Caring for the Older Patient, Part II: Age-Related Anatomic and Physiologic Changes and Pathologies

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This is the second article of a four-part series on gerontology and its applications to the care of elderly patients in nuclear medicine. This article reviews anatomic and physiologic changes and pathology associated with aging. It also discusses tailoring nuclear medicine procedures according to patients' needs and conditions, as well as adopting changes within the nuclear medicine department to better serve older patients.

Upon completion of this article, the reader should be able to: (a) describe normal age-related anatomic and physiologic changes that are observed in older patients; (b) identify common age-related disorders; (c) discuss considerations in tailoring nuclear medicine procedures for older patients; and (d) identify changes in the nuclear medicine facility that would better accommodate older patients.

Key Words: aged; aging; age-related changes; geriatrics; gerontology; pathology

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NORMAL AGE-RELATED CHANGES

Although it seems that some decline in capacity is inevitable, new generations of healthy elders may revise some of the traditional views of "normal" age-related changes.

Changes in Posture and Appearance

Postural changes in aging include a stooping forward, with head tilted backward and knees, hips and elbows flexed. Body proportions change with age as shoulder width decreases and the chest, pelvic and abdominal areas increase in diameter. Some structural changes are due to bones losing calcium and some are due to changes in musculature. The trunk shortens as intervertebral distances narrow. The center of gravity moves from the hips to the upper torso, affecting balance.

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Changes in Body Composition

Body composition also changes with age. By age 75, body fat increases by 16% and body water decreases by 8%. Lean body mass declines by about 15% over the life span, although this is not uniform. The arms and legs lose body fat while the abdomen and hips gain body fat. Men lose more subcutaneous fat than women. This loss of fat leads to decreased cold tolerance, as do declines in sweat gland size, number and function.

Skin cell replacement drops by about 50% in old age, and the ability of skin to heal decreases significantly. The blood supply to the skin decreases, with the greatest decrease occurring in the arms and legs. Vascular fragility increases, especially in women, leading to purpura. Changes in the skin and decreases in subcutaneous fat decrease the elder's ability to heal from wounds and increase the risk of decubitus ulcer formation.

Changes in the Respiratory System

As the muscles become more rigid, inspiratory and expiratory muscle strength decreases, causing reductions in both ventilation and vital capacity. The rib cage also becomes more rigid and costal cartilage becomes calcified. Muscles, such as the diaphragm, have to be used more for expiration than they were previously. The anterior diameter of the chest increases.

The greatest changes in the lungs occur after age 70. Respiratory fluids decrease by about 30%; this dries the airways, increasing the risk of mucus obstruction and infection. The functional capacity of the lungs drops by about 50%, resulting in dyspnea with exertion or stress, although no functional changes will occur at rest.

Whereas the inspiratory reserve volume decreases, expiratory reserve volume increases from residual air in the lung bases at the end of respiration. Alveoli decrease in number and size.

Changes in the Cardiovascular System

Although cardiac enlargement occurs in some older adults, this is not a proven age-related change. The left ventricle does

become about 25% thicker, and myocardial elasticity decreases. Fat infiltration occurs, connective tissue decreases and lipofuscin (aging pigment) appears in cardiac cells.

Although the resting heart rate remains unchanged, the ability of the heart rate to increase with stress declines. From age 19 on, stroke volume and cardiac output decrease by about 1% per yr. The heart tolerates tachycardia poorly in old age and requires more time to come to a normal rate. Since blood flow to all organs decreases, and the brain and coronary arteries receive the largest blood volume, these organs can be compromised. The rate of coronary artery flow decreases by about 35% between ages 20 and 60.

Changes in the Gastrointestinal System

Tooth loss is not, as is commonly believed, a normal age-related change. Many individuals keep their teeth intact throughout the life span. The tooth enamel does thin and teeth do become brittle. Saliva production decreases in the mouth, causing xerostomia (dry mouth). The taste buds decline in number and there is a decrease in the sense of taste, thought to be greater in men and in smokers. The gag reflex decreases.

In the esophagus, decreased peristaltic activity and relaxation of the lower esophageal sphincter cause delayed emptying and an increased risk of aspiration. The incidence of hiatal hernia increases with age.

The stomach sees an accumulation of fat tissue and a thinning of the smooth muscle, resulting in delayed gastric emptying and a difficulty in digesting large quantities of food. There may be no changes in the small intestine, although nutrient absorption may decline.

In the large intestine, the musculature weakens, peristalsis decreases and nerve sensation diminishes. Constipation is a frequent complaint in the elderly, and may occur due to normal age-related changes, poor diet and reduced exercise or mobility. One third of persons over age 60 show diverticulosis of the sigmoid colon.

Liver size decreases after age 70, as does hepatic enzyme concentration. The functional capacity of the liver remains essentially unchanged with age, although ability to synthesize protein from the liver decreases.

Gallbladder emptying becomes more difficult with age. Bile decreases in amount and becomes thicker. The cholesterol content of the bile also increases. Although 40% of individuals show gallstones by age 80, the condition is not necessarily linked to aging.

In the pancreas, the production of the enzymes trypsin, amylase and lipase decreases, associated with poor tolerance of high-fat meals and poor absorption of fat-soluble vitamins. The release of insulin also decreases.

Changes in the Genitourinary System

Kidney size decreases with age, the number of nephron units decreases and the amount of extracellular fluid increases. Due to a reduction (up to 50%) in renal blood flow, the glomerular filtration rate decreases. This begins around age 40, and by age 90 is about 50% of what it was at age 20. Blood urea nitrogen levels also are about 20% higher by age 70.

The capacity of the bladder decreases by about half in old age; frequency and nocturia increase. It is more difficult to empty the bladder due to weakening of the bladder and perirenal muscles. Large amounts of urine may be retained. In men, increased frequency or dribbling can result from a weakened bladder or enlarged prostate. The pelvic diaphragm, often weakened in childbirth, may cause stress incontinence in women with age.

Changes in the Neurologic System

The size of the brain may decrease by as much as 7% with age. Cerebral blood flow and oxygen use decreases. This change may be more severe in men than in women. Neurons are lost with age. This is most prominent in the cerebral cortex, which loses about 20% of its neurons. The aging pigment, lipofuscin, appears in the cytoplasm. The hypothalamus becomes less effective in regulating heat production and heat loss.

Regardless of whether or not dementia occurs, senile plaques and neurofibrillatory tangles develop. The fact that monoamine oxidase and serotonin levels increase and norepinephrine levels decrease may contribute to the increased depression seen in older adults.

Changes in the Endocrine System

In the pituitary, the vascular network decreases and connective tissue increases, without functional change. For some reason, the secretion of follicle-stimulating hormone increases in postmenopausal women but remains unchanged in men.

There are no functional changes seen in the thyroid, although the plasma triiodothyronine level decreases 25% to 40%, and the metabolic rate slows with age. Changes in the parathyroid are unclear. There is only minimal atrophy and degeneration, and it is unknown if aging causes a decrease in the secretion of parathyroid hormone.

The secretion of glucocorticoids decreases in the adrenal glands. The secretion of cortisol drops about 25%. The urinary excretion rate of glucocorticoids drops about 25%.

Changes in the Musculoskeletal System

Bone loss starts at about age 40. This is influenced by diet, hormonal changes and physical activity. Bone loss affects about 25% of women and 12% of men, predisposing them to fractures. Joints also change due to cartilage loss that typically begins in the 20s.

Since muscle cells are not replaced in the adult, muscle mass decreases. Although strength tends to increase up to age 40, it will decline about 10% to 20% in old age.

