Cognitive Dysfunction in Cats: Clinical Assessment and Management

Danièlle A. Gunn-Moore, PhD

Increasing numbers of cats are living to become elderly and they commonly develop behavioral changes. The objectives of this article are to consider the possible causes and prevalence of behavioral problems in pet cats, to describe how cognitive dysfunction syndrome (CDS) typically presents, and how its diagnosis and management are often complicated by the concurrent presence of multiple interacting disease processes. The most frequently reported behavioral problems in old cats are loss of litter box training and crying out loudly at night. The most common causes of these problems are CDS, osteoarthritis, systemic hypertension (commonly secondary to chronic kidney disease or hyperthyroidism), hyperthyroidism (even without hypertension), deafness, and brain tumors. These conditions all occur frequently in older cats, many of which suffer from a number of concurrent interacting conditions. Owners and veterinary surgeons often mistake these for "normal aging changes," so many treatable conditions are neglected and go untreated. Almost one third of cats 11 to 14 years of age develop at least one geriatric-onset behavior problem that appears to relate to CDS, and this increases to over 50% for cats 15 years of age or older. For optimum management of elderly cats with behavioral problems, all interacting conditions need to be diagnosed and addressed concurrently with management for CDS.
© 2011 Elsevier Inc. All rights reserved.

Keywords: cognitive dysfunction syndrome, geriatric behavioral changes, feline

With improvements in nutrition and veterinary medicine, the life expectancy of pet cats is increasing. In the United States over the last 20 years, the percentage of pet cats over 7 years of age has increased to over 40%,[1] there has been a 15% increase in numbers of cats over 10 years of age,[2] and over 10% of pet cats are over 12 years of age.[1] In the United Kingdom, it is currently estimated that there are over 2.5 million "senior" cats,[3,4] and because this accounts for approximately 30% of the pet cat population,[5] the good management of these individuals is becoming an ever more important consideration for small animal veterinary practitioners.

Unfortunately, accompanying this growing geriatric population there are increasing numbers of pet cats with signs of altered behavior and apparent senility. These behavioral changes may result from many different disorders (Box 1) including systemic illness (e.g., hyperthyroidism), organic brain disease (e.g., brain tumors), true behavioral problems (e.g., separation anxiety), or cognitive dysfunction syndrome (CDS). Diagnosis involves a full investigation looking for underlying illness (Box 2) and assessment for behavioral problems. Once these have been ruled out, CDS should be considered, although, antemortem, this is a diagnosis of exclusion. The most commonly seen behavioral changes include spatial or temporal disorientation, altered interaction with the family, changes in sleep-wake cycles, house-soiling with inappropriate urination/defecation, changes in activity, and/or inappropriate vocalization (often displayed as loud crying at night) (Box 3).

Potential Causes of Behavioral Changes in Geriatric Cats

Perhaps the most common causes of behavioral changes in older cats are CDS, osteoarthritis (OA), systemic hypertension (commonly secondary to chronic kidney disease [CKD], hyperthyroidism or, possibly, diabetes mellitus [DM]), hyperthyroidism (even without hypertension), deafness, and brain tumors (most commonly meningioma). Much has been written elsewhere about the diagnosis and treatment of the other potential causes of behavioral disorders in old cats so this article will concentrate on CDS.

Cognitive Dysfunction Syndrome

CDS is the term applied to age-related deterioration of cognitive abilities, characterized by behavioral changes (Box 3), where no medical cause can be found.[6-10] A survey looking at older cats (7-11 years of age) revealed that 36% of owners reported behavioral problems in their cats, and this increased

From the R(D)SVS School of Veterinary Studies, Division of Veterinary Clinical Sciences, The University of Edinburgh, Hospital for Small Animals, Easter Bush Veterinary Centre, Roslin, Midlothian, Scotland.
Address reprint requests to: Danièlle A. Gunn-Moore, PhD, R(D)SVS School of Veterinary Studies, Division of Veterinary Clinical Sciences, The University of Edinburgh, Hospital for Small Animals, Easter Bush Veterinary Centre, Roslin, Midlothian, Scotland EH25 9RG.
© 2011 Elsevier Inc. All rights reserved.
1527-3369/06/0604-0171\.00/0
doi:10.1053/j.tcam.2011.01.005

