Cardiovascular Function and Disease in the Elderly

Janice B. Schwartz, M.D.

Cardiac function is altered in an age-related manner and cardiovascular diseases increase with increasing age in North American populations. The purpose of this brief overview is 1) to identify cardiac changes which are characteristic of physiologic aging (i.e., not disease), 2) highlight the altered presentation and modifications of therapy for older patients with common cardiovascular diseases such as hypertension, atrial arrhythmias, and coronary artery disease, and 3) identify cardiovascular diseases and treatments which are unique to older populations.

Cardiovascular changes with Physiologic Aging vs. Disease (see Table for summary)

Rhythm

Heart Rate

Resting heart rate is not generally affected by aging; however, decreased heart rate in response to exercise and stress (esp. beta-adrenergically mediated) is characteristic of healthy aging. The clinical consequence of this is that maximal heart rate on treadmill is decreased (220-age) and the heart rate response to fever, hypovolemia, and postural stress is also decreased with healthy aging. The response to beta-adrenergic blockade (as well as stimulation) is also reduced with healthy aging. Daytime bradycardia with heart rates < 40 bpm and sinus pauses of over 3 seconds are not seen with healthy aging.

Atrioventricular Conduction

The time for conduction through the atrioventricular (AV) node is increased with healthy aging. Therefore, the P-R interval on the ECG increases with age and the upper limit of normal for people >65 is 210-220 milliseconds (not 200 ms). Second and third degree AV block are not normal consequences of aging. Right bundle branch block is seen more frequently in older compared to younger populations but has not been shown to identify increased risk for further conduction abnormalities. A gradual leftward shift of the QRS axis is observed with aging and left anterior hemiblock is seen with increasing frequency in older populations. Isolated left anterior hemiblock is not an independent predictor of cardiovascular morbidity or mortality in otherwise healthy elderly. Combined right bundle branch block and left anterior fascicular block is associated with cardiovascular disease in 75% of older patients and only 25% with this finding have otherwise normal hearts. Left bundle branch block is not associated with normal aging and is associated with cardiovascular disease and risks for cardiac events.

Arrhythmias

Atrial premature contractions increase with age and are frequent in up to 95% of older healthy volunteers at rest and during exercise in the absence of detectable cardiac disease. Atrial fibrillation is usually associated with coronary, hypertensive, valvular, sinus node disease or thyrotoxicosis but may occur in older patients with no other detectable diseases (1/5 of older men and 1/20 of older women with atrial fibrillation). Similarly, isolated and even multiform ventricular ectopy has been reported in up to 80 % of older men and women without detectable cardiac disease.

Cardiac Contractility/ Left Ventricular Function at Rest and During Exercise

In contrast to the decline in skeletal muscle mass seen with aging in healthy populations, left ventricular mass is preserved or increased with age.

Systolic Function

Resting left ventricular systolic function (ejection fraction and/or stroke volume) is not altered by aging in most studies of subjects rigorously screened to exclude coronary artery disease; however, a few studies report declines of stroke volume with sedentary older populations. Cardiac output is equal to stroke volume x heart rate. So, resting cardiac output and left ventricular ejection fraction do not usually decrease with normal aging. Contractile responses to beta-adrenergic responses are decreased with aging. Therefore, exercise cardiac output may be reduced due to both the decrease in maximal heart rate and a limit to the ability to increase contractility (stroke volume) in response to beta-adrenergic blockade in the elderly. The age-associated decline in maximal cardiac output and cardiovascular reserve capacity may not limit usual ability in otherwise healthy elderly because the

vast majority of daily activiies are performed at low and submaximal workloads. In addition, the age-related decline in exercise capacity can be attenuated by physical conditioning.

Diastolic Function

The time for cardiac relaxation and for ventricular filling are prolonged with aging leading to altered early diastolic filling times on echocardiography and nuclear studies. The etiology of the prolonged time for relaxation may be multifactorial--increased ventricular mass, collagen infiltration, or altered myocardial calcium handling. Prolonged filling times may limit cardiac output with increased heart rates. While altered diastolic function accompanies aging, congestive heart failure is not a normal consequence of the prolonged times required for cardiac relaxation or diastolic filling.

Valvular Changes

Degenerative calcification (leading to sclerosis) and myxomatous degeneration (which can lead to regurgitation) affect the aortic and mitral valves with aging. These changes are considered "secondary" to aging and differ from the primary changes due to rheumatic heart disease or congenital valve abnormalities. These changes can progress to impair the function of the valve; then the changes are considered pathologic and no longer "normal aging".