Changes in the Visual Sensory System

By age 40, many people begin to need glasses. The multiple structural changes seen in older people are known as presbyopia. Discoloration, opacity and rigidity of the lens may lead to cataract formation. Changes in the lens and vitreous humor may cause decreased visual acuity. Glaucoma may occur due to the decreased depth of the anterior chamber and reduced

TABLE 1
Accumulative Increases in Chronic Disease

Age (yr) Stage	20 Start	30 Noticeable	40 Subclinical	50 Problematic	60 Severe	70 Terminal
Emphysema	Smoking	Mild airway obstruction	X-ray hyperinflation	Shortness of breath	Recurrent hospitalization	Chronic irreversible oxygen debt
Diabetes	Obesity	Glucose intolerance	Elevated blood glucose	Sugar in urine	Medication required	Blindness Neuropathy
Osteoarthritis	Abnormal cartilage staining	Joint space narrowing	Bone spurs	Mild joint pain	Moderate pain Stiffness	Disability
Artherosclerosis	Elevated cholesterol	Appearance of small plaques	Larger plaques	Leg pain with exercise	Angina pectoris	Heart attack

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aqueous humor resorption. The pupil becomes smaller, reducing the amount of light striking the retina, and the eye's ability to adapt to darkness decreases.

Changes in the Immune System

The thymus gland begins a progressive involution (degeneration) beginning at puberty. By age 50, only about 5% to 10% of the mass of the thymus remains, and by age 60, no thymic hormones are produced. The natural antibodies decrease in number, whereas autoantibodies increase, causing a greater risk of autoimmune disease.

AGE-RELATED DISORDERS

Normal age-related changes do not necessarily lead to disorders of aging. However, increased life expectancy is accompanied by a greater prevalence of degenerative diseases such as heart disease, diabetes, hypertension and osteoarthritis. As shown in Table 1, many of the chronic diseases of the elderly begin early in life and progressively worsen over a lifetime. Although controversial, one of the goals of health education and health promotion is to reduce or delay the morbidity resulting from chronic disease.

This section reviews selected age-related disorders. Nuclear medicine is used to study many of the disorders mentioned, while others are frequently observed in the patients sent to nuclear medicine for other reasons.

Musculoskeletal System

Arthritis. There are many types of arthritis, each having its causes and symptoms. Osteoarthritis, or degenerative joint disease (other terms include hypertrophic arthritis and senescent arthritis), occurs when the cartilage of a joint deteriorates and new bone is formed at the joint surface. The loss of cushioning material causes pain and joint stiffness with accompanying loss of movement over time. Weight-bearing joints, such as knees, spine and hips, are most often affected. Osteoarthritis is well demonstrated on bone radiographs. One study reported that by age 75, 85% of individuals demonstrated radiographic evidence of osteoarthritis in weight-bearing joints (it is thought that 97% of all individuals over age 60 have some osteoarthritis), but only 30% of those individuals reported symptoms associated with the disease (*1*). While the exact cause of osteoarthritis is unclear, certain factors such as age, genetics, obesity and previous trauma appear to be predisposing factors in the development of osteoarthritis.

Osteoarthritis tends to be localized in one or more joints, especially those that receive the greatest trauma and strain. Rheumatoid arthritis, formerly called arthritis deformans, however, is a systemic, autoimmune disease that attacks connective tissue throughout the body. It might be linked to genetic hypersensitivity or autoimmunity. It begins between ages 20 and 40 yr with greater systemic involvement occurring in old age (*2*). In older adults, the large joints are more often affected and the onset of the disease may be sudden. Inflammation and deformity of the joints are present in this type of arthritis. Stiffness, joint pain during rest and activity, and swelling are common symptoms. Subcutaneous nodules over the joints and flexion contractures may develop (*2*).

Gouty arthritis arises from the deposition of uric acid crystals in a joint. Uric acid is the end product of purine metabolism. High levels of purines are found in certain foods such as organ meats and some types of fish. Gout is a metabolic disease caused by the inability to break down purines, resulting in excess levels of uric acid in the blood. Uric acid is then precipitated out into joints. The crystal deposits cause sudden, intense pain that subsides as the deposits are reabsorbed. Gout also can develop as a result of other medical conditions or the use of certain medications. Symptoms of gout begin to appear in individuals between the ages of 40 and 55 yr, and increase with age (*3*).

Fractures. Fractures caused by osteoporosis, skeletal metastases from other primary cancers, and trauma are a major contributor to morbidity in the elderly. The most common fracture sites are those containing trabecular (porous) bone. Trabecular bone loss begins at an earlier age than cortical bone loss. Therefore, areas of the skeleton containing more trabecular bone, such as the wrists, hips (neck of femur) and vertebrae, will be at greater risk for fracture in later years. Environmental hazards and polypharmacy, the concurrent use of multiple medications, are possible contributing factors.

TABLE 2
Risk Factors for Osteoporosis

Age
Gender (female)
Race (Caucasian, Asian)
Thin or slender build
Family history of osteoporosis
Early menopause (before age 45, either natural or artificial)
Calcium-deficient diet
Lack of weight-bearing exercise
Cigarette smoking
Alcohol consumption
Certain medications (steroids, anticoagulants, anticonvulsives)

Hip fractures usually result from falls. About 15–20% of individuals die from complications related to immobility associated with a hip fracture. Colles fracture, a fracture of the distal radius, is the fracture seen most frequently in older women with osteoporosis. Both wrist and clavicle fractures typically result when the person reaches out with an open hand to break a fall.

Edwards et al. (*4*) estimated that about one-third of older adults fall annually. Certain factors predispose individuals to falling. Age-related changes in visual acuity and depth perception prevent the elderly from seeing certain obstacles in their path. Also changes in gait, strength and coordination and certain pathologies, such as Parkinson's disease and transient ischemic attacks, lead to unsteadiness or inability to prevent falls from occurring. Likewise, medications may cause hypotension or a decreased awareness of the environment. Other environmental factors, such as inadequate lighting, loose area rugs and slippery or uneven surfaces, may contribute to a fall.

Osteoporosis. Osteoporosis is the most common metabolic bone disease (*2*). It affects adults, mostly women, in mid to late life. Women are more likely to develop this disease because they have less bone mass than men and postmenopausal estrogen deficiency enhances bone resorption and may decrease intestinal absorption of calcium. Men, however, are also at risk for developing osteoporosis as a result of cumulative bone loss and age-related impaired calcium absorption. A definite diagnosis of osteoporosis typically cannot be made until 30% to 50% of bone loss has occurred.

Risk factors for the development of osteoporosis and, thereby, increased fracture risk, are shown in Table 2. Certain conditions prevalent among the elderly also may lead to the development of osteoporosis. For example, diverticulitis can interfere with intestinal absorption of calcium. The increased metabolic rate found in hyperthyroidism leads to rapid bone resorption that exceeds the rate of bone formation. Diabetes mellitus appears to contribute to the development of osteoporosis, although the exact causal relationship is unclear (*2*).

Gastrointestinal System

With increased age, gastrointestinal symptoms such as indigestion, heartburn and epigastric discomfort increase. Levitan reported that approximately 18% of patients seen in geriatric clinics had significant gastrointestinal symptoms (*5,6*). Furthermore, gastrointestinal diseases are the second leading cause of death in the elderly, preceded only by lung cancer.

