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Literature Review—Canine and Feline Geriatric Health

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INTRODUCTION

Aging is defined as "a complex biological process resulting in the progressive reduction of an individual's ability to maintain homeostasis under internal physiological and external environmental stresses, thereby decreasing the individual's viability and increasing its vulnerability to disease".[1] While aging *per se* is not a disease, it is a process that involves a progressive and irreversible loss of functional reserve capacity in the body's major organ systems, which alters responses to stressors and can predispose to illness. These changes are subclinical until such time as a patient is subjected to these stressors, whether by accident, infection or drugs (medications or general anesthetic).[2] Many of these changes show similarities in both nature and progression between humans and other mammals. For example, age-related changes in canine brains are similar to the pre-Alzheimer's changes seen in humans, and dogs have been proposed as a model for the investigation of age-related cognitive dysfunction (ARCD) in humans.[3]

Despite the efforts of healthcare throughout the last century to extend lifespan, we appear to be programmed to age. Cellular changes that lead to aging happen in preference to changes that keep them dividing; it is thought that this is a defense against the development of cancer.[4] Cats and dogs age differently. Cats of different breeds generally age uniformly, whereas aging and lifespan in dogs is

CLINICAL BOTTOM LINE

- Aging is a biological process rather than a disease *per se*, which affects many body systems and increases susceptibility to disease.
- Age ranges at different life stages vary by species and breed, but animals can be considered geriatric when they are in the last 25 percent of their predicted lifespan.
- Aging is associated with a reduction in immune response, a decline in cognitive function and a diminished functional reserve of the cardiovascular, pulmonary and renal systems, among others.
- Changes to the cardiovascular, pulmonary, hepatic and renal systems alter the absorption, distribution and elimination of drugs. Special consideration must be given to the effect of aging on drug metabolism and pharmacology when prescribing drugs, especially when long courses of therapy are necessary and when patients are prepared for general anesthesia.
- Older animals are at increased risk for diseases such as diabetes, mitral valve disease, thyroid dysfunction, osteoarthritis, periodontal disease and behavior problems.
- Potential medical problems should be screened for and investigated before working up a primary behavior problem in geriatric patients, as many medical problems can cause or exacerbate behavioral issues.
- Published guidelines for preventive screening and management of disease in older patients are available from various industry organizations, such as the American Animal Hospital Association.

negatively correlated with body size.[5] Larger dogs have a shorter lifespan than smaller dogs, however this is complicated by breed; there are differences in longevity between individual breeds of a similar weight, and mixed-breed dogs live longer on average than purebred dogs.[6]

At present, there is no agreed standard for age ranges that define life stages. Nutrient requirements for various life stages have been described by the Association of American Feed Control Officials (AAFCO), (*e.g.*, growth, maintenance and gestation/lactation), but these life stages have not been formally defined.[7] Various authors have proposed life-stage classifications; *e.g.*, Gunn-Moore classifies feline age stages as kitten (birth to 1 year), adult (1 to 7 years), mature (7 to 11 years), and geriatric (> 11 years). Hayek and Fortney, et al. have proposed ages at which dogs can be considered senior or geriatric, depending on weight, and Lund, et al. used seven age groupings.[8,9] Banfield currently uses four life stages in its analyses; juvenile (birth to 1 year), young adult (1 to 3 years), mature adult (3 to 10 years) and geriatric (> 10 years).

PHYSIOLOGY OF AGING

Physiological changes that occur throughout the aging process reflect the gradual loss of functional reserve in various organ systems. This reduction in functional reserve seems to be a result of a combination of cumulative environmental insult and pre-programmed genetic events. In companion animals, the best-studied body systems are the immune, cardiovascular and central nervous systems, and among domestic pets, more research has been conducted on canine than feline age-related disease.

Aging physiology—the interaction between the effects of age-related changes in various body systems—is complex. On a cellular level, there seems to be an aging "clock" that counts down and arrests the cell cycle when aging signals are activated.[4] Cellular aging is a result of other influences as well, such as cellular signals and DNA damage,[10] but it is thought that molecules at the ends of chromosomes, called telomeres, are responsible for the countdown.[4] A link has been demonstrated between shortened telomeres and *in vitro* senescence in human cells,[11] and older cats and dogs have been found to have shorter telomeres than younger animals.[12,13] Given that patterns of telomerase activity in somatic cells are similar between dogs, cats and humans,[12,14] it is reasonable to assume that telomere shortening in dogs and cats is also the aging clock that counts down to cellular senescence and contributes to aging.