Box 1. Potential Causes of Behavioral Changes in Geriatric Cats

- Cognitive dysfunction syndrome
- Osteoarthritis*
- Systemic hypertension (high blood pressure may either be primary or secondary to hyperthyroidism, chronic kidney disease, or, possibly, diabetes mellitus, acromegaly, or hyperadrenocorticism)
- Hyperthyroidism
- Chronic kidney disease
- Diabetes mellitus
- Urinary tract infection
- Gastrointestinal disease
- Liver disease (hepatic encephalopathy)
- Reduced vision or hearing
- Brain tumors (e.g., meningioma, lymphoma)
- Infectious disease (e.g., feline immunodeficiency virus, feline leukemia virus, toxoplasmosis, feline infectious peritonitis)
- Pain and/or inflammation in general (e.g., dental or periodontal disease)
- True behavioral problems, stress

*The importance of osteoarthritis should not be overlooked.[37] Radiographic evidence of degenerative joint disease is present in 70% to 90% of cats over 10 years of age.[38-41] Associated pain and/or dysfunction can result in reduced activity and mobility, aggression, altered interactions with the family, and/or loss of litter box training. Owners can help their arthritic cats by adjusting their house; for example, by moving food and water bowls to lower surfaces, adding ramps to allow easier access to favored sleeping areas, providing deep, comfortable bedding that will support and protect the cat's joints (heated beds can be particularly soothing), and placing low-sided litter boxes within easy cat reach.

to 88% in cats between 16 and 19 years of age.[11] A more recent study suggests that 28% of pet cats aged 11 to 14 years develop at least one geriatric-onset behavior problem that appears to relate to CDS, and this increases to over 50% for cats of 15 years of age or older: excessive vocalization and aimless activity are the most common problems in this older age group.[9,12]

The cause of the syndrome is still unknown, but (1) compromised cerebral blood flow and (2) chronic free radical damage are both believed to be important.[9,10] Numerous vascular changes can occur in the brain of old cats, including a decrease in cerebral blood flow, the presence of small hemorrhages around the blood vessels, and a form of arteriosclerosis.[8,13] The brain of elderly cats may also be subject to compromised blood flow and hypoxia due to hypertension, heart disease, anemia, or blood clotting defects. A small amount of the oxygen that is used by cells in normal energy production is normally converted to free radicals. As cells age they become less efficient, producing less energy and more free radicals. Normally, these free radicals are removed by the body's natural antioxidant defenses, including a number of specific enzymes and free radical scavengers, such as superoxide dismutase and vitamins A, C, and E. The balance between the production and removal of free radicals can be upset by disease, age, and stress. An excess of free radicals can lead to damage, and the brain is particularly susceptible because it has a high fat content, a high demand for oxygen, and a limited ability to repair.[8,14] Ultimately, chronic damage can eventually lead to disease processes similar to those seen in humans with Alzheimer's disease, with alteration of proteins within nerve cells (e.g., tau hyperphosphorylation) and deposition of protein plaques outside the nerve cells (made from β-amyloid protein). In humans and dogs, genetics, diet, and lifestyle choices have all been shown to influence the prevalence and distribution of neuropathologic changes (particularly β-amyloid plaques) and the nature of the associated cognitive dysfunction. Although these relationships are still to be determined in cats, it is likely that they will be similar.

Box 2. Investigation of Behavioral Changes in Older Cats Should Include the Following

- Full history, including the possibility of previous trauma (which may have led to osteoarthritis), any potential exposure to toxins or drugs, and any recent environmental changes (in the household, family members, diet, etc.). Asking specific questions about alternations in the cat's behavior can help determine how the cat has changed (see Table 1).
- Full physical examination (including body weight, calculation of percentage change in body weight, body condition score, and retinal examination)
- Assess systemic blood pressure (this is important because hypertension occurs commonly in older cats and produces many of the same signs as CDS).
- Mobility assessment, plus neurological and orthopedic examinations, which can be challenging in some elderly cats.
- Assess hematology and serum biochemistry, including thyroxin concentration
- Urine analysis (including bacterial culture and urine protein to creatinine ratio)

Depending on the individual case, further investigation may include:

- Serological testing for FeLV, FIV, toxoplasmosis, or FIP
- Thoracic, abdominal, or skeletal radiography, abdominal ultrasound examination, ECG, echocardiography, intestinal endoscopy/exploratory laparotomy/exploratory laparoscopy and biopsy collection, as indicated from initial findings
- Head CT or MRI

Abbreviations: CDS, Cognitive dysfunction syndrome; FeLV, feline leukemia virus; FIV, feline immunodeficiency virus; FIP, feline infectious peritonitis; ECG, electrocardiogram; CT, computed tomography; MRI, magnetic resonance imaging.