Diverticular Disease. Diverticula are small outpouchings that form along the intestinal mucosa. Diverticulosis, the presence of diverticula in the large bowel, is the most common disease of the colon in industrialized countries. It is estimated that about 20% of individuals over 60 yr of age have diverticulosis, while the incidence increases to more than 40% in those over 80 yr (*7*). Some estimate the incidence higher. Painter and Burkitt approximated the risk of developing diverticulosis to be 50% in the U.S. (*8*). Women are more likely than men to develop this condition. Diverticulosis is thought to be associated with lack of dietary fiber, but chronic constipation, obesity and atrophy of the musculature of the bowel wall may be factors as well.

Diverticulitis is an inflammation or infection that can occur when fecal matter accumulates in the diverticula. Diverticulosis does not necessarily lead to diverticulitis, but this inflammatory condition can lead to perforation of the intestinal wall resulting in peritonitis, obstruction of the intestinal tract or the development of abscesses or fistulas. The usual forms of treatment for diverticulitis are low-residue or bland diets, weight reduction and correction of constipation.

Cancer. Cancer is a disease of aging in the sense that the longer one lives, the more likely one is to develop cancer. The majority (50%–66%) of cancer deaths in the U.S. occur after the age of 65, the age group that makes up only 12% of the population. Cancer is the second leading cause of death in this group (*9,10*). The increased incidence of cancer in the elderly is postulated to result from a combination of factors, including the body's inability to repair DNA alterations and cell mutations, reduced effectiveness of the immune system, genetic predisposition to certain cancers and a variety of agents in the environment (*11*).

Malignancies of the gastrointestinal system with a greater incidence in the older adult population include colorectal, gallbladder, pancreas and stomach cancers. Gastrointestinal symptoms are frequent in older adults. While many of these symptoms are due to the normal aging process, it is important to determine which are signs of more serious pathology such as cancer. Colorectal cancer is one of the most common cancers in people over 70 yr of age (*11*). It is second only to lung cancer in both incidence and mortality (*10*). Gallbladder cancer is rare. It is seen in women more frequently than in men, and most often appears after age 70 (*3*). Now the fourth leading cause of cancer deaths in the U.S., pancreatic cancer is three times more prevalent in men than in women (*11*). For reasons that are not clear, the incidence of stomach cancer has been declining. However, it is still one of the common cancers found in older adults (*11*).

Pernicious Anemia. With aging, the gastric mucosa degenerates, decreasing gastric secretions that are necessary for digestion, absorption of certain nutrients and protection of the gastric mucosa. One of these important nutrients is vitamin B_{12}, necessary for the production of red blood cells. It is supplied to the body through foods containing the vitamin. In order for the body to absorb vitamin B_{12}, it must be bound to

intrinsic factor, produced by the parietal cells of the gastric mucosa. With aging, degeneration of the gastric mucosa results in a loss of parietal cells that secrete intrinsic factor. Hence, vitamin B_{12} absorption is compromised and the patient develops a condition called pernicious anemia in which the patient's red blood cells have a much shortened life span. Treatment involves intramuscular injections of vitamin B_{12} for the remainder of the patient's life, since oral vitamin B_{12} cannot be absorbed.

Respiratory System

Pneumonia. Pneumonia, especially bronchopneumonia, is one of the leading causes of death in the elderly, although antibiotics have significantly reduced the morbidity and mortality of this disease. Age-related changes to the respiratory and immune systems may contribute to the prevalence of pneumonia in the elderly. Pharyngeal reflexes are reduced in the elderly which may lead to aspiration of foreign material. Patients confined to bed, suffering from esophageal or neurologic disorders or from diminished levels of consciousness, are more prone to developing aspiration pneumonia. Decreased chest expansion and shallow breathing may minimize the lungs' mechanical ability to break up mucus formations and bronchial obstructions. Respiratory infections occur with greater frequency in the older population because of their lowered resistance to infection. Also, the incidence of pneumonia in the elderly in chronic care facilities is 2–3 times higher than among the same population in the community (*12*). Older patients may demonstrate nonspecific symptoms not typically associated with respiratory infections, such as confusion, loss of appetite and weakness.

Chronic Obstructive Pulmonary Disease. Characteristics of chronic obstructive pulmonary disease (COPD), the fifth leading cause of death in the U.S., include airway obstruction and decreased expiratory flow rates (*13*) (Fig. 1). Diseases such as emphysema, chronic bronchitis, bronchiectasis and asthma are considered to be COPDs. Chronic obstructive pulmonary disease is more common in men than in women, although the ratio of men to women affected by COPD has dropped to 2.5:1 from 6:1, probably due to the increased number of women smokers (*14*). Fatality rates for COPD are more than two times as high in men than in women between the ages of 65 and 74, and more than three times as high between the ages of 75 and 84 (*12*). Important risk factors in the development of COPD include cigarette smoking and environmental and industrial pollutants. People with COPD have increased susceptibility to and complications from respiratory infections.

Lung Cancer. Lung cancer is primarily a disease of older persons who have smoked cigarettes, and is the leading cause of cancer deaths in men (*15*). The death rate in women from lung cancer has increased and surpassed that of breast cancer, primarily due to changes in the smoking habits of women. While there appears to be an increased incidence of lung cancer in the elderly, it is unknown whether this increase is due to more cases of lung cancer occurring or to improved awareness and diagnosis of the disease.

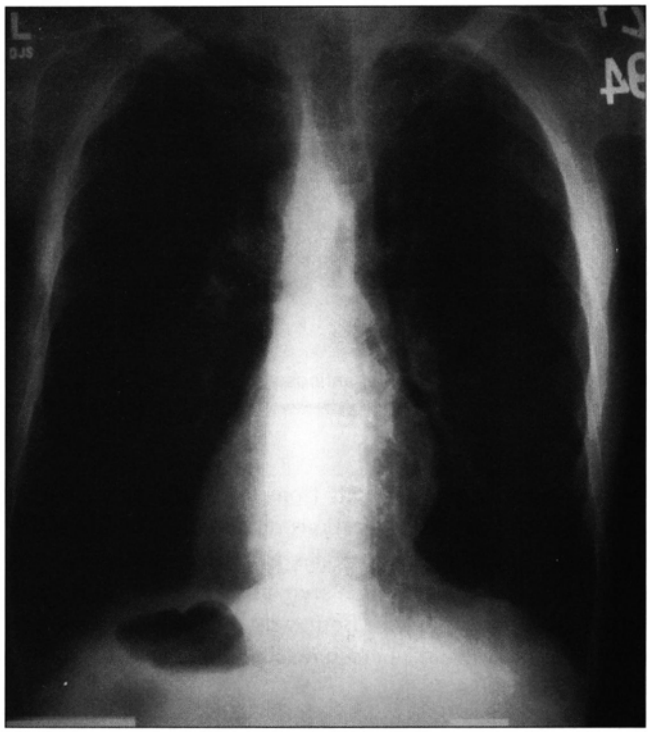

FIGURE 1. Hyperexpansion of the lung fields secondary to chronic obstructive lung disease in a 79-yr-old patient.

Pulmonary Emboli. The incidence of pulmonary emboli in the elderly is high. Conditions such as congestive heart failure, cardiac arrhythmias and hip fracture predispose these individuals to developing pulmonary emboli. Contributing factors that occur frequently in the older population include immobilization and malnourishment. Because the pain sensation is blunted with age, older patients may not experience chest pain, or the pain may be attributed to other problems.

Cardiovascular System

Heart disease is the leading cause of death among older adults. Atherosclerosis is the most important underlying factor associated with heart disease, stroke and related disorders. The chances of experiencing myocardial infarction, hypertension, congestive heart failure or stroke increase with age.