Immune System

Aging has been associated with decreased function of the immune system in a variety of species.[15] The immune system is incredibly complex, so demonstrating these changes relies largely on laboratory evidence. Clinicopathologic studies in German Shepherd dogs and Beagles have demonstrated decreased numbers of white blood cells and immature neutrophils, along with increased numbers of mature neutrophils and increased concentration of immunoglobulin G.[16-18] The lymphocytes of older Fox Terriers and Labradors have been shown to have a reduced ability to divide *in vitro*,[15] however reports on the effect of age on the function of other aspects of immunity are conflicting. Kearns, et al. reported a reduced antibody response to foreign antigens,[15] but Greely, et al. reported that age made no difference.[19] Kearns, et al. also reported that cell-mediated immunity did not decline with age but Massimino reported a reduced response.[15,17] The conflicting reports, however, used different antigens, so age-related immune responses may be antigen-dependent.

Central Nervous System

Various changes have been described in the canine central nervous system but, in general, the functional consequences of these changes remain poorly understood.[20] Changes that have been described include: an increase in the lateral ventricle space; retraction of cerebral gyri and widening of sulci; accumulation of pigment and inclusion bodies composed of glucose polymers within cells; astrocyte hypertrophy; fibrosis and patchy calcifications of meninges and the choroid plexus; vascular changes (including hemorrhagic foci); cerebrovascular amyloidosis; senile plaques with amyloid deposition; and finally, activated perivascular macrophages.[3,20,21]

Of these, the increase in lateral ventricle space has been correlated with increasing age, and β-amyloid accumulation has been shown to correlate with cognitive dysfunction in dogs.[22] Some of these changes, such as the increase in ventricle size, accumulation of senile plaques, cerebral vascular changes and neuronal changes are similar to changes seen in the brains of aging human patients, and dogs have been proposed as a model for human age-related cognitive dysfunction.[3,23]

Cardiovascular

Little research into cardiovascular degeneration has been conducted in dogs and cats; most information comes from human studies. As in humans, older animals tend to have varying degrees of myocardial fiber atrophy, increased myocardial fibrosis and valvular fibrocalcification.[2] Arteriosclerosis of cardiac arteries has also been reported as a common finding in older dogs.[24] These changes translate into a decreased cardiac functional reserve and a reduced ability to respond to changes induced by exercise or anesthetic drugs.[2,25] In humans, ventricular compliance decreases with age, which means that cardiac output must be maintained by volume. However, this presents a problem, as the aged heart operates within a narrow range of optimal volume and pressure and is intolerant of changes in volume.[2] In older dogs, maximum heart rate and response to autonomic drugs also decreases[2,26] and chronic valvular disease is more common, which can lead to inefficient pumping and myocardial hypoxia.[2,27] Vascular smooth muscle is also less responsive to stimulation by the sympathetic nervous system,[28] which leads to an increase in afterload and decreased exercise capacity.[26]

Response to stress induced by exercise has been shown to be reduced in older dogs. Even though baseline electrocardiogram data, body temperature, hematology, blood chemistry and blood gas data were not significantly different between young and old dogs, differences measured post-exercise reflect the cardiovascular system's reduced functional reserve and reduced ability to adapt.[25] Heart rate, both during and after exercise, and temperature after exercise, were significantly lower in older dogs, and values for hematocrit, red blood cell count and hemoglobin were also significantly lower in older dogs. Since all of these except hemoglobin are modulated by catecholamines, this indicates that the cardiovascular system of older dogs is less able to respond to exercise-induced stress than younger dogs.[25]

Pulmonary

In older dogs, chest wall compliance decreases with age, as a result of reduced intercostal and diaphragmatic muscle mass.[29] In humans, there is also a decrease in vital capacity, total lung capacity and maximum breathing capacity and an increase in anatomic dead space and ventilation-perfusion mismatch.[2,30] This results in a reduced exercise tolerance and a reduced tolerance of hypoxia under anesthesia.