Table 1

Age-Related Changes	**vs.**	**Cardiovascular Disease**
Decreased Heart Rate Response		Sinus Pauses
Longer P-R Intervals		Second and Third Degree AV Block
Right Bundle Branch Block		Left Bundle Branch Block
Increased Atrial Ectopy		Atrial Fibrillation
Increased Ventricular Ectopy		Sustained Ventricular Tachycardia
Altered Diastolic Function		Decreased Systolic Function (Ejection Fraction)
Aortic Sclerosis		Aortic Stenosis, Aortic Regurgitation
Annular Mitral Calcification		Mitral Regurgitation, Stenosis Systolic Hypertension Diastolic Hypertension

Common Cardiovascular Diseases and Management in Older Patients

Atrial Fibrillation

The prevalence of chronic atrial fibrillation rises from <1 per 1000 people at 25-35 years of age to about 40 per 100 at ages 80-90 (Framingham data, Baltimore Longitudinal Study, Cardiovascular Health Study). Chronic atrial fibrillation has been shown to be an important risk factor for cerebrovascular accidents (strokes) and control of rate is associated with better exercise tolerance. The goals of therapy in an individual patient may vary and include rate control, prevention of stroke, or restoration of sinus rhythm.

Rate control

Immediate or long-term rate control can be achieved with the use of digoxin, beta-blockers, calcium antagonists (verapamil or diltiazem), or amiodarone in refractory cases. There is less experience with the use of new Class III agents (ibutelide). The adequacy of rate control must be assessed with activity--more active patients are less likely to have adequate rate control with digoxin alone. Drug doses should be adjusted for age and disease state and one must remember that adequate rate control may be lost during acute illnesses such as pneumonia, but will be regained with treatment of the acute illness.

Prevention of stroke

with acceptable risk benefit ratios can be achieved with anticoagulation with coumadin. However, the optimal therapy to prevent stroke for the older patient with atrial fibrillation has not been found. This author favors anticoagulation with coumadin to a target INR of 2-2.5 with close monitoring in elderly patients without contraindications to anticoagulation, esp. in patients with additional risk factors for stroke (hypertension, vascular disease, prior CVA). Aspirin alone is not a reasonable choice in the latter group.

Restoration of sinus rhythm

should be considered in patients with abnormal cardiovascular function (esp. in the setting of aortic stenosis or hypertrophic cardiomyopathy), atrial fibrillation which is not of long-standing, or is difficult to control. This goal is more frequently sought in younger patients. Anticoagulation must be instituted

prior to cardioversion and continue during the period of highest risk for fibrillation recurrence (?3mo). Analyses of risk of recurrence based on age alone have not been performed.

Hypertension

The prevalence of hypertension--esp. systolic-- increases with aging in North American men and women. This increase in systolic pressure is thought to be due to thickening of the arterial wall which makes it less distensible and less able to buffer the rise in pressure that occurs with cardiac ejection. These changes result in an elevated systolic blood pressure with a relatively unchanged diastolic blood pressure. A large body of data have now demonstrated that cardiovascular morbidity and mortality increase with increasing systolic as well as diastolic blood pressure in the elderly. Furthermore, treatment of both diastolic and isolated systolic hypertension has been shown to decrease mortality and morbidity in both older men and women--there is a decrease in adverse events for every degree of blood pressure reduction toward the normal range. Treatment goals are now the same for older patients as they are for younger patients---systolic blood pressure < 140 mmHg and diastolic pressure < 90 mmHg.

