CANINE AGGRESSION: NEUROBIOLOGY, BEHAVIOR AND MANAGEMENT

Ilana R. Reisner, DVM, PhD, DACVB

Canine aggression is almost always a normal behavior. Dogs are social animals and communicate with a broad repertoire of ritualized behaviors, including threats and attacks, both toward people and toward other dogs. As veterinarians we are often called upon to identify, explain and treat aggressive behavior. Aggression directed to people, particularly to owners or others who are familiar, continues to be the most common reason for which dogs are presented to behavioral practices[1].

In spite of the adaptation of ritualized behavior and inhibited aggression among dogs (via their wolf ancestors), the intensity of aggression is sometimes extreme. Whether this is because of our inability to "read" the signals preceding a bite, or because some aggression is pathological, is unclear[2]. Most important is that the motivation and expression of aggressive behavior is complex and multifactorial. Treatment thus depends upon many things, including family composition, lifestyle, predictability and severity of bites, and contextual factors. The field of veterinary behavior is only beginning to examine the diagnostic criteria of aggression.

Defining Aggression

When we think of aggression we typically imagine a bite. However, dogs may bite without threat (as in play), or may growl impressively without biting. Many definitions of this complex behavior have been proposed [3-5]. One researcher has suggested that aggression is a harmful stimulus directed toward a subject, with evidence of intent and arousal, and toward which the target responds aversively [6]. This definition would thus exclude play (even if the "victim" is bitten) and would include the repertoire of postural threats preceding some bites (direct stare, stiffening, erect posture, baring teeth, growling, barking, "bunting", lunging and snapping).

Classification

The classification of canine aggression into clinically convenient categories is problematic. Aggression may be classified by its target (e.g., species and degree of familiarity) or by presumed function. Although identification of the target of aggression is more objective, classification by function helps to distinguish between appropriate and inappropriate (possibly abnormal) aggression. In addition, the design of a treatment program relies more upon the reason for the aggression than upon the victim. For example, a dog may bite its owner because it is afraid or because it is dominant to the owner. In each case, the owner is the target of aggression; however, whereas treatment of the fearful dog involves desensitization to fear-inducing stimuli, treatment of the dominant dog involves modification of behavior so that the dog assumes a subordinate role.

In an effort to define the functions of dog aggression, classification schemes have been suggested by several investigators[7-14]. However, terms and definitions have been inconsistent. To accommodate both target-based and function-based classifications, it may be most accurate to use both schemes: first to classify aggression according to its target (i.e., owners, unfamiliar people, or other animals[15]), then to subclassify into possible reasons for aggression toward this target[13], basing such reasons upon both the dog's posture and the stimulus eliciting the aggression.

The applied classification of canine aggression was expanded by Borchelt and Voith[10, 11], who attempted to associate categories with problems described by owners in a clinical setting. For example, dominance-related aggression was defined by its target (family members), by postures displayed by the dog, and by stimuli eliciting the aggression.

There may be several reasons for inconsistencies in the classification of canine aggression. Contexts in which the behavior occurs, postures exhibited by the dog, and a detailed behavioral history yield a probable diagnosis, but the motivation for aggression is often unclear. In addition, more than one motivation may be involved.

A simpler (but less clinically relevant) classification is based upon the association or absence of affect (emotion) with aggression. Affective aggression is defined as aggression involving "intense patterned autonomic responses"[16] as well as posturing, vocalization, and "often mutilating attacks on the same or other species unrelated to normal prey and eating behavior"[17]. Dominance-related aggression would be included in this category. Conversely, nonaffective aggression is not accompanied by autonomic events such as warning signals. Examples are predatory, play-related and sexual aggression.

Theories and hypotheses aside, dominance, territorial defense and fear often appear to overlap, although one may predominate (or may be the primary concern of the owner). Similarly, several aspects of treatment are common to all types of aggression. Although fearful dogs, for example, benefit from desensitization and anxiolysis, desensitization to targets of aggression is also useful in many cases of dominance and territorial defense.