Hepatic

Liver mass decreases with age, resulting in a decrease in hepatic function. This leads to an increase in the plasma half-life of drugs dependent on hepatic metabolism. While there is a lack of research in dogs and cats on the effect of aging on clotting and glycemic control associated with hepatic function, this is something to be aware of in older pets.

Renal

In dogs, age-associated changes in the kidneys include a decrease in the number of glomeruli, decreased tubule size and weight and increased renal fibrosis, which results in kidneys that are smaller and lighter than those of younger dogs.[31] There is also a decrease in renal blood flow, with an associated reduction in glomerular filtration rate.[2] As changes occur, the distal renal tubules become more resistant to antidiuretic hormone, and the ability to concentrate urine and conserve sodium is reduced.[2]

Nutrition

In dogs, as in humans and most other mammals, maintenance energy requirements decrease with age.[32] However, in cats, maintenance energy requirements seem to decrease with age until about 11 years, then increase again.[33] Free fat mass does not seem to increase with age,[34] thus energy requirements in older cats are more complex than those in older dogs. Appetite does not seem to decline in aged cats, either,[35] but voluntary food intake seems to decrease in dogs.[36] Data on the effect of age on water intake in dogs and cats is lacking. Carbohydrate metabolism does not appear to be affected by age,[5] however older dogs have delayed glucose absorption and older cats have reduced glucose tolerance.[37] Changes in nutrient digestibility with age vary between dogs and cats. While the digestibility of protein, fat and energy does not appear to change with age in dogs, cats appear less able to digest these macronutrients.[38] Older cats compensate for these changes by eating more, thereby increasing their total energy intake.[39]

Clinical parameters

White blood cell numbers have been reported to decrease with age in dogs,[15,18,40] however baseline values of other hematological parameters, biochemical parameters, body temperature, blood gases and electrocardiograms have not been found to be different between geriatric and young dogs.[25] A decrease in diastolic and mean blood pressure has been reported in dogs, however no difference was observed in systolic blood pressure between old and young dogs.[41]

AGE-RELATED DISEASES

Many diseases have a wide age range in which they may manifest, but aging predisposes dogs and cats to certain diseases, many of them chronic in their course. It is beyond the scope of this review to discuss the diagnosis and management of these diseases. Rather, the intent is to draw the reader's attention to them, to highlight the importance of disease screening as animals enter their senior years, and to refer the reader to industry standard guidelines on senior/geriatric care programs. Diseases associated with advancing age and/or the geriatric life stage include obesity, endocrine dysfunction (such as diabetes and thyroid disease), renal disease, degenerative joint disease, periodontal disease, cardiac disease, behavior issues and neoplasia. The 10 most common diagnoses of geriatric dogs and cats that visited Banfield hospitals in 2009 are shown in *Figures 1* and *2*, page 5.

Obesity

Although obesity is associated with increasing age, it is typically a disease of middle age rather than senior or geriatric age groups.[42] This is most likely due to the decreased amount of lean muscle in senior and geriatric

Figure 1: Ten 10 Most Common Diseases of Geriatric Dogs that Visited Banfield Hospitals in 2009