Treatment begins with diet (weight reduction if obese; low sodium for all, and < 1 oz of alcohol/day) and exercise. The long-term benefits of antihypertensive therapy in the elderly have been demonstrated for thiazide diuretics (chlorthalidone 12.5-25 mg/day, hydrochlorothiazide 25 mg/day) alone or in combination with beta-blockers (atenolol 50 mg/day, metoprolol 50 mg/day). Thiazide diuretics and/or beta blockers are recommended as first-line pharmacologic therapy for the older patient with hypertension (and no other diseases) because of demonstrated longevity benefit and lower cost. Alpha-methyl-dopamine and reserpine have also shown mortality benefits but are less widely used secondary to side effects. Calcium channel blockers, angiotensin converting enzyme (ACE) inhibitors, alpha-blockers, and angiotensinogen II inhibitors are highly effective in lowering blood pressure in older patients and may have advantages in hypertensive patients with multiple diseases (i.e., calcium channel blockers for coronary artery disease, cerebrovascular disease, diabetes, chronic obstructive pulmonary disease, diabetes with renal disease; ACE inhibitor for congestive heart failure, diabetic with renal failure, etc.; alpha blocker for prostate disease). Similarly, beta-blockers have an advantage in the post-myocardial infarction patient. No adverse effects on quality of life or mood have been demonstrated with the use of beta-blockers in the elderly in randomized clinical trials. All drug dosages should be adjusted for age and disease-related changes.

Coronary Artery Disease

It has long been recognized that the prevalence of coronary artery disease rises with increasing age and that multi-vessel disease in older patients with coronary artery disease is more common. The age-related increase in coronary artery disease occurs in women as well as men but begins at a later age in women. The same risk factors that predict atherosclerosis in younger adults (lipid abnormalities, smoking, hypertension, diabetes) are predictive in older individuals as well. Modification of these risk factors is effective in reducing the risk of atherosclerosis in older patients. Therefore, preventive strategies for the older patient include stopping smoking, blood pressure control, control of lipid abnormalities, and treatment of diabetes.

The approach to diagnosis in the elderly is similar to that in the younger patient. The history may be somewhat more difficult to interpret because exercise may be limited by other factors (arthritis, pulmonary disease, etc.) and chest discomfort may be atypical because of the prevalence of diabetes (10% of the elderly) and the greater preponderance of women in the older populations. ECG criteria for the diagnosis of coronary artery disease are also not as reliable in women of any age as in men. Nuclear imaging (usually thallium) with or without pharmacologic stress is often used to overcome the limits of ECG interpretation, but again is not as good in women as men (estimated 20% false positives). Because the prevalence of coronary artery disease is high in the elderly, the goal of diagnostic testing may be to quantify the amount of ischemia rather than to diagnose its presence and perfusion imaging allows localization, quantification, and differentiation between infarcted and ischemic myocardium. Pharmacologic stress testing combined with echocardiography may also have some advantages in the older patient since it can provide assessment of valvular function, left ventricular function, and the presence and extent of wall motion abnormalities indicative of ischemia or infarction. Angiography is of value for both assessment and as a prelude to interventions. Slightly greater complications are seen in older patients than in younger patients (local bleeding, stroke) but remain low. This should be recognized but should not preclude procedures.

Treatment considerations for coronary artery disease in the older patient do not differ from those in the younger patient with coronary artery disease with the exception of the elderly diabetic patient with coronary artery disease (see below). The therapeutic choices include medications (nitrates, beta-blockers, calcium blockers), lipid lowering regimens (effective in older patients as well as young) and revascularization

procedures. Note that resting heart rates should not be used as an indication of beta blockade or as a contraindication of beta blockade. Revascularization procedures (angioplasty or surgery) may be of greater benefit than pharmacologic therapy in patients with multivessel disease and decreased left ventricular function. In the elderly diabetic with multivessel disease, surgical intervention has a more favorable outcome than angioplasty. Complication rates for angioplasty and surgery are slightly higher in the older patient but still relatively low. It has been noted that fewer women than men have been treated with angioplasty or surgery and that women undergoing such procedures have more advanced disease. This finding could represent atypical presentation or failure of the medical community to recognize the prevalence of coronary artery disease in older women. Another current issue is the possible decrease in cognitive function in older patients undergoing coronary artery bypass graft procedures.

Myocardial infarction

The older patient with myocardial infarction also benefits from the same therapies as the younger patient and age >75 alone should not be a contraindication to thrombolytic therapy. Beta blockers and aspirin should be administered post-infarction. ACE inhibitors are also of probable benefit if given in lower doses and not during the immediate acute MI period. However, goals of the post-MI period may differ for the older patient vs. the younger patient. All physiologic processes related to healing and stress appear to be attenuated with aging, so timing for diagnostic testing after the acute event may need to be slightly later in older patients. In addition, the probability of post-MI ischemia is greater in the older patient because of the higher incidence of multivessel disease. No studies of predominantly older patients have been performed to identify the best post-MI strategy for further risk stratification and to guide in clinical decision making regarding medical vs. revascularization strategies. Therapy should therefore be individualized and it is not appropriate to consider the older patient, esp. in the presence of multiple diseases, as a "routine" post-MI pathway patient.