Cardiac Arrhythmias. Digitalis toxicity is the most common cause of cardiac arrhythmia in the elderly. Digitalis preparations are frequently prescribed to treat congestive heart failure, a common condition in the elderly, and certain cardiac arrhythmias. The effects of digitalis preparations can be increased by other medications, and the risk of toxicity is increased when these preparations are used in conjunction with cortisone, diuretics and thyroid preparations, medications that are commonly prescribed for conditions prevalent in the elderly (*2*). Other causes of cardiac arrhythmia include ischemic heart disease, acute infection, hemorrhage and hypokalemia.

Atrial fibrillation, heart block and sick sinus syndrome are the more common types of arrhythmias seen in the elderly, resulting from fewer pacemaker cells and considerable deposits of fat and fibrous tissue throughout the cardiac conduction

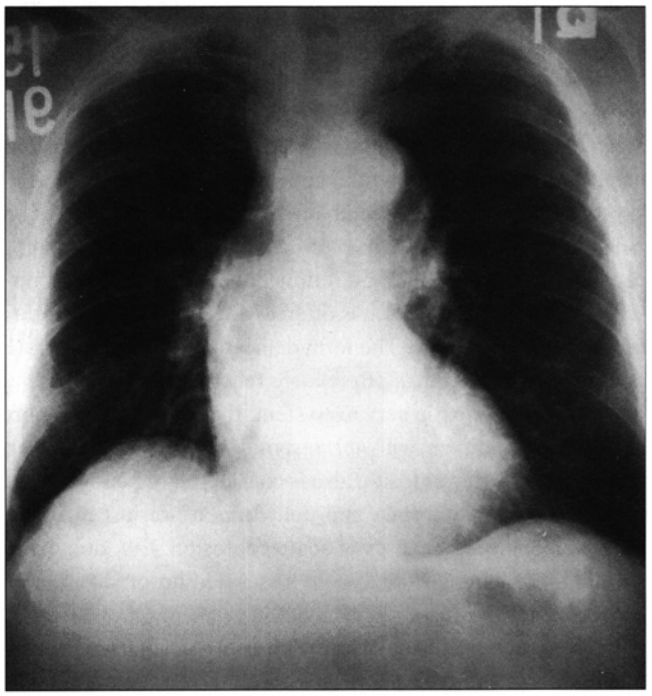

FIGURE 2. Mild congestive heart failure with a mild interstitial pulmonary edema in a 78-yr-old patient.

system (*16*). Sick sinus syndrome is characterized by alternating episodes of bradycardia, normal sinus rhythm, tachycardia and periods of long sinus pause during which the atria and ventricles are not stimulated to contract. Symptoms of these arrhythmias may include weakness, fatigue, forgetfulness, palpitations, dizziness, hypotension and syncope.

Congestive Heart Failure. Congestive heart failure (CHF) is a common problem in older adults, due to both age-related changes and increased incidence of conditions that predispose individuals to CHF (Fig. 2). With age, blood pressure rises, accompanied by reduced elasticity and lumen size of blood vessels. Both of these changes affect blood flow to the myocardium. Other cardiac conditions such as coronary heart disease and mitral valve stenosis, pneumonia and myxedema are a few of the conditions that can induce CHF (*2*).

Coronary Artery Disease. Some form of coronary artery disease (CAD) or ischemic heart disease is present in most people over the age of 70 yr. Atherosclerosis, a process beginning in childhood, is the usual cause of CAD. It is estimated that the prevalence of CAD in older adults is 50–70% (*17*). Although this age group makes up about 12% of the U.S. population, 80% of all deaths due to myocardial infarction occur in this group. Coronary artery disease is the most common cause of death in those over 65 yr (*18*).

While the incidence of CAD increases with age, symptoms of myocardial ischemia and infarction in older patients may be overlooked because the symptoms experienced by this age group are atypical compared to those reported by younger adults. Anginal symptoms may be described as a vague discomfort under the sternum associated with eating. Some patients may experience such recurring symptoms over a long period of time before medical intervention. Anginal symptoms are most often reported by women, however, after age 80 angina in both men and women decreases. Again, in the case of myocardial infarction, atypical symptoms and the absence of pain may be reported by elderly patients. In the very elderly, shortness of breath or acute confusion may be the most prominent symptoms associated with myocardial infarction (*19*). It is hypothesized that absence of pain may be due to age-related decreased sensitivity to pain. Confusion and desensitivity also may result from reduced blood flow to the brain due to decreased cardiac output. Delayed intervention may result in the development of cardiac arrhythmias that could progress to fibrillation and death.

Hypertension. Hypertension, the most prevalent cardiovascular disease in the elderly, used to be considered a normal consequence of aging due to vasoconstriction that produces peripheral resistance. However, age-related blood pressure increases do not occur in everyone, nor do they occur in the populations of less industrialized societies. Diet and physical activity may contribute more to the development of hypertension and heart disease in developed countries than does aging. Other conditions also can be responsible for increases in blood pressure, for example hyperthyroidism, anemia and parkinsonism. However, the definite causes of hypertension in the elderly have not been identified. When hypertension is of unknown cause it is called essential hypertension.

The National High Blood Pressure Education Program defines isolated systolic hypertension (ISH) as systolic blood pressure greater than 160 mm Hg with diastolic blood pressure less than 90 mm Hg and combined systolic-diastolic hypertension as systolic blood pressure greater than 160 mm Hg and diastolic blood pressure less than or equal to 90 mm Hg (*20*). Isolated systolic hypertension is more prevalent in the elderly (*21*). With age, the aorta becomes more rigid and arteries lose their elasticity (*22*). ISH is associated with these age-related changes. Elevated systolic pressure has been identified as the single greatest risk factor for increased cardiovascular disease in the elderly (*23*). For individuals over age 60, systolic pressure is more predictive of coronary artery disease than elevated diastolic pressures (*24*).

While hypertension is a significant risk factor for cardiovascular disease (e.g., CHF) and death in the elderly, treatment of hypertension in the elderly is controversial. The goal is to achieve a blood pressure high enough to provide optimum circulation but low enough to prevent related complications such as stroke.

Genitourinary System

Renal Failure. While the efficiency of renal function declines with age, renal failure is not a normal consequence of aging. The same renal diseases afflict both younger and older patients, however, the prognosis for older patients is somewhat less favorable. In the case of acute renal failure, the death rate is higher in older individuals. Death rates ranging from 57% to 70% have been reported (*25*). Dehydration, radiographic procedures using contrast media, and antibiotic therapy are factors that increase the risk of developing acute renal failure in older people. Normal kidney function may be restored when

these factors are eliminated. Chronic renal failure, sometimes referred to as end-stage renal disease (ESRD), is the permanent loss of renal function. In older patients, this condition is frequently accompanied by other diseases such as diabetes. Combinations of chronic diseases, such as diabetes and ESRD, tend to shorten the life span of older patients.

Urinary Tract Infection. In older adults, infections of the respiratory and urinary tracts are most common. Some estimate that as many as 10% of the elderly will have urinary tract infections. Patients in nursing homes and hospitals were found to have a higher incidence of urinary tract infections (UTI) than individuals who lived in private households (*3*). Bladder catheterization, diabetes mellitus, prostate cancer or hypertrophy, estrogen deficiency or any condition that obstructs the flow of urine are a few of the conditions that predispose the older patient to UTI.

Cancer. Prostate cancer is the second most common cancer in men (*10*). While many factors have been associated with the development of prostate cancer, time and testosterone are two factors that have been determined to be necessary (*26*). After about age 50, the risk of developing prostate cancer increases significantly. Over 80% of prostate cancers are diagnosed in men over 65 (*10*). The five-year survival rates for those diagnosed with prostate cancer increased from 48% to 70% over the last two decades (*10*). The small change in the death rate for prostate cancer has been attributed to earlier diagnosis of asymptomatic patients and more successful therapy for those cases.