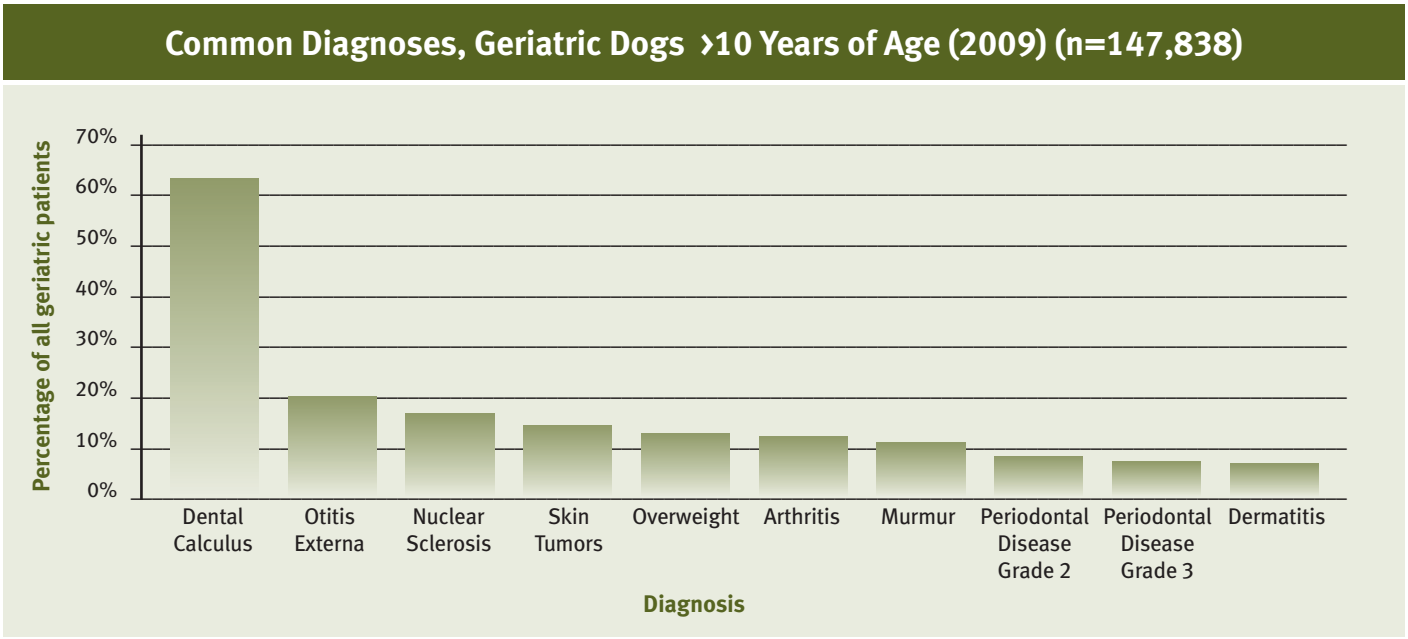
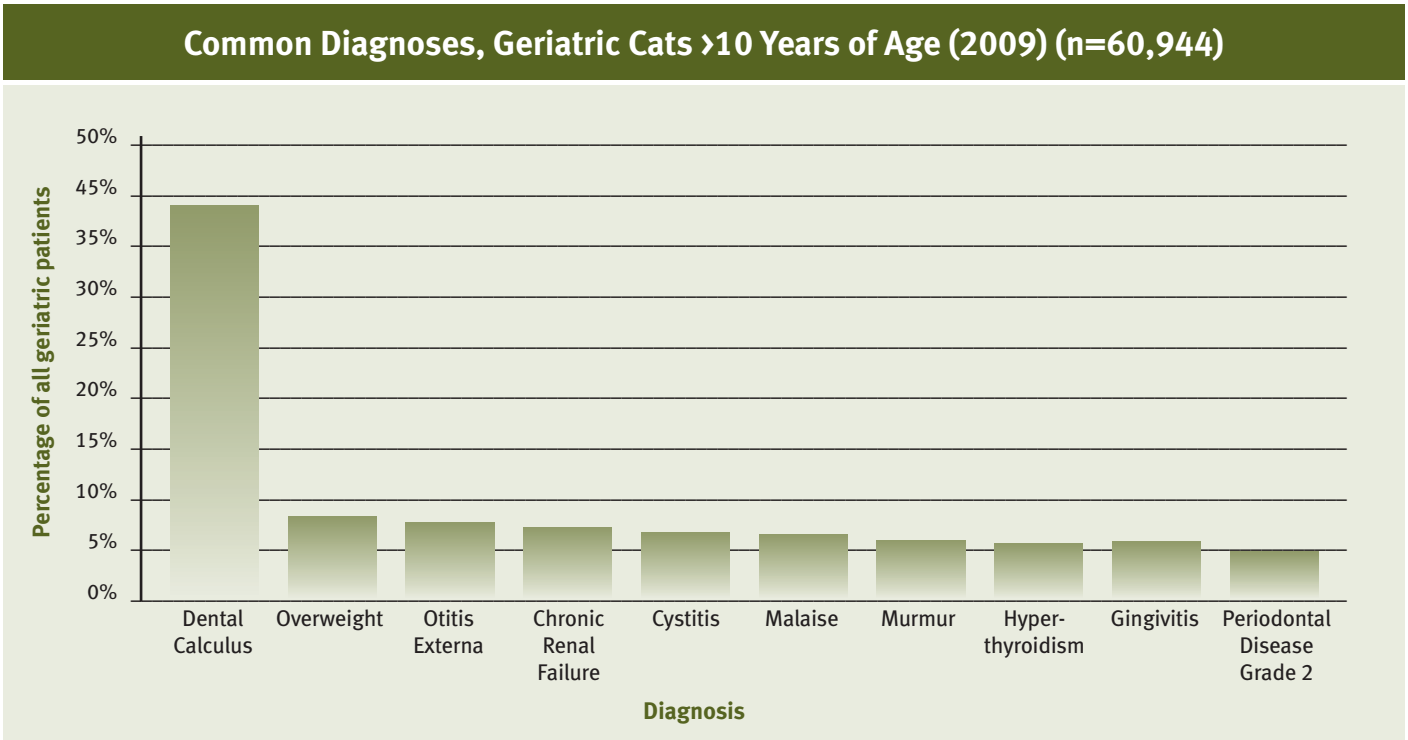