Congestive Heart Failure

Systolic

The therapy of congestive heart failure due to systolic dysfunction does not differ in the older patient. The mainstays of therapy are digoxin, diuretics, and esp. angiotensin converting enzyme inhibitor drugs. Renal function and potassium may need to be monitored more closely in the older patient because of the likely concomitant administration or ingestion of nonsteroidal anti-inflammatory drugs (high incidence of arthritis in the older population) and the additive effects of NSAID's to lower renal perfusion and potassium excretion. The role of beta blockers in the management of patients with congestive heart failure is just emerging and there are no data regarding the older patient.

Diastolic

Congestive heart failure with preserved left ventricular systolic function is termed "diastolic heart failure" and is more prevalent in the older population, may account for one half of the older population with congestive heart failure, and may be more common in women than men. The prognosis of patients with CHF due to diastolic dysfunction is less ominous than in patients with systolic dysfunction yet the morbidity can be high with frequent treatment failures and hospital readmissions. No long-term studies of drug therapies for diastolic congestive heart failure have been performed. Drugs which selectively affect diastolic filling and relaxation (calcium channel antagonists or beta-adrenergic blockers) can alter these parameters after short-term administration and might provide a specific therapy. However, one of the more surprising findings from a recent trial was the lower incidence of recurrent hospitalizations and death in patients with congestive heart failure who received digoxin (vs. placebo) in combination with diuretics and ACE inhibitors. This was true for CHF patients with both decreased and preserved systolic function. Thus, optimal management of the older patient with diastolic congestive heart failure is evolving. Control of hypertension, prevention of myocardial ischemia, treatment of congestive heart failure symptoms, and maintenance of normal sinus rhythm have received emphasis. It appears that digoxin and diuretics do play a role and that beta blockers and/or calcium blockers may also play a role. Treatment of acute exacerbation of congestive heart failure or pulmonary edema in the setting of diastolic heart failure focuses on diuretics and, if needed, positive inotropes on a short-term basis. The role of ACE inhibitors is unclear unless used for the treatment of hypertension or to attempt regression of hypertrophy.

Multidisciplinary team approach

The concept of a team approach for the care of the patient with congestive heart failure is rapidly gaining favor. The team compositions vary but usually consist of physicians and nurses and other health professionals (dieticians, social workers, physical therapists, or exercise technicians) who focus not only on medication prescribing but patient and family dietary education, close follow-up of weight and

symptoms of patients in the home (phone or home care), with a goal of improving CHF and preventing hospitalizations. In a recently completed trial of older patients with congestive heart failure, the team care patients had fewer hospitalizations, improved perceived quality of life, and lower medical costs for up to one year after randomization, compared to the conventional care group. These data suggest that the geriatric multidisciplinary team approach is beneficial for cardiac diseases in the older patient.

Valvular Diseases

Aortic Stenosis

The frequency of aortic stenosis increases with age and it is the most clinically significant valvular lesion in the elderly. Progressive degenerative calcification is now the most common cause, as opposed to rheumatic disease. The calcification occurs along the margins of the valve leaflet (vs. commisural fusion in rheumatic fever) and thus does not affect valve opening or closing during the early stages but will produce a murmur. Because of the stiffened peripheral arteries in the older patient, the carotid pulse may feel normal to palpation even in the presence of significant aortic stenosis. Other physical findings associated with critical aortic stenosis due to rheumatic heart disease are often absent with calcific aortic stenosis (decreased S1 and S2). The intensity of the murmur does not correlate with the severity of stenosis. Progression to critical aortic stenosis is often gradual but is unpredictable. Therefore, diagnostic testing is essential for the diagnosis or evaluation of a symptomatic elderly patient with an aortic systolic murmur. Fortunately, noninvasive echocardiographic and Doppler testing can now accurately assess the severity of obstruction as well as define the aortic valve. About 20% of elderly patients with aortic disease have a rheumatic etiology--these patients usually have associated mitral valve disease and should receive antibiotic prophylaxis before all invasive procedures including dental procedures. The only effective treatment for critical aortic stenosis is surgical. Aortic valve replacement, even in older patients, improves survival and quality of life. Experience with aortic balloon valvuloplasty shows that re-stenosis occurs frequently within months and it has thus been largely abandoned.