Box 3. Common Geriatric-onset Behavioral Changes in Cats

- Spatial disorientation or confusion, e.g., getting trapped in corners or forgetting the location of the litter box (house-soiling is the most common reason for referral of old cats to behavioralists)
- Altered social relationships, either with their owners or other pets in the household, e.g., most commonly increased attention seeking, less commonly aggression
- Altered behavioral responses, e.g., increased irritability or anxiety, or decreased response to stimuli
- Changes in sleep/wake patterns
- Inappropriate vocalization, e.g., loud crying at night
- Altered learning and memory, such as forgetting commands or loss of housetraining
- Changes in activity, e.g., aimless wandering or pacing, or reduced activity
- Altered interest in food, either increased or, more typically, decreased
- Decreased grooming
- Temporal disorientation, e.g., forgetting that they have just been fed

Diagnosis of Older Cats with Behavioral Disorders

Gaining a correct diagnosis involves a full investigation (Box 2). Unfortunately, the diagnosis and management of older cats are often complicated by the concurrent presence of multiple interacting disease processes. In some cases, interacting conditions may worsen clinical signs, for example, OA, CKD (or other causes of polyuria), plus or minus increased fecal urgency (with chronic gastrointestinal disease), or difficult defecation (with constipation) may each exacerbate apparent loss of litter box training. Concurrent hyperthyroidism and DM can be very confusing because the clinical signs can be similar, and because each condition can affect laboratory findings for the other. For example, DM may suppress the serum thyroxin concentration to within the reference range,[15,16] whereas the increased protein turnover associated with hyperthyroidism can reduce the serum fructosamine to a lower level than would be expected in a cat with uncomplicated DM.[17,18] In some cases the treatment of one disease may worsen another, e.g., treatment of hyperthyroidism can unmask the severity of CKD.[19] It is because of the potential for multiple, concurrent, and interacting disorders in elderly cats that prompt and full investigation is essential if management is to be effective.

Unfortunately, it is not always easy for owners to recognize signs of ill health in their cat—they often do not know what signs to look for. Veterinary surgeons need to educate owners as to what should be monitored and encourage them to report any changes in their cat. Owners need to understand that the changes they see are not "normal because their cat is getting old"—changes may represent the presence of very treatable disease. Owners need to monitor their older cats for changes in food and water consumption, body weight, production of urine and feces, and behavior. It is because of this that the implementation of senior health care clinics can be very beneficial. Although the clinics do need to be tailored to individual cats, in general they should involve regular and thorough physical examinations including assessment of body weight, calculation of percentage change in body weight, body condition score, systemic blood pressure, and retinal examination, and, ideally, in-practice mobility assessment plus full orthopedic and neurologic examinations (which can be challenging to perform in elderly cats because they need time to relax and move about on their own volition, preferably on a floor surface that gives them sufficient grip without catching their nails). A blood sample should be collected for biochemical screening, thyroxin concentration, and hematology and, where appropriate, serological testing for feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV), and, where indicated toxoplasmosis and/or feline infectious peritonitis. A urine sample should be assessed by routine urine analysis, urine protein to creatinine ratio, and a bacterial culture. Initially, most cats will only need to attend a clinic once or twice a year. However, those cats showing significant aging changes may need to attend more frequently for repeated reassessment, monitoring, and treatment.

Table 1. Mobility/Cognitive Dysfunction Questionnaire*

My cat	Yes	No	Maybe
Is less willing to jump up or down	☐	☐	☐
Will only jump up or down from lower heights	☐	☐	☐
Shows signs of being stiff at times	☐	☐	☐
Is less agile than previously	☐	☐	☐
Shows signs of lameness or limping	☐	☐	☐
Has difficulty getting in or out of the pet door	☐	☐	☐
Has difficulty going up or down stairs	☐	☐	☐
Cries when picked up	☐	☐	☐
Has more accidents outside the litter box	☐	☐	☐
Spends less time grooming	☐	☐	☐
Is more reluctant to interact with me	☐	☐	☐
Plays less with other animals or toys	☐	☐	☐
Sleeps more and/or is less active	☐	☐	☐
Cries out loudly for no apparent reason	☐	☐	☐
Appears forgetful	☐	☐	☐

It can be difficult to differentiate between many of the changes caused by CDS and/or other behavioral/neurological diseases in old cats, and those caused by OA. In addition, it is not unusual for an individual cat to have multiple interacting conditions.

*Ensure there have been no environmental reasons for the change(s).