Bladder cancer has a higher incidence in men than in women, about 7% and 3%, respectively. It represents less than 5% of all diagnosed cancers (*26*). Smoking and industrial exposure to certain organic chemicals have been identified as contributing to the development of this disease.

Neurologic System

Cerebrovascular Disease. Transient ischemic attacks (TIAs) are short episodes of decreased blood flow to the brain. These episodes may last from a few minutes to as long as an hour. Depending on the blood vessel that is affected, the patient can experience a variety of symptoms including blurred vision, headache, motor weakness and vertigo that resolve without intervention. However, TIAs are a warning sign of an increased risk for cerebrovascular accident (stroke), the third leading cause of death in the older population (*27*).

Cerebrovascular accident (CVA) results from a blockage in a cerebral blood vessel or a rupture of one of these vessels. When part of the brain is deprived of oxygen supplied through the blood, neurons in the affected part of the brain stop functioning. Major risk factors for stroke include hypertension, heart disease and diabetes (*3*). Men and African-Americans are two groups at greater risk for stroke (*28*). The increased incidence of high blood pressure among African-Americans is believed to contribute to this group's risk. In addition to the high mortality associated with stroke, many of its survivors are left with some neurologic deficit that may affect their ability to carry out their activities of daily living (*3*).

Confusion/Dementia. The terms confusion, dementia, senility and delirium are sometimes used interchangeably in reference to the elderly. None of these conditions, ill-defined in some contexts though they may be, are a normal consequence of aging. A patient with dementia will have episodes of confusion, however, it is quite wrong to assume that all patients exhibiting signs of confusion are demented.

Hall and Wakefield define confusion as "an altered thought process characterized by attention deficit and clouded consciousness" (*29*). Confusion is often divided into the categories of acute and idiopathic. The term delirium is often used. Acute confusion is caused by a physiologic reaction that temporarily impairs the autonomic nervous system. It develops over a short period; and patients will *not* respond well to reorientation techniques. Acute confusion also is considered to be reversible. Medications, hypothermia and dehydration are just a few of the possible physical causes of acute confusion. Emotional and social antecedents include recent losses and hospitalization or change of residence.

In idiopathic confusion, there is no known established cause. Such patients will typically respond well to reorientation techniques, such as questions that help link the past to the present. It is very wrong to assume that simply because a patient has been classified as confused that they will be unable to cooperate. There are many levels of confusion and reorientation techniques are often helpful in securing cooperation.

For example, a patient is asked his birth year and he responds correctly with "1900." Suppose you then ask him the current year and he laughs and says, "1918." Ask him for the current president and he responds, "Cal Coolidge." Is this patient confused? Perhaps. In this case, the patient knew full well that it was not 1918 and that Cal Coolidge was not president. But he also knew that he did not know the correct answer. He was confused, but was also aware enough to know he was confused and not oriented to current events.

Could such a patient cooperate? Probably. He is disoriented, but has sufficient awareness to know that. A focused approach to an examination will help him to provide the cooperation needed to complete that examination. A technologist who realizes that there are levels of confusion and that patients who are confused at times also can be quite lucid at times will be able to secure patient cooperation.

Dementia, in contrast to delirium or confusion, is a progressive deterioration of mental function over an extended period of time. Table 3 compares the symptoms of delirium and dementia. In dementia, the loss of mental faculties eventually interferes with the social and occupational functioning of the individual. The causes of dementia, for example Alzheimer's disease, Creutzfeld-Jacob disease, multiple brain infarctions, subdural hematoma, Parkinson's disease and brain neoplasms, have an established pathologic basis. It is estimated that 15% to 20% of people over age 80 suffer from dementia. If individuals reach the age of 80 without symptoms of dementia, it is believed that they have an excellent chance of never developing this disorder (*27*).

TABLE 3
Comparison of Symptoms Associated with Dementia and Delirium

	Dementia	Delirium
Orientation	Disoriented	Disoriented, clouding of consciousness, fluctuating level of awareness
Judgment	Focus on irrelevant concerns	Yes or no
Memory	Impaired for recent events, intact remote memory	Impaired, especially recent events; memory disturbed
Behavior	Agitation or apathy, unable to care for self	Agitation, changes in sleep, unable to care for self
Onset	Gradual, months to years	Abrupt, hours to days
Mood/affect	Labile, inappropriate	Varies
Speech	Sparse, repetitive; does not attempt to conceal problems	May be incoherent, sparse or fluent; inappropriate
Prognosis	No return to predemented state	Resolves with treatment of cause

Modified with permission from: Dawes BGG. Neurologic and cognitive function. In: Lueckenotte AG. *Gerontologic Nursing.* St. Louis, MO: Mosby-Year Book; 1996:739.

Endocrine System

Diabetes. Noninsulin-dependent diabetes mellitus (DM), also known as Type II DM, is a common endocrine disorder in older adults. It is the body's inability to use insulin effectively, hence, the patient experiences hyperglycemia. The prevalence of DM and impaired glucose intolerance (IGT) increases with age. It is estimated that 40% of individuals age 65–74 yr have IGT, increasing to 50% of individuals age 80–89 yr (*30*).

The complications of diabetes tend to be serious and are mostly responsible for the disability and death resulting from this disease. Diabetics have a significantly higher incidence of cardiovascular disease, hypertension and vascular problems than individuals without DM. Renal and ocular disorders also are common in this group.

Hypothyroidism. Hypothyroidism is the second most common endocrine disorder in the elderly, after diabetes. While common, it is difficult to diagnose because its symptoms in this population are not typical and because many cases are subclinical with few symptoms. In older patients, the condition progresses slowly so that when symptoms do appear they may be attributed to normal aging or to other conditions usually associated with older patients. Interestingly, depression is a symptom of hypothyroidism in about half the cases. Bradycardia, angina, dyspnea, muscle weakness and progressive deafness all may signal hypothyroidism in the older population (*30*).

Hyperthyroidism. Hyperthyroidism is more common in older adults than previously thought (*31*). It is estimated that 25–30% of all cases occur in people over 65 yr (*32*). The symptoms exhibited by older people with hyperthyroidism are not the classic signs. Instead, they are more generalized or seemingly unrelated to the condition. Presentation of hyperthyroidism in the older adult includes symptoms such as lethargy, weakness, depression, atrial fibrillation and congestive heart failure (*33*).

Sensory Disorders

Cataracts. The lens of the eye is normally clear and transparent. Due to aging, eye injury, heredity or certain diseases, an area of the lens may become clouded and opaque due to the formation of a cataract. Cataracts are the most common eye disorder in the older population. Almost 50% of people in one study between 75 and 85 yr of age had significant visual impairment due to cataracts (*34*). Surgery is the only treatment for cataracts. However, even very elderly patients are able to tolerate this surgery well and most patients receive greatly improved vision from this procedure (*2*).

Glaucoma. Glaucoma occurs when drainage of the aqueous humor in the anterior chamber of the eye is blocked. If this fluid is formed faster than it can be drained into the venous circulation, pressure increases within the eye that is transferred to the optic nerve. Pressure on the optic nerve leads to irreversible vision loss and eventual blindness if the condition is not treated. Loss of peripheral vision over time is typically the earliest symptom of glaucoma. While there is no cure for this condition, there are methods to reduce pressure within the eye and prevent further loss of vision.