Dominance Aggression

By conventional definition, dominance-related aggression[18] is directed to owners in competitive contexts, in response to dominant-appearing postures or interactions by the owner, and is exhibited (at least by definition) with self-confident, rather than submissive, postures by the dog. However, dogs often exhibit fearful or ambivalent postures during threats; fearful, territorial and even predatory behavior can contribute to dominance-related aggression. An association between territorial and dominance-related aggression has been reported[11, 19, 20]. In general, if aggression is related to social competition or the perceived rank order in the home, and is not elicited solely in fear-inducing contexts, it is at least partly attributable to dominance.

Dominance-related aggression tends to appear most dramatically at social maturity, between the ages of 1 and 3 years. More typically a male behavior, it can be seen in either sex. Although some breeds appear predisposed to this type of aggression (examples are the Cocker and English Springer Spaniels, Lhasa Apsos, Rottweilers and Akitas), it has been seen in virtually all pure breeds.

Dominance-related aggression is seen in the following circumstances: When the dog is protecting possessions, such as dog food, human food, rawhide, garbage, toys, stolen objects or anything perceived as "special"; when the dog is approached, spoken to or physically disturbed while sitting or lying on furniture or in any area perceived as a bed or den; when a favored family member is approached, touched, or otherwise engaged by another familiar person; or when the dog perceives certain intentions, postures, communication or other behavior by a family member as a violation of its high social rank. This would include overt provocations such as verbal or physical punishment as well as more subtle interactions such as petting.

Territorial Aggression

Territorial aggression is, by conventional definition, directed toward unfamiliar people: visitors, delivery persons, and pedestrians. The signalment is similar to that of dominance-related aggression. Again, although it may be seen in any pure breed, certain breeds, particularly the guard breeds (e.g., Rottweiler, German Shepherd Dog) and terriers, appear predisposed to this type of aggression. In general, complaints of stranger-directed aggression are fewer than those of dominance-related aggression, presumably because this behavior is less alarming, or more understandable, to owners. However, territorial aggression can be a serious problem because of risks to visitors (including children) and for reasons of liability.

Fear-related Aggression

Fear-related, or defensive, aggression can be displayed toward either family members or unfamiliar people. Owners may elicit a fear-related growl or bite when punishing their pets. Such behavior may be difficult to distinguish from dominance-related aggression without a detailed history of circumstances and postures assumed by the dog. At least in theory, fearful dogs attempt first to avoid the source of their fear, for example by escaping, and will bite only when directly confronted. Fear-related aggression may be displayed by either sex, at any age. All breeds are affected; severely fearful dogs can be either genetically predisposed or environmentally conditioned (or both). Poor early socialization can result in insecurity and defensiveness. There may be a significant component of fear in territorial aggression. This type of aggression is best treated as a form of anxiety disorder, with appropriate anxiolytic drug therapy (when indicated) and desensitization to fear-inducing stimuli.

Predatory Aggression

Although its inclusion in the classification of aggression is controversial, predatory aggression can be a serious problem. Dogs are predators and will easily catch and kill smaller animals. Clinically this problem may

appear as aggression (chasing, capturing, biting) towards cats or other small mammals or birds in the home. Fatal attacks on human infants, children and the elderly have been reported in the literature [21-24]. Many are presumed to be predatory because of the facilitation of aggression by dog packs and because of partial ingestion of the victims. Predatory behavior is a strong drive in some dogs and cannot reliably be changed. For this reason prevention (rather than treatment) is most important. Infants should never be left untended, whether asleep or awake, with dogs.

Neurobiology of Aggression

Current research suggests a relationship between aggressive behavior and the neurotransmitter serotonin (5-hydroxytryptamine, 5-HT) in a variety of animal species and in humans [25-30]. In a study of rhesus monkeys, for example, there was a negative correlation between cerebrospinal fluid (CSF) concentrations of the serotonin metabolite, 5-hydroxyindoleacetic acid (5-HIAA), and a high frequency of aggressive displays[27]. Low CSF 5-HIAA is also correlated with particularly intense or severe aggression[28]. Extensive work on the role of brain serotonin and other monoamines in aggression has been done in humans[30-38]. Brain serotonin appears to modulate aggression by inhibition of impulsive behavior [28, 31, 33].

