asymptomatic or may produce signs or symptoms of CHF or dysrhythmia. Left or right ventricular hypertrophy, ventricular dilation, or ventricular dysfunction may occur.

Doppler echocardiography is a noninvasive, effective tool for evaluation of valvular heart disease. Doppler echocardiography estimates valvular gradients to quantify severity of stenosis,[5,13] enables cardiac chamber measurements, and can also help quantify regurgitation. However, the degree of regurgitation is also dependent on the hemodynamic status of the individual, which may vary sequentially between 2 studies.[14] Standard echocardiography and degree of dilation, which are crucial to the evaluation of severity, can be applied to the functional impairment Table 4-5 to formulate an impairment estimate.

Diagnostic left-sided heart catheterization is usually not necessary to evaluate patients with either stenotic or regurgitant valvular heart disease. The main indications for such evaluation would be discrepancies between the clinical presentation or examination and the echocardiographic assessment, if the echocardiographic assessment were technically deficient, or for planned surgical intervention.

Valvular replacement is common for advanced valvular heart disease. Valvular repair is also currently a proven option for many patients and has become the procedure of choice for most patients with isolated mitral valve insufficiency. Valvular operations may result in class 1 or class 2 degrees of impairment.