Management of Cats with CDS

Although CDS cannot be cured, its clinical signs can be reduced with suitable intervention. While there are no published studies relating to the treatment of cats with CDS, it is possible to consider potential treatment options by extrapolation from studies of CDS in dogs and even from humans with Alzheimer's disease. Potential interventions include dietary modification, environmental management, and drug therapies.[9,10,20]

Dietary Modification and Environmental Management

Diets enriched with antioxidants and other supportive compounds (e.g., vitamin E, beta carotene, and essential fatty acids) are believed to reduce oxidative damage, and so reduce β-amyloid production and improve cognitive function. In humans, studies have shown that high intake of fruits, vegetables, vitamins E and/or C, folate and/or B_{12} may improve cognition. In addition, alpha-lipoic acid and L-carnitine enhance mitochondrial function, and omega-3 fatty acids promote cell membrane health and, in humans, have been found to be beneficial in the treatment of dementia. Unfortunately, excessive intake of some of these compounds can be harmful. In general, combinations of these compounds are believed to work best.

There have been a number of studies investigating the potential benefit of various supplements in dogs with CDS.[14,20-22] For example, a study of dogs over 6 years of age, when given a supplement containing omega-3 fish oils, vitamins E and C, L-carnitine, alpha-lipoic acid, coenyzyme Q, phosphotidylserine, and selenium (Aktivait; VetPlus) over a 2-month period, resulted in significant improvements in signs of disorientation, social interaction, and house soiling.[23] Unfortunately, a different formula is needed for cats because alpha-lipoic acid is toxic in this species.[24] Although the new feline-safe version of Aktivait is now on the market, trials in cats still need to determine its efficacy. A number of other supplements have also been investigated in dogs. For example, placebo-controlled studies have shown significant improvements in dogs with CDS when given a supplement containing ginkgo biloba, vitamins B_6 and E, and resveratrol (Senilife; CEVA Animal Health),[25] and activity and awareness were improved when S-adenosyl-l-methionine was given as a supplement.[26,27] Although S-adenosyl-l-methionine has not been studied for the treatment of CDS in cats, it is known to be safe in this species and may be worth considering for the management of feline dementia.[10] There is now a growing list of compounds that have been suggested to have beneficial effects on the aging feline brain[10]; however, no placebo-controlled studies have yet been reported relating to their use in this species, either as single ingredients or in potentially synergistic combinations.

Environmental enrichment can lead to an increase in nerve growth factors, which can stimulate the growth and survival of nerves and an increase in cognitive function. The combination of environmental stimulation (e.g., toys, company, interaction, and food hunting games) and a diet enriched with antioxidants is believed to have a synergistic action in improving cognitive function. In aged dogs, a 4-year study on the use of an antioxidant-enriched diet (e.g., vitamins E and C, selenium, fruit and vegetable extract [beta carotene, other carotenoids, flavinoids]), mitochondrial cofactors (DL-lipoic acid and L-carnitine), and essential fatty acids (omega-3 fatty acids) (Hill's b/d), plus environmental enrichment (e.g., toys, kennel mate, walks, and cognitive experience testing) revealed rapid (2-8 weeks into treatment) and significant improvements in learning and memory. Interestingly, although there was no reversal of existing pathology, the antioxidants did appear to prevent the deposition of more β-amyloid, whereas the environmental enrichment did not.[28,29]

The clinical signs of CDS in dogs have also been reduced by feeding a diet enriched with plant-derived medium-chain triglycerides, which provide ketones as a more efficient energy source for the brain (Purina One Vibrant Maturity 7+; Nestlé Purina).[30] Unfortunately, cats are generally not keen on eating diets enriched with medium-chain triglycerides so it is unclear if this approach will be useful for cats with CDS.

Although similar studies showing improvement of CDS in cats in response to dietary supplementation are not yet available, a 5-year study feeding healthy old cats (7-17 years old; n = 90) a diet (Nestlé Purina Pro Plan Age 7+; Nestlé Purina) supplemented with antioxidants (vitamin E and β-carotene), essential fatty acids (omega-3 and 6 fatty acids), and dried whole chicory root (which contains the prebiotic inulin to modify intestinal flora) resulted in the supplemented cats living significantly longer (and more healthily) than the unsupplemented ones.[31] A preliminary study looking at a diet supplemented with tocopherols, L-carnitine, vitamin C, beta-carotene, docosa-hexaenoic acid, cysteine, and methionine, which was fed to 46 elderly cats, showed increased activity compared with that in control cats.[32] Other similarly supplemented diets are now on the market (e.g., Hill's Feline j/d, which is actually designed for cats with OA), supplemented with a mixture of antioxidants (e.g., vitamins C and E, and beta carotene), essential fatty acids, chondroprotectants (e.g., methionine, glycosaminoglycans, glucosamine, and chondroitin sulfate), and L-carnitine and lysine. In a 2-month study of 75 cats 12 years of age or older that were not selected for signs of CDS or (OA) where owners were asked to complete questionnaires, >70% improved in one or more signs of cognitive function (and > 50% improved in one or more signs of mobility).[33]