Although pathology has been suggested in cases of severe dominance-related aggression[39], findings have been inconsistent [16, 40]. In a recent post-mortem study performed by the author, dominant-aggressive dogs had lower levels of CSF 5-HIAA than non-aggressive dogs[41]. Furthermore, the sudden and poorly inhibited nature of canine dominance-related aggression may reflect reduced impulse control, an hypothesis supported in the same study, in which a subset of the aggressive dogs with a history of attacking without warning had lower levels of CSF 5-HIAA than dogs who growled[41].

Genes and Aggression

There is both clinical and research-generated evidence that the tendency toward aggressiveness is (in some cases) genetically linked. Breed predisposition suggests it: the English Springer Spaniel, for example, is presented to behaviorists for dominance-related aggression in numbers disproportionately high relative to regional breed distributions[42] and to national breed-registration statistics[1]. At least one well-known kennel, and at least one of its sires, has been statistically associated with aggressive behavior in the breed [19]. However, at this point heritability has not been confirmed.

Evidence of a genetic basis for aggressive behavior has been found in the laboratory animals and in humans. In a recent study of transgenic mice, lack of a serotonin receptor subtype (5-HT1B) resulted in increased intensity of aggression[43]. A familial defect in monoamine oxidase A (MAO A), an enzyme responsible for metabolism of 5-HT and other monoamine neurotransmitters, has been linked to impulsive aggression in a human family[44].

Physical or Behavioral?

Considering the well-established evidence that behavior changes, including "normal" learning, have neuroreceptor (and therefore neurochemical) associations, the distinction between physical and behavioral problems is no longer clear. Whether through direct studies of structural and chemical changes, or through clinical studies of the effects of psychotropic drugs, the understanding of these associations continues to grow.

General Management of Aggression

Safety Issues

Although the risk of biting (regardless of diagnostic category of aggression) will never be completely eliminated, it can be reduced in many cases. An advantage of the full behavior consultation, with thorough history-taking, counseling and demonstration of basic control techniques, is the time devoted to educating dog owners about issues of safety. Regardless of what else the owner is able or willing to do at home, they will need to know how to avoid future bites. These are the "facts of life" in living with an aggressive dog -- particularly one with a history of biting. The owner may not want to face the prospect of permanent caution, but it is the clinician's responsibility, once asked, to emphasize safety.

1. Change or avoid specific circumstances in which aggression is elicited.

2. Avoid physical corrections and punishment, which can elicit a bite. In general, advice to "show the dog you are the leader" can backfire, particularly with dominant-aggressive dogs.

3. Always actively supervise with, or separate from, young children. Supervision may not be adequate (i.e. leash control or muzzling may be necessary).

4. Accustom the dog to a wire muzzle for routine use. Even while muzzled, aggressive dogs should still be supervised in some circumstances.

Drug Therapy

By far, the most frequently sounded request from pet owners is for a drug to cure their dogs' aggressive behavior. In general, the suggested response is to treat the behavior problem as a whole (with a full consultation) and not to rely on drugs alone, for several reasons. First, there is no generally efficacious "aggression drug" just as there is no unitary etiology for biting behavior (or, for that matter, for human violence). Second, of the drugs currently prescribed for aggression, none is approved for such use. Any psychotropic drug can have unexpected results, including increased agitation, and can increase clinical liability as well. Further studies are needed before specific indications are identified. Finally, in some cases the use of medication may lead to owner complacency and laxity of supervision. Just as in human psychiatry, quick fixes are unlikely for

complex behavior patterns. Duration of treatment ranges from short-term relief of anxiety (e.g. during behavior modification), to long-term use.

Anxiolytics : May be useful for anxiety- or fear-based aggressive behavior, or for aggressive dogs with a history of anxious behavior. While some drugs are specifically designed to reduce anxiety (buspirone), others are nonspecific (tricyclic antidepressants; TCA). May require 6-8 weeks for therapeutic effect.

Buspirone	BuSpar	5 mg per dog BID-TID small dogs; 10 mg per dog TID large dogs	Side effects are few; expense may be prohibitive in medium to large dogs. May disinhibit aggression.
Amitriptyline	Elavil	2.2 mg/kg SID-BID	Anticholinergic; possibly arrhythmogenic; antihistaminic; contraindicated in glaucoma, hx of seizures, hyperthyroid conditions.
Clomipramine	Anafranil	1.0 mg/kg BID for 2 weeks; 2.0 mg/kg BID for 2 weeks; target dose 3 mg/kg BID	Potent tricyclic effects (See amitriptyline effects). Maximum daily dose 200 mg for dogs. Cardiac rhythm strip pretreatment (TCA effects = flattened T waves & prolonged QT intervals. Serotonin reuptake inhibition > amitriptyline.