DEPARTMENT ADAPTATIONS FOR THE ELDERLY

Medical imaging facilities can be daunting to anyone not familiar with the procedures or equipment. The elderly are particularly vulnerable to this type of environmental stress. Age-related physical changes such as deficits in hearing or vision and psychological factors such as loss of control over certain aspects of life may make coming to the nuclear medicine department an anxiety-producing event (*35,36*). Therefore, helping older patients become oriented to place and personnel, as well as instituting and using certain adaptations within the nuclear medicine department can be considered age-specific competencies that any practitioner working with older patients should demonstrate.

When the initial meeting with a patient occurs, the technologist should state his name and function and explain where the patient is and why the patient is in the nuclear medicine department. The patient's responses may provide clues about sensory deficits and cognitive function. Two frequently encountered problems in communicating with older patients involve hearing loss and confusion. Patients can exhibit confusion for a variety of reasons. Symptoms include disorientation to time and place demonstrated by inappropriate verbal or

behavioral responses, incoherent or nonsensical speech, visual or auditory hallucinations and physical combativeness (*37*). In the nuclear medicine setting, the cause of the confusion is often not the issue, but rather how to deal appropriately with a patient in this state. Since age-related sensory changes have been shown to lead to misinterpretation of the environment and, subsequently, confusion (*38*), confused patients should be oriented to their surroundings and the people caring for them. In a meaningful environment they may be less likely to overreact to what is unfamiliar. The technologist should attempt to assist such patients with their memory deficits by describing what is real and verifying facts about what is occurring. Reducing distractions and communicating simply and directly help focus the patient who easily becomes agitated or diverted. The technologist should remain calm and offer reassurance throughout the procedure. While none of these actions guarantees the cooperation of a confused patient, they give technologists some strategies for dealing with what is typically a stressful situation for both parties.

Hearing losses due to normal aging make it difficult for the individual to hear high-pitched sounds and certain consonants, to localize sound or to distinguish background from foreground noise. Older people also are more sensitive to loud noises. When interacting with patients with hearing loss, technologists should first ensure that they have the patient's attention. Technologists with higher pitched voices should make a special attempt to modulate their voices. Speaking loudly without shouting and using short phrases can help patient understanding. Minimizing background noise allows the patient to focus as well as removing extraneous sound that prevents the patient from hearing. Background noise is always present in the nuclear medicine department, whether it be from radios, paging systems or computers and equipment. If such noise cannot be minimized, choose an area removed from these distractions at least for the initial contact with the patient. It is also important for the technologist to face the patient so that the patient can see the technologist's lips. Lastly, remembering that what is occurring is most likely foreign to the patient, the technologist should demonstrate patience and courtesy if asked to repeat any information.

Vision changes due to normal aging include loss of depth perception, peripheral vision and the ability to adapt rapidly to changes in light intensity. Adequate and even lighting with minimal glare are conditions that best accommodate these types of vision changes. Indirect rather than overhead lighting and shaded windows minimize glare. Moving from a well-lighted waiting area into a darkened imaging room may be disconcerting to an older person whose eyes cannot quickly adapt to such a dramatic change in light intensity. Turning lights on in the imaging room to lessen the differences in light intensities from one area to another may be one way to minimize this effect. Once the patient is safely and comfortably positioned on the imaging bed, the technologist may darken the room for easier viewing of the computer monitor.

Adequate lighting is also important in preventing patient falls. Environmental factors such as poor lighting, slippery floors, inadequate footwear and obstacles in the path all contribute to the incidence of falls in the elderly. Alterations in balance and coordination accompanied by a decline in muscle strength are factors as well. Such age-related changes require that technologists exercise special care in transferring older patients to and from imaging beds and ensuring their security while they are on the bed. Older patients who find it more difficult to maintain their balance can easily fall as they try to negotiate their way onto narrow tomographic beds. Likewise, once the patient is on the bed some type of restraint can provide both physical and psychological security.

Orthostatic hypotension, dizziness or fainting when coming to an upright position, also can cause the patient to fall. This symptom has been associated with falls, mental confusion, some cardiac conditions and combinations or dosages of certain medications. It is estimated that 15% of people 65–75 yr of age exhibit this symptom, and 25% of those over 75 yr (*39*). When imaging is complete, the technologist should assist the patient to an upright position, ensuring that the patient is not experiencing any dizziness or lightheadedness before assisting the patient from the table. Turning the room lights on and returning the patient's eyeglasses before attempting to remove the patient from the table will help accommodate visual deficits.

Changes in the integumentary system affect the patient's ability to lie for extended periods on hard surfaces such as imaging tables. Whenever possible, place a thin pad on the imaging table to provide some padding to make up for the loss of subcutaneous fat. This also will lessen the patient's susceptibility to hypothermia, since older patients are at increased risk for this condition at temperatures below 68°. Room temperatures in some departments may be fixed at or below this temperature for the comfort of personnel or the maintenance of computer equipment. For this reason, patients should be warmly covered even though the room temperature may seem comfortable to the technologist.

With aging, the skin becomes more fragile and easily broken. The speed of healing decreases significantly as well. Based on these effects of aging, the technologist should use special care when administering intravenous preparations. Tourniquets can bruise or pinch when skin that has lost its elasticity and firmness is rolled into the tourniquet as it is applied. The use of smaller-gauge winged infusion sets (butterfly needles) in place of hypodermic needles may reduce puncture injury. Significant injury may result, even though the patient may not complain of pain, because the pain threshold of older patients is increased due to loss of nerve endings.

Decreased saliva production and difficulty swallowing may pose problems in administering oral medications. Capsules or tablets may become lodged in the oral cavity in the patient experiencing dry mouth, thereby causing localized radiation exposure to the oral mucosa if the preparation is a radiopharmaceutical. In this situation, the radiopharmaceutical also will not be properly absorbed in a timely manner. Large pills may be difficult for the patient to swallow, particularly if the patient is already experiencing dysphagia. Therefore, when administering oral medications, the technologist may first offer water

to alleviate the dry mouth and to assess the patient's swallowing ability.

TAILORING PROCEDURES ACCORDING TO THE PATIENT'S NEEDS AND CONDITIONS

Older patients are likely to have more than one chronic disease that may complicate the diagnosis. They also tend to exhibit vague, nonspecific or atypical symptoms (*40*). For these reasons, it is important to choose the diagnostic tests that will not only give the most specific information, but also can be tolerated by an elderly patient. While it is not the purview of the technologist to order a diagnostic test, the technologist does have a responsibility to educate patients and other medical personnel about the requirements of a nuclear medicine test. The knowledgeable technologist also will be aware of the clinical efficacy of nuclear medicine and other medical imaging tests. This information can be used to benefit the patient as the technologist reviews the request for a nuclear medicine test and considers the clinical indication for the test for a particular patient. This can be a sensitive issue, but the technologist should consult the nuclear medicine physician for guidance.

Some practitioners may believe that limiting radiopharmaceutical dosages is not important in older patients since genetic and reproductive issues and the risk of long-term cancer induction are not relevant to this population. From an ethical point of view, using the prescribed dose is the best approach since the length of any patient's life and the possibility of cancer induction are unknown. There are also technical reasons for limiting the administered dose. After radiopharmaceutical administration, any patient can be considered an unsealed radioactive source. There is potential for irradiating others to a greater degree if radiopharmaceutical doses are increased. Also, there may be instrumentation considerations when imaging or performing external counting on a patient containing more than the usual amount of radioactivity.