Unfortunately, once cats develop significant clinical signs of CDS, instigating environmental change can actually have a negative effect. This is because affected cats often become stressed and cope poorly with change; whether in their environment, their daily routine, their diet, or with members of the household. The cat's response to this stress is to show more obvious signs of CDS (e.g., anorexia, hiding, and/or upset of toileting habits).[34] For these cats, where possible, change should be kept to a minimum, and when it cannot be avoided it should be made slowly and with much reassur-

ance. Some cats may be so easily disorientated and cope so poorly with change that they may benefit from having their area of access reduced in size, e.g., to a single room containing everything they need, that is, the key resources for cats: food, water, litter box, resting places, either somewhere to hide and/or some way of escaping, and companionship (as dictated by the particular needs of the individual cat). This core territory can then be kept safe and constant. Environmental application of synthetic feline appeasement pheromone (Feliway; Ceva) can also help in reducing feline anxiety.

Potential Drug Therapies

There are a growing number of possible drug options for Alzheimer's disease. These include various cholinesterase inhibitors (to increase the availability of acetylcholine at the neuronal synapses), selegiline (to manipulate the monoaminergic system), antioxidants (e.g., vitamin E), and nonsteroidal antiinflammatory drugs (to reduce neuronal damage). However, there are currently very few that have actually been approved for the treatment of human dementia. Selegiline (Selgian; Ceva: Anipryl; Pfizer), propentofylline (Vivitonin; Intervet), and nicergoline (Fitergol; Merial, which has now been discontinued), are the only drugs that have been approved for the treatment of canine dementia in either the United Kingdom or the United States. Although there are no drugs licensed for the treatment of CDS in cats, a number of drugs have been used "off label."[8,20,35,36] These include selegiline (suggested dose, 0.25-1.0 mg/kg orally every 24 hours), propentofylline (suggested dose, 12.5 mg/cat orally every 24 hours), and nicergoline (suggested dose, one fourth of 5 mg every 24 hours—now discontinued), all of which have been used in cats with varying degrees of success. For example, a small open trial using selegiline showed a reduction of disorientation, vocalization, and stereotypic behavior,[20] and the American Association of Feline Practitioners supports the use of this drug for the treatment of CDS. Other drugs that have been suggested to treat particular signs of CDS in cats[10] include anxiolytic drugs, such as a number of nutraceuticals (e.g., Zylkène; Intervet Schering Plough), buspirone, and benzodiazepines (e.g., diazepam, although hepatotoxicity is a particular risk with this drug) or antidepressants (that lack anticholinergic effects) such as fluoxetine.

Figure 1. Sally, a 16-year-old neutered female domestic shorthaired cat presented for crying loudly at night and urinating around the house.

Case Report: Sally

History

Sally, a 16-year-old neutered female domestic shorthaired cat (Fig 1) was presented with a 2-week history of crying loudly at night and a 6-month history of urinating around the house, which was now occurring with increasing frequency. She was still defecating in her litter box. Sally had always had a "picky" appetite, but her owner reported that she had even become very fussy with her food, had lost weight, and stopped grooming. Overall, the owner felt Sally had aged considerably in the last 2 years. Sally was an indoor/outdoor cat, the only pet in the household, and was fed dry and wet cat food.

Physical Examination

Sally was bright and alert, but thin (body condition score 2-3 of 9), her coat was ill kept and matted, and she appeared slightly dehydrated. Her heart rate was 190 beats per minute, with a grade II of VI systolic murmur, loudest over the sternum, and with occasional gallop sounds. Her respiratory rate was 40 breaths per minute. Her left thyroid gland felt slightly enlarged, and there was considerable bony enlargement of both of her elbows and stifles (consistent with OA).

What Are the Major Problems on the Problem List for This Case?

1) Inappropriate urination, 2) night-crying, 3) tachycardia, cardiac murmur, and occasional gallop sound, and 4) OA.

What Are the Major Differential Diagnoses for These Problems?

Inappropriate urination. 1) Feline lower urinary tract disease, 2) polyuria/polydipsia (e.g., CKD, DM, hyperthyroidism, liver disease, hypercalcaemia, etc.), 3) neuromuscular/orthopedic disease (e.g., OA), and 4) central nervous system/behavioral problems (see Box 1).