Figure 2: Ten Most Common Diseases of Geriatric Cats that Visited Banfield Hospitals in 2009



dogs and cats resulting from the increase in protein turnover with age.[8] Despite the fact that obesity is not strictly a geriatric disease, evidence suggests that obesity reduces lifespan in dogs[43] and thus is an important factor when considering the onset of age-related diseases.

Renal disease

Renal disease is common in older pets, but the kidney has such a large functional reserve that disease is not easily detectable. Once typical signs such as polyuria and polydipsia are apparent, at least 67 percent of functioning nephrons have been lost.[44] As such, screening for proteinuria may facilitate early detection and management of renal disease.[45]

Endocrine disease

Endocrine diseases are also common in older dogs and cats and can represent a diagnostic challenge.[1,46] Important endocrine diseases include diabetes mellitus, feline hyperthyroidism and canine hypothyroidism, as well as hyperadrenocorticism and hyperparathyroidism.[1] Advancing age has been identified as a risk factor for the development of feline diabetes,[47] feline hyperthyroidism[48] and canine hypothyroidism.[49] Although the clinical presentation of feline hyperthyroidism may be fairly typical, diagnosis of canine hypothyroidism may be challenging.

Osteoarthritis

In geriatric dogs, osteoarthritis is a common cause of pain and reduced function. Clinical signs may be vague and the onset of signs may be slow, making diagnosis difficult unless there is obvious difficulty walking or climbing, or obvious pain or crepitus in joints.[50] In some cases, however, pain may be severe enough to cause changes in behavior. Cats, too, may suffer from osteoarthritis[51] but the signs may be much less obvious than in dogs. In many canine breeds the prevalence of cardiac disease, especially mitral valve disease, increases with age and is especially common in geriatric dogs.[27]

Mitral valve disease

Mitral valve disease is a progressive developmental disorder; most congenital cardiovascular disorders will have occurred much earlier in a patient's life.[52] Increased age is also associated with a greater prevalence of periodontal disease, especially in small breed dogs.[53] Management of dental disease in geriatric patients is essentially the same as in younger patients. However, special consideration must be given to the effect of aging on drug metabolism and pharmacology when preparing patients for general anesthesia and dental cleaning.

Behavioral changes

In patients of any age, almost any medical condition and many environmental changes can affect behavior.[54] Aging induces changes in cognitive function, sensation, visual acuity and mobility that may exacerbate other changes brought on by disease, people or other animals or environmental modifications.[54] Signs consistent with cognitive dysfunction, such as disorientation, altered sleep-wake cycles, decreased response to stimuli or decreased activity levels, are quite prevalent in older dogs and cats.[55,56] These signs become more common with increasing age, and older animals generally have a greater number of signs consistent with cognitive dysfunction.[55,56] Common behavior problems in older dogs include separation anxiety, aggression toward people, soiling inside the house, excessive vocalization and phobias.[54] In cats, the most common age-related behavioral problem by far is soiling inside the house.[54] Diagnosis of age-related behavioral disorders can be challenging, as many medical conditions can affect behavior.[54] Because of the myriad changes to organ systems that occur with aging and the influence of medical problems on behavior, it is important in older

patients with behavioral disorders to consider the animal as a whole. Potential medical problems should be screened for and investigated before working up a primary behavior problem.[54]