Aortic Regurgitation

The most common cause of aortic regurgitation in the elderly is aortic root dilation secondary to the age-related rise in blood pressure and increased peripheral resistance. With the advent of widespread echocardiography, mild degrees of aortic regurgitation are diagnosed frequently and are usually not of clinical significance. Aortic regurgitation due to rheumatic valvular disease or associated with disease of a bicuspid valve is more likely to progress to clinically significant disease. When significant aortic regurgitation is present, therapy is aimed at afterload reduction and clinical symptom relief with monitoring for definitive surgical intervention prior to left ventricular failure.

Mitral valve disease

Mitral regurgitation accounts for 2/3 of mitral valve disease in the elderly. The etiologies include rheumatic disease (usually with concomitant aortic disease), papillary muscle dysfunction due to ischemia or infarction, calcification of the mitral annulus (more common in women than men), and myxomatous degeneration causing mitral valve prolapse. Medical management centers on maintenance of sinus rhythm or control of atrial fibrillation, afterload reduction and prevention of infection by use of prophylactic antibiotic regimens before all invasive procedures (including dental). The subset of patients with significant mitral regurgitation and mitral valve prolapse may have an increased risk for stroke and should be considered for anticoagulation. Acute symptoms may also benefit from diuretics. As disease progresses, the ventricle dilates and pulmonary hypertension develops and medical treatment is no longer effective. Surgical interventions have the best results prior to the development of ventricular dysfunction or marked dilation. Operative results to date show return toward normal pressures and ventricular size, but improvement is not as marked as that seen after aortic valve replacement. Therefore, optimal surgical timing has not been identified but morbidity and mortality are high once left ventricular failure occurs. Surgical repair as opposed to replacement is currently being used and evaluated for patients with regurgitation and noncalcified, nonstenotic valves. This may preclude the need for anticoagulation with mechanical valves, which could potentially be of clinical advantage in the older patient since surgical mitral valve replacement (whether it is a tissue or mechanical valve) requires lifelong high intensity anticoagulation. The management of the less common mitral stenosis in the elderly also targets control of heart rate and symptoms (digoxin and diuretics), anticoagulation to prevent emboli, and antibiotic prophylaxis to prevent infections. Surgical therapy is the only definitive therapy. Valvuloplasty is seldom of long-term benefit.

Summary

It is important to differentiate the cardiac manifestations of normal aging which do not require medical management from cardiac disease in the older patient. A rationale for greater utilization of diagnostic techniques can be made in the older patient who may present with atypical symptoms, multiple confounding medical problems, and age-related alterations in physical findings of some cardiac diseases. The management of most cardiac diseases in the older patient is similar to that of the younger patient, with the important recognition of the need to reduce medication dosages and be aware of the increased risk of adverse effects or drug interactions. Age should not be a contraindication to invasive procedures or surgical procedures or thrombolytic therapy, since when properly selected, they benefit older patients to the same or greater degree as younger patients. For several diseases unique to aging (i.e., diastolic heart failure or atrial fibrillation), optimal therapeutic strategies are still evolving.

Table1. Unique Features of Cardiovascular Disease in the Elderly

	Presentation	Diagnosis	Treatment
Acute M.I.	Shortness of breath, CHF Chest discomfort, nausea or vomiting, acute confusion	ECG, serum markers or imaging	Thrombolysis ?Revascularization
Atrial Fibrillation	Shortness of breath, CHF rate slower than in young (so may appear regular)	Apical pulse, ECG	Rate control, anticoagulation
Coronary Artery Disease	Chest discomfort or shortness of breath with emotion or exertion, women as well as men	Exercise Test Nuclear stress imaging Stress Echo	Smoking cessation Medicine Angioplasty Coronary Bypass Lipid reduction
Congestive Heart Failure	Same as young	Diastolic > systolic	Diuretics Digoxin + beta-blockers or CaH blockers (diastolic)
Hypertension	Systolic, asymptomatic	Three readings at > 2 weeks apart	Diet, exercise Alcohol withdrawl Medications
Valvular Disease	Altered physical findings	Echocardiography	Critical--surgery

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Edited by the Buehler Center on Aging, McGaw Medical Center.
For information regarding content contact:
James R. Webster, j-webster@northwestern.edu

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For information regarding publication contact:
James Shedlock, j-shedlock@northwestern.edu

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