Night-crying (see Box 1)

Tachycardia, cardiac murmur, and occasional gallop sound. Primary cardiac disease (which is unlikely in a cat of this age), secondary cardiac disease (e.g., due to hyperthyroidism, hypertension, CKD, DM, etc.).

OA, idiopathic or secondary to trauma, infection, obesity, or developmental defects.

What Is Your Diagnostic Plan?

See Box 2, including electrocardiogram (ECG), echocardiography, chest radiography, and head MRI.

Results

Serum biochemistry revealed the following: albumin 28 (2.8) (reference range: 28-39 g/L [2.8-3.9 g/dL]), alanine transaminase 64 (reference range: 15-60 U/L), globulin 32 (3.2) (reference range: 23-50 g/L [2.3-5.0 g/dL]), alkaline phosphatase 112 (range, 10-100 U/L), creatinine 180 (2.0) (reference range: 140-177 μmol/L [1.6-2.0 mg/dL]), urea 11.2 (31.4) (reference range: 5.5-10.5 mmol/L [15.4-29.4 mg/dL]), glucose 7.6 (138) (reference range: 3.3-5.0 mmol/L [60-90 mg/dL]), Ca 2.2 (8.8) (reference range: 2.1-2.9 mmol/L [8.4-11.6 mg/dL]), PO_4 2.5 (7.7) (reference range: 1.4-2.5 mmol/L [4.3-7.7 mg/dL]), K 4.0 (reference range: 4.0-5.0 mmol/L [mEq/L]), Na 148 (reference range: 145-156 mmol/L [mEq/L]), thyroxin 60 (4.7) (reference range: 19-65 nmol/L [1.5-5.0 μg/dL]). Systolic blood pressure was 150 (reference range: 120-180 mm Hg) and FeLV and FIV tests were negative. For urine (collected by cystocentesis): SG was 1.035 (reference > 1.035), pH was 7.8, glucose was negative, ketones were negative, protein was positive and sterile; the urine protein to creatinine ratio was 0.3 (ref < 0.4). Hematology was unremarkable. Thoracic radiographs, abdominal ultrasound, and head MRI were all unremarkable. Echocardiography revealed moderate cardiac hypertrophy with a basal septal bulge. An electrocardiogram showed tall QRS complexes.

What Is Your Interpretation of These Findings?

Marginal renal insufficiency: slightly increased serum urea and creatinine concentrations (in a cat that has very little muscle mass and has not been fed for 12 hours), with a urine SG just within normal limits (but she is slightly dehydrated and a reasonable proportion of her diet consists of dry cat food, so her urine SG should be higher than this).

Possible early hyperthyroidism: serum thyroxin is at the top of the reference range, but Sally is an old, ill cat who might be expected to show thyroxin suppression; there are also slight increases in her liver enzymes and bile acid concentration, which might be consistent with early hyperthyroidism.

Stress: slight increase in blood glucose concentration.

Increase in urine pH: this can be caused by stress (hyperventilation), diet, urease-producing urinary tract infection, or an old urine sample.

Moderate cardiac hypertrophy: this could indicate either primary cardiac disease or (perhaps more likely in a cat of this age) cardiac disease secondary to hyperthyroidism, hypertension, CKD, DM, etc.

What Are Your Most Likely Diagnoses?

CDS, OA (elbows + hips), moderate cardiac hypertrophy, marginal renal insufficiency, and possible early hyperthyroidism.

How Would You Manage This Case?

CDS: environmental modification, diet change or supplementation, drugs?

OA: environmental modification, diet change or supplementation, NSAIDs?

Monitor cardiac hypertrophy.

Regularly reassess: monitor renal function, systemic blood pressure, serum biochemistry including thyroxin concentration, etc.

Follow-up

Sally was initially managed with environmental modification. This evolved ensuring that she had easy access to all of her key resources (food, water, litter box, resting places, hiding places/escapes routes, and company); her food and water bowls were raised up slightly (Fig 2), ramps were added to allow easier access to favored sleeping areas, a deep, comfortable, heated bed was added, and a large, low-sided litter box was placed within easy reach. These changes were made gradually. It was hoped that they would help Sally's CDS and OA, and the newly added litter box meant any polyuria caused by the early CKD had less chance of resulting in peruria. Sally's food was slowly changed to a diet containing a mixture of antioxidants (e.g., vitamins C and E, and beta carotene), essential fatty acids, chondroprotectants (e.g., methionine, glycosaminoglycans, glucosamine, and chondroitin sulphate), and L-carnitine and lysine; this formulation was

Figure 2. Blue, an 18-year-old neutered female domestic shorthaired cat with cognitive dysfunction syndrome and osteoarthritis who has her food and water raised up slightly to facilitate and encourage her to eat and drink.

considered beneficial to both her OA and CDS. Together these changes resulted in a significant improvement that was noted within a month of instigating the changes; Sally cried less at night, had no further episodes of periuria, and ate better.