Neoplasias

Finally, many types of neoplasia increase in frequency with age. In humans, the risk for most adult-onset cancers increases substantially with age[57] and this also seems to be the case in dogs and cats. The risk of neoplasia in cats and dogs has been shown to increase with age for the following cancers: ductular and acinar pancreatic carcinomas (dogs);[58] intranasal tumors (dogs);[59] pulmonary tumors (dogs and cats);[59] osteogenic sarcoma (dogs, greater risk in large breed);[60] thyroid cancer (dogs and cats);[61,62] adrenal cortical tumors (dogs);[59] renal tumors (dogs);[63] nervous system (dogs and cats);[64] oral tumors (dogs; melanoma, SCC and fibrosarcoma);[65] and tumors of the reproductive system (primarily in non-neutered dogs; sertoli cell tumor, seminoma, testicular interstitial cell tumor, ovarian epithelial tumors).[66,67] Breed predispositions have also been identified in dogs;[57,60] to date, there is no information on breed predispositions in cats but data is much more limited. However, it has been shown that even though the incidence of malignant tumors is similar between dogs and cats,[68] cats have a greater ratio of malignant to benign tumors than dogs.[69] Age also seems to influence the biological behavior of tumors; prostatic tumors are more likely to metastasize aggressively in young dogs than in older dogs, whereas vascular tumors (hemangiomas) were more likely to be benign in younger dogs.[57]

SENIOR AND GERIATRIC PET HEALTHCARE AND SCREENING GUIDELINES

The recommendation of the American Animal Hospital Association (AAHA)[70] and other professional organizations is that veterinary practitioners take a proactive approach to senior and geriatric health issues through regular screening.[70] In communication with owners, it is critical to convey the concept that their pet is entering its senior years and to explain the necessary preventive measures.[70,71] AAHA recommends that client education on senior healthcare begins in the pet's middle age. There are many ways to define life stages, but AAHA recommends that a pet be considered senior if it has entered the last 25 percent of its predicted lifespan. For the purposes of this review, "senior" refers to the portion of lifespan after middle age and into geriatric age.

Disease screening includes all aspects of patient assessment, including history, physical examination and laboratory testing. Recommended areas on which to focus include: changes in body condition; assessment of the body surface for lumps; palpations of lymph nodes; palpation of the thyroid in cats; evaluation of the central nervous system (especially mentation and postural reflexes); and assessment of mobility and crepitus in the joints, as well as other standard components of a thorough physical examination. It is also recommended that laboratory testing be carried out at these examinations and, ideally, repeated annually. Apart from complete blood count (CBC), clinical biochemistry and urinalysis, laboratory tests that may be of value include tests for total T4 and potassium in cats, serum electrolytes, urine protein to creatinine ratio, FIV/FeLV, ECG and blood pressure measurement,[70,71] among others. Other aspects of senior and geriatric healthcare management worthy of special attention include pharmacology, nutrition and behavior.

Since renal disease is common in older patients and can affect well-being, drug metabolism and response to anesthesia, early screening for renal disease is a priority in older patients. Screening for subclinical

disease can be difficult, however, due to the kidney's large functional reserve. Persistent proteinuria is a consistent finding in both dogs and cats with chronic kidney disease (CKD).[45] Established methods of detection of proteinuria include the urine protein to creatinine ratio.[72,73] Other diseases such as neoplasia and heartworm disease may also cause proteinuria,[73,74] so it is important to keep this in mind when screening for early renal disease. When performing any assay for renal disease, even with standard assays such as urinalysis or measurement of serum urea and creatinine, it is important to interpret results in light of the urine specific gravity (USG). The measure of the kidney's ability to concentrate or dilute urine ultimately determines whether test results are normal or warrant further investigation.