Requirements of certain nuclear medicine procedures may need to be modified to accommodate normal or pathologic age-related changes in older patients. For instance, decreased mobility and flexibility and postural changes may make whole-body bone imaging difficult for the patient to tolerate and technically more demanding for the technologist. Age-related changes in the musculoskeletal system may make it impossible for patients to lie flat or to assume particular positions. The challenge for the technologist is to obtain the necessary diagnostic information while accommodating the limitations of the patient. In the case of a whole-body bone image, the technologist may be better able to accomplish this goal by performing multiple spot views of the skeleton while the patient is sitting or lying in a position that is not completely supine. Likewise, pharmacologic stress testing offers an alternative for patients who, for various reasons, are unable to exercise. This modification in physical stress testing makes myocardial perfusion imaging available to a population for whom this test is clinically indicated and who benefit greatly from this development.

Various nuclear medicine tests require that the patient fast. Instructions for fasting typically require that the patient fast from midnight or overnight. This can pose a danger to patients who are diabetic and require medication and nutrition at specific times during the day. The prevalence of diabetic patients scheduled for stress/rest myocardial perfusion imaging requires modification of the fasting requirement. For diabetics undergoing a one-day thallium/sestamibi rest/stress procedure, these instructions might be altered as follows (Headley P and Sprayberry R, *personal communication*, 1996). Diabetic patients should be scheduled to permit the patient to eat an early, light breakfast accompanied by an appropriate insulin dose, followed by a 4-hr fast. In this imaging protocol, the patient first is injected with ^{201}Tl at rest, then the patient is physically or pharmacologically stressed and injected with ^{99m}Tc-sestamibi. Immediately after completion of the stress test, the patient is permitted to eat and take insulin. Patients should be instructed to bring with them their insulin or oral medication and a glucometer, if they use one to test their blood sugar, to the imaging facility. In the case of brittle diabetics, the patient is permitted a light meal 2 hr before the beginning of the test. In some instances, the patient may not be able to fast. Consequently, the test is performed without fasting. The objective is to adhere to the fasting requirement as much as possible but, more importantly, to maintain the stability of the patient.

Restriction of food and liquids and the use of laxatives or enemas can alter an elderly person's fluid balance. Due to age-related changes, an older person's body may not respond to fluid alterations quickly enough to prevent fluid imbalance. Dehydration and electrolyte imbalance that result from fluid imbalance have been associated with changes in mental status and the development of a confusional state (*37,41,42*). A return to the previous mental status can be achieved with adequate hydration. Hospitalized patients, particularly those who are confined to bed, may become dehydrated because water or other fluids are not within easy reach throughout the day. When this situation is accompanied by fasting requirements for diagnostic tests, there is potential for alteration in mental status due to fluid imbalance. The technologist should bear this in mind when preparing a patient for a nuclear medicine procedure that requires fasting. Certain examinations, such as gastric emptying, may require that the patient receive nothing by mouth for a period of time. However, other studies, such as a Schilling test, may require only that solid food be withheld. When the technologist requests that an inpatient be NPO, the technologist should be specific about whether this truly means "nothing by mouth" or whether it means that solid food should be discontinued. Likewise, once a nuclear medicine examination is complete, the technologist should ensure that both the patient and nursing staff know that the fasting order can be discontinued.

Many nuclear medicine examinations use interventional nonradioactive drugs (*43*). Use of such drugs has made nuclear medicine more invasive and introduced certain risks that were not present when radiopharmaceuticals alone were administered. It is important for technologists to be prepared for adverse reactions. It is equally important for technologists to

TABLE 4
Why Pharmacokinetics Differs in the Elderly

Factor	Effect
Absorption	*Decreased gastric secretion of hydrochloric acid.* As patients age, fewer cells in their stomach secrete gastric acid, reducing the absorption of some food or drugs. *Altered intestinal motility.* Elderly patients usually have decreased intestinal motility, which increases drug absorption. Certain diseases (for example, inflammatory bowel disease) can increase intestinal motility, decreasing medication absorption. Certain laxatives (such as bisacodyl [Dulcolax]) also can increase intestinal motility so that the drug is eliminated more rapidly than usual. *Decreased gastric blood flow.* Decreased cardiac output can cause decreased gastric blood flow, resulting in decreased drug absorption. *Interactions with other drugs.* For example, anticholinergics, tricyclic antidepressants and phenothiazines, all of which may delay gastric emptying, may decrease or increase the absorption of other drugs when given concurrently. For instance, when penicillin, which is broken down by stomach acid, is exposed to the acid for extended periods, significant amounts can become deactivated. On the other hand, if a drug is absorbed in the stomach, delayed gastric emptying may result in increased absorption of the drug.
Distribution	After the body absorbs a drug, it has to distribute the drug to the appropriate site for the desired effect. In the older patient, drug distribution can be altered by: *Decreased total body fluid and mass.* Drugs may accumulate in tissues in concentrations that exceed the concentration in plasma. This accumulation acts as a drug reservoir that lengthens the duration of potential adverse reactions. *Increased total body fat compared with body mass.* When a medication such as a barbiturate, diazepam (Valium), or chlorpromazine (Thorazine) binds to fat tissues, you can anticipate delayed and prolonged drug effects. *Decreased cardiac output and a decreased proportion of total blood volume sent to the heart.* This can delay the rate at which a drug is distributed to the heart or brain.
Metabolism	*Reduced blood flow to the liver.* A normal result of aging, this decreased blood flow decreases the effectiveness of liver enzyme pathways that clear the drug from the body. This can increase the drug's plasma concentration as well as its half-life (the time needed for half of the absorbed drug to be excreted). *Diseases.* Cardiac or circulatory failure, dehydration and hyperthermia may reduce hepatic clearance and increase plasma levels of medications. If alcoholism, cirrhosis or hepatitis has damaged the liver, medication effects may be prolonged and exaggerated.
Excretion	*Reduced renal blood flow and glomerular filtration rate.* This causes drugs to be excreted more slowly and less efficiently. The lower the glomerular filtration rate, the longer it takes to excrete the drug. This may extend the half-life of medications normally excreted by the kidneys, including digoxin, lithium, procainamide and gentamicin, and the patient may experience signs and symptoms of drug overdose. Older persons are also at risk for additional renal impairment from dehydration, heart failure and other stresses.

Modified with permission from: Drake AC, Romano E. How to protect your older patient from the hazards of polypharmacy. *Nursing* 1995; 36 (June) (Springhouse Corp., Springhouse, PA).

realize that older patients are more vulnerable to these reactions because aging changes the way the body handles medications. Table 4 describes how pharmacokinetics, the way in which drugs are absorbed, distributed, metabolized and excreted, change with age and chronic disease. The pharmacologic effect of drugs, pharmacodynamics, differs in older individuals as well. It is believed that older people may have altered sensitivity to medications, especially those affecting the cardiovascular and neurologic systems (*44*), and interventional drugs are used for nuclear medicine examinations in both these organ systems. Adenosine, dobutamine and dipyridamole are used for myocardial perfusion studies and acetazolamide is used for cerebral perfusion studies.

SUMMARY

Anatomic and physiologic changes occur due to aging. These changes are considered normal and do not necessarily lead to disorders typically associated with aging. However, as people live longer, they are more likely to develop certain chronic diseases that require accessing the health care system.

As the older population increases, nuclear medicine technologists are more likely to come in frequent contact with the elderly. Learning to view aging as a normal process and developing practice strategies to best meet the needs of this age-group will make technologists more effective and humanistic caregivers.