Specific serotonin-reuptake inhibitors : A relatively new class of psychiatric antidepressant, SSRI's do not affect the cholinergic, histaminergic and adrenergic systems as do the tricyclic antidepressants. May reduce aggressive behavior, although clinical evidence is meager in both psychiatric and (especially) veterinary literature. Most useful purpose may be in reduction of impulsive behavior. May require at least 6-8 weeks for therapeutic effect.

Fluoxetine	Prozac	0.5-1.0 mg/kg SID	Nervousness; insomnia; inappetance. Expense may be prohibitive in medium to large dogs.
Sertraline	Zoloft	?	Not commonly used
Paroxetine	Paxil	1.0 mg/kg SID	Rarely used; effects and appropriate dose undetermined.

Mood stabilizers : Lithium carbonate is the drug of choice for bipolar (manic depressive) disorder in humans, and has been shown to reduce aggressive behavior across a range of psychiatric disorders. Its use in veterinary medicine is rare, probably because of the required close monitoring of blood levels, and behavioral effects (in dogs) are not well studied.

Lithium carbonate	0.6 mg/kg BID	Blood levels must be monitored and titrated; clinically effective range (0.8-1.2 mEq/l) close to toxic range.

Progestins : No longer commonly used because of potential long term adverse effects, synthetic progestins may be useful in the treatment of sexually dimorphic aggression (e.g. dominance-related or territorial).

Megestrol acetate	Ovaban	2.2-4.4 mg/kg SID for 2 weeks; decrease dose by 1/2 every 2 weeks.	Synthetic progestin; long term adverse effects include endocrinopathy, mammary hyperplasia or adenocarcinoma.
Medroxy-progesterone acetate	Depo-Provera	5-10 mg/kg SQ, IM	(See megestrol acetate comments)

Anticonvulsants : The treatment of aggressive behavior with anticonvulsive agents remains controversial. Anticonvulsives have been used spottily in the treatment of sudden aggression because of its putative resemblance to seizure behavior. Carbamazepine has been used in human psychiatry for psychomotor seizures -- however, diagnosis in dogs is ambiguous, and the T1/2 very short. Barbiturate administration may depress aggression by sedation but effects are nonspecific.

Phenobarbital	1-2.5 mg/kg BID	Monitor blood levels and adjust dose; therapeutic range 15-40 mcg/ml
Carbamazepine Tegretol	4-8 mg/kg BID (?)	Rarely used.

Behavior Modification

It is possible to change behavior, whether by changing the brain (with drugs), changing the environment (avoiding the targets of aggression when possible), or by passive or active (direct) modification of the aggressive behavior through training, or operant conditioning.

1. Passive behavior modification

a. Withdrawal of attention. Dogs are social animals, and their relationship with their owners, even if contentious, is primary. Attention from owners is therefore at a premium, and if handled selectively, can be used to control dogs without the risks of physical

punishment. Petting, speaking and general attention can be rationed, for example, by giving none for 2 weeks, then offering attention only at the owner's initiative for 2 weeks, then settling into a more permanent pattern in which owners pay attention only sometimes (if the dog solicits), and then requiring that the dog first obey an obedience command.

b. Nothing in life is free. Dogs are conditioned to defer most choices to the owner by being told to sit or lie down before any and all positive events (being fed, petted, going for a walk, etc.). In the long term, this tool is very useful for helping owners regain control and "dominate" the dog's activity.

c. Keep four feet on the floor. Because height is a social signal of control, dogs must not be permitted on furniture or on laps, or to jump up on owners (this includes "hugging" and "dancing"). Similarly, pawing and nudging should no longer be reinforced.

d. Heighten importance of owner's "critical resources". Dominant-aggressive dogs often "protect" socially meaningful places and possessions, including food. For this reason it may be helpful to keep the dog away from the dining table during meals, to feed the dog last, and to keep the dog out of the bedroom (or any room in which he has exhibited such "protective" behavior). This would also apply