Similarly, changes to the cardiovascular, pulmonary, hepatic and renal systems alter the absorption, distribution and elimination of drugs.[75] These changes, especially the reduction in cardiac output, also alter various organs' susceptibility to toxicity. Age-related changes are also affected by disease, and geriatric patients are more likely to have dysfunction in more than one organ system. In humans, the frequency of adverse drug reactions is three to 10 times greater than in younger people,[76] and it is likely that this is also the case in animals. Thus, recommendations have been proposed when considering drug administration in older patients *(Table 1)*.[75]

Table 1

Drug Administration in Older Patients

- Avoid using drugs unless there are definite therapeutic indications for them.
- If organ dysfunction or subclinical disease exist (*e.g.,* renal or hepatic), try to select drugs that are metabolized by the liver (in the case of renal insufficiency) or are not metabolized before renal excretion (in the case of hepatic insufficiency).
- If therapeutic monitoring is available, *e.g.,* with drugs such as phenobarbitone, potassium bromide (KBr) or cyclosporine, try to tailor the dosage to the patient.
- If monitoring is not available, investigate adjusted dosage regimens.
- If insufficient evidence exists to inform adjusted dosage regimens, investigate information on the drug's pharmacokinetics.
- It is recommended that if the volume of distribution (Vd) changes, alter the dose and if the elimination half-life changes, alter the dosing interval.
- Follow up and monitor patients, looking for indications of efficacy or toxicity.

GERIATRIC NUTRITION

Nutrition is extremely important in older pets. Good geriatric nutrition should aim to promote ideal body condition, prevent the reduction in lean body mass and decline in the immune system, and provide nutrients to support bodily functions. In general, appropriate levels of protein and adjustments in the amount of antioxidants, minerals, vitamins and fatty acids may be advisable. Energy requirements in geriatric dogs are less than in younger animals so it is appropriate to reduce the energy intake of older dogs. Voluntary food intake also tends to decrease with age in dogs, so this should be kept in mind when adjusting an older dog's diet.[77] Protein requirements increase with age, so diets should contain a higher protein-to-calorie ratio; diets with approximately 25 percent of calories from protein should meet most dogs' needs.[77] Cats need an energy-

dense, highly digestible diet. Energy requirements in cats decrease until about 11 years of age, then increase again,[77] so it is important to keep this in mind when tailoring diets in older feline patients. Cats of all ages also have high protein requirements.[77] Many diseases are also nutrient-sensitive. For example, patients with subclinical malabsorptive disease may be deficient in fat-soluble nutrients such as A and E, whereas patients with polyuria may become deficient in water soluble nutrients such as B vitamins.[77] In cats, decreased levels of dietary phosphorous and increases in amounts of long-chain omega-3 fatty acids may help to prevent or delay renal disease, while maintaining ideal body weight may help to prevent diabetes mellitus.[78] In both dogs and cats, nutrients such as long chain omega-3 fatty acids and green-lipped mussel extract may assist with management of osteoarthritis, and dietary antioxidants such as vitamins E and C, taurine and beta carotenes may help to promote the immune system and reduce DNA damage.[78]

BEHAVIOR IN GERIATRIC PETS

Apart from nutrition, behavior is another important issue that owners of geriatric pets will likely encounter on a daily basis. In managing age-related behavior changes or problems, underlying medical disorders must first be treated, or managed if a cure is not possible (*e.g.*, renal disease or arthritis). Behavior management in the form of continued enrichment can help to maintain cognitive function,[54] and a regular daily routine can help to reduce anxiety, reduce disorientation and improve sleep at night.[54] Changes to the household or routine should be made gradually, to help the pet adapt; as sensory and cognitive function decline, incorporating tactile and sound cues into the routine can help to maintain familiarity with the environment.[54]

CONCLUSIONS

Aging is not a disease, but a complex physiological process that affects all aspects of a patient's life. Managing the myriad changes and diseases can be challenging, especially since they can affect both the patient's and owner's quality of life. Practitioners of veterinary medicine have a great deal of knowledge and expertise in the diagnosis and management of each of the issues that affect geriatric patients. The approach to diagnosis and management can be easier, though, if these issues are considered holistically; none of these problems occur in isolation, and the geriatric patient is one that requires special care. Early and consistent client communication that helps clients understand their pet's needs for care over life stages is essential. This communication with owners may also help with preventive screening and compliance, which can be a challenge when managing chronic diseases, and may help to open up discussion around the pet's non-medical needs. As the companion animal population ages, geriatric care will be in high demand. Veterinary practitioners are a critical link in ensuring that these patients get the care they deserve.

ABOUT THE AUTHOR

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