REFERENCES

1. Giansiracusa DF, Kantrowitz FG. Rheumatic disease. In: Rowe JW, Besdine RW, eds. *Health and disease in old age*. Boston, MA: Little, Brown; 1982: 267–296.
2. Eliopoulos C. *Gerontological nursing*. 3rd ed. Philadelphia, PA: JB Lippincott Co.; 1993.
3. Kart CS, Metress EK, Metress SP. *Human aging and chronic disease*. Boston, MA: Jones and Bartlett Publishers; 1992.
4. Edwards N, Cere M, Leblond D. A community-based intervention to prevent falls among seniors. *Family & Commun Health* 1993;15:57–65.
5. Levitan R. GI problems in the elderly, part I: age-related considerations. *Geriatrics* 1989;44:53–56.
6. Levitan R. GI problems in the elderly, part II: prevalent diseases and disorders. *Geriatrics* 1989;44:80–86.

7. Minaker KL, Rowe JW. Gastrointestinal system. In: Rowe JW, Besdine RW, eds. *Health and disease in old age*. Boston, MA: Little, Brown; 1982:297–315.
8. Painter NS, Burkitt DP. Diverticular disease of the colon, a twentieth century problem. *Clinics in Gastroenterology* 1975;4:3–21.
9. Baird SB, McCorkle R, Grant M, eds. *Cancer nursing: a comprehensive textbook*. Philadelphia, PA: WB Saunders; 1991.
10. Garfinkel L. Cancer statistics and trends. In: Holleb AI, Fink DJ, Murphy GP, eds. *American cancer society textbook of clinical oncology*. Atlanta, GA: American Cancer Society; 1991:1–6.
11. Guillory JA. Cancer. In: Lueckenotte AG. *Gerontologic nursing*. St. Louis, MO: Mosby-Year Book, Inc.; 1996:341–363.
12. Gail DB, Lenfant C. The aging respiratory system. In: Evans JG, Williams TF, eds. *Oxford textbook of geriatric medicine*. New York, NY: Oxford University Press; 1992:335–348.
13. O'Donnell DE, Webb KA, McGuire MA. Older patients with COPD: benefits of exercise training. *Geriatrics* 1993;48:59–62, 65–66.
14. Webster JR, Kadah H. Unique aspects of respiratory disease in the aged. *Geriatrics* 1991;46:31–34, 39–40, 43.
15. Tockman MS, Ball WC Jr. Lung cancer. In: Hazzard WR, Andres R, Bierman EL, et al, eds. *Principles of geriatric medicine and gerontology*, 2nd ed. New York, NY: McGraw-Hill; 1990:548–554.
16. Steven D, Kirk-Gardner R. Cardiovascular function. In: Lueckenotte AG. *Gerontologic nursing*. St. Louis, MO: Mosby-Year Book, Inc.; 1996.
17. Ambepitiya GB, Iyengar EN, Roberts ME. Review: silent exertional myocardial ischaemia and perception of angina in elderly people. *Age and Ageing* 1993;22:302–307.
18. Gurwitz JH, Osganian V, Goldberg RJ, et al. Diagnostic testing in acute myocardial infarction: does patient age influence utilization patterns? The Worcester heart attack study. *Am J Epidemiol* 1991;134:948–957.
19. Bayer AJ, Chadha JS, Farag RR, et al. Changing presentation of myocardial infarction with increasing old age. *J Am Geriatrics Society* 1986;34:263–266.
20. The Working Group on Hypertension in the Elderly, National High Blood Pressure Education Program. Statement on hypertension in the elderly. *JAMA* 1986;256:70–74.
21. Drizd T, Dannenberg A, Engel A. Blood pressure levels in persons 18–74 yr of age in 1976–1980 and trends in blood pressure from 1960–1980 in the United States. *Vital health statistics*, no. 11. Washington, DC: U.S. Government Printing Office; 1986.
22. Gifford RW Jr. Management of isolated systolic hypertension in the elderly. *J Am Geriatrics Soc* 1986;34:106–111.
23. Applegate W. Hypertension. In: Hazzard WR, Andres R, Bierman EL, et al, eds. *Principles of geriatric medicine and gerontology*, 2nd ed. New York, NY: McGraw-Hill; 1990.
24. Kannel WB, Gordon T, Schwartz MJ. Systolic versus diastolic blood pressure and risk of coronary heart disease. The Framingham study. *Am J Cardiol* 1971;27:335–346.
25. Rodgers H, Staniland JR, Lipkin GW, et al. Acute renal failure: a study of elderly patients. *Age and Ageing* 1990;19:36–42.
26. Engberg SJH, McDowell BJ, Wilkerson G. Urinary function. In: Lueckenotte AG. *Gerontologic nursing*. St. Louis, MO: Mosby-Year Book, Inc.; 1996:693–726.
27. Dawes BSG. Neurologic and cognitive function. In: Lueckenotte AG. *Gerontologic nursing*. St. Louis, MO: Mosby-Year Book, Inc.; 1996:727–766.
28. Gillum RF. Stroke in blacks. *Stroke* 1988;19:1–9.
29. Hall GR, Wakefield B. Acute confusion in the elderly. *Nursing* 1996;26:32–37.
30. Peterson A, Baker K. Endocrine function. In: Lueckenotte AG. *Gerontologic nursing*. St. Louis, MO: Mosby-Year Book, Inc.; 1996.
31. Gregerman RI, Katz MS. Thyroid disease. In: Hazzard WR, Bierman EL, Blass JP, et al, eds. *Principles of geriatric medicine and gerontology*, 3rd ed. New York, NY: McGraw-Hill; 1994:807–823.
32. Gilbert PD. Thyroid function and disease. In: Libow LS, Sherman FT, eds. *The core of geriatric medicine: a guide for students and practitioners*. St. Louis, MO: CV Mosby; 1981:246–274.
33. Lueckenotte AG. *Gerontologic nursing*. St Louis, MO. Mosby-Year Book, Inc.; 1996.
34. Kahn HA, Leibowitz HM, Ganley JP, et al. The Framingham eye study. I. Outline and major prevalence findings. *Am J Epidemiol* 1977;106:17–32.
35. Matteson MA, McConnell ES. *Gerontological nursing: concepts and practice*. Philadelphia, PA: WB Saunders Co.; 1988.
36. Spirduso WW. *Physical dimensions of aging*. Champaign, IL: Human Kinetics; 1995.
37. Williams MA, Holloway JR, Winn MC, et al. Nursing activities and acute confusional states in elderly hip-fracture patients. *Nurs Res* 1979;28:25–35.
38. Kopac CA. Sensory loss in the aged: the role of the nurse and the family. *Nurs Clin North Am* 1983;18:373–384.
39. Craig GM. Clinical presentation of orthostatic hypotension in the elderly. *Postgrad Med J* 1994;70:638–642.
40. Kawaguchi S, Iio M, Chiba K, et al. Practical problems in geriatric nuclear medicine. In: Iio M, Wagner HN Jr, eds. *Geriatric nuclear medicine*. New York, NY: Igaku-Shoin Medical Publishers; 1983:61–64.
41. Roslaniec A, Fitzpatrick JJ. Changes in mental status in older adults with four days of hospitalization. *Res Nurs Health* 1979;2:177–187.
42. Seymour DG, Henschke PJ, Cape RD, et al. Acute confusional states and dementia in the elderly: the role of dehydration/volume depletion, physical illness and age. *Age and Ageing* 1980;9:137–146.
43. Park HM, Duncan K. Nonradioactive pharmaceuticals in nuclear medicine. *J Nucl Med Technol* 1994;22:240–249.
44. Drake AC, Romano E. How to protect your older patient from the hazards of polypharmacy. *Nursing* 1995;25:34–39.