Six months after the initial investigation Sally was reported to be doing well, but still crying at night, which her owner felt was due to progression of the OA because the vocalization appeared to occur when Sally was changing position when sleeping or when she was leaving her bed. Full reassessment, including repeated assessment of serum biochemistry, urine-specific gravity, and systemic blood pressure revealed little change. Sally was started on a 2-week trial course of low-dose meloxicam (0.01 mg/kg orally every 24 hours). At Sally's reassessment 2 weeks later her owner reported that the night-crying had almost completely resolved. Repeat serum biochemistry and urine analysis showed no worsening of kidney function. It was recommended that Sally's owner should monitor Sally's behavior and appetite closely, and only give the meloxicam if Sally was first willing to eat her food. To date, Sally has been on this regimen for nearly 6 months and continues to do well, with regular full check-ups scheduled every 3 to 4 months.

Further information for owners of cats with many geriatric diseases can be found on the FAB website (www.fabcats.org). Very useful books designed to help owners of cats with CKD, feline lower urinary tract disease, hyperthyroidism, or blindness are available from www.catprofessional.com.

References

1. Laflamme DP, Abood SK, Fascetti AJ, et al: Pet feeding practices of dog and cat owners in the United States and Australia. J Am Vet Med Assoc 232:687-694, 2008
2. Broussard JD, Peterson ME, Fox PR: Changes in clinical and laboratory findings in cats with hyperthyroidism from 1983 to 1993. J Am Vet Med Assoc 206(3):302-305, 1995
3. Gunn-Moore DA: Considering older cats. Compend Contin Educ Pract Vet 26:1-4, 2003 (Suppl)
4. Habacher G, Gruffydd-Jones T, Murray J: Use of a web-based questionnaire to explore cat owners' attitudes towards vaccination in cats. Vet Rec 167:122-127, 2010
5. Venn A: Diets for geriatric patients. Vet Times (1992 May issue)
6. Chapman BL, Voith VL: Behavioral problems in old dogs: 26 cases (1984-1987). J Am Vet Med Assoc 196:944-946, 1990
7. Ruehl WW, Bruyette DS, DePaoli A, et al: Canine cognitive dysfunction as a model for human age-related cognitive decline, dementia, and Alzheimer's disease: clinical presentation, cognitive testing, pathology and response to l-deprenyl therapy. Prog Brain Res 106:217-225, 1995
8. Landsberg GL, Araujo JA: Behavior problems in geriatric pets. Vet Clin Small Anim Pract 35:675-698, 2005
9. Gunn-Moore DA, Moffat K, Christie LA, et al: Cognitive dysfunction and the neurobiology of aging in cats. J Small Anim Pract 48:546-553, 2007
10. Landsberg GM, Denenberg S, Araujo JA: Cognitive dysfunction in cats: a syndrome we used to dismiss as 'old age.' J Feline Med Surg 12:837-848, 2010
11. Landsberg G: Behavior problems of older cats, in Schaumburg I (ed): Proceedings of the 135th Annual Meeting of the American Veterinary Medical Association, San Diego, CA, 1998, pp 317-320
12. Moffat KS, Landsberg GM : An investigation of the prevalence of clinical signs of cognitive dysfunction syndrome (CDS) in cats [abstract]. J Am Anim Hosp Assoc 39:512, 2003
13. Dimakopoulos AC, Mayer RJ: Aspects of neurodegeneration in the canine brain. J Nutr 132:1579S-1582S, 2002 (Suppl 2)
14. Roudebush P, Zicker SC, Cotman CW, et al: Nutritional management of brain aging in dogs. J Am Vet Med Assoc 227:722-728, 2005
15. Crenshaw KL, Peterson ME: Pretreatment clinical and laboratory evaluation of cats with diabetes mellitus: 104 cases (1992-1994). J Am Vet Med Assoc 209:943-949, 1996
16. Hoenig M, Ferguson DC: Impairment of glucose tolerance in hyperthyroid cats. J Endocrinol 121:249-251, 1989
17. Reusch CE, Tomsa K: Serum fructosamine concentration in cats with overt hyperthyroidism. J Am Vet Med Assoc 215: 1297-1300, 1999
18. Peterson ME, Gamble DA: Effect of nonthyroidal illness on serum thyroxine concentrations in cats: 494 cases (1988). J Am Vet Med Assoc 197:1203-1208, 1990
19. Graves TK, Peterson ME: Diagnosis of occult hyperthyroidism in cats. Probl Vet Med 2:683-692, 1990
20. Landsberg G: Therapeutic options for cognitive decline in senior pets. J Am Anim Hosp Assoc 42:407-413, 2006
21. Ikeda-Douglas CJ, Zicker SC, et al: Prior experience, antioxidants, and mitochondrial cofactors improve cognitive function in aged beagles. Vet Ther 5:5-16, 2004
22. Head E, Zicker SC: Nutraceuticals, aging and cognitive dysfunction. Vet Clin North Am Small Anim Pract 34:217-228, 2004
23. Heath S, Barabas S, Craze P: Nutritional supplementation in cases of canine cognitive dysfunction. J Appl Anim Behav Sci 105:284-296, 2007
24. Hill AS, Werner JA, Rogers QR, et al: Lipoic acid is 10 times more toxic in cats than reported in humans, dogs or rats. J Anim Physiol Anim Nutr (Berl) 88:150-156, 2004
25. Araujo JA, Landsberg GM, Milgram NW, et al: Improvement of short-term memory performance in aged beagles by a nutraceutical supplement containing phosphatidylserine, *Ginkgo biloba*, vitamin E, and pyridoxine. Can Vet J 49:379-385, 2008
26. Bottiglieri T: S-Adenosyl-L-methionine (SAMe): from the bench to the bedside—molecular basis of a pleiotrophic molecule. Am J Clin Nutr 76:1151S-1157S, 2002
27. Rème CA, Dramard V, Kern L, et al: Effect of S-adenosylmethionine tablets on the reduction of age-related mental decline in dogs: a double-blinded, placebo-controlled trial. Vet Ther 9:69-82, 2008
28. Milgram NW, Head E, Zicker SC, et al: Long-term treatment with antioxidants and a program of behavioral enrichment reduces age-dependent impairment in discrimination and reversal learning in beagle dogs. Exp Gerontol 39:753-765, 2004
29. Milgram NW, Head E, Zicher SC, et al: Learning ability in aged Beagle dogs is preserved by behavioural enrichment and dietary fortification: a two year longitudinal study. Neurobiol Aging 26:77-90, 2005
30. Pan Y, Larson B, Araujo JA, et al: Dietary supplementation with medium-chain TAG has long-lasting cognition-enhancing effects in aged dogs. Br J Nutr 103:1746-1754, 2010

31. Cupp CJ, Jean-Philippe C, Kerr WW, et al: Effect of nutritional interventions on longevity of senior cats. Intern J Appl Res Med 4:34-50, 2006
32. Houpt K, Levine E, Landsberg G, et al: Antioxidant fortified food improves owner perceived behavior in aging the cat. Proceedings of the ESFM Conference, Prague, Czech Republic, 2007
33. Hill's data on file, 2008
34. Houpt KA, Beaver B: Behavioral problems of geriatric dogs and cats. Vet Clin North Am Small Anim Pract 11:643-652, 1981
35. Landsberg GL, Hunthausen W Ackerman L: The effects of aging on behavior in senior pets, in Handbook of Behavior Problems in the Dog and Cat, ed 2. London, WB Saunders, pp 269–304, 2003
36. Studzinski CM, Araujo JA, Milgram NW: The canine model of human cognitive aging and dementia: pharmacological validity of the model for assessment of human cognitive-enhancing drugs. Prog Neuropsychopharmacol Biol Psychiatry 29: 489-498, 2005
37. Caney S: Feline arthritis. Vet Focus 17:3):10-16, 2007
38. Hardie E, Roe S, Martin F: Radiographic evidence of degenerative joint disease in geriatric cats (1994-1997). J Am Ved Med Assoc 220:628-632, 2002
39. Clarke SP, Mellor D, Clements DN, et al: Prevalence of radiographic signs of degenerative joint disease in a hospital population of cats. Vet Rec 157:793-799, 2005
40. Godfrey DR: Osteoarthritis in cats: a retrospective radiological study. J Small Anim Pract 46:425-429, 2005
41. Lascelles BDX, Henry JB, Brown J, et al: Cross-sectional study of the prevalence of radiographic degenerative joint disease in domesticated cats. Vet Surg 39: 535-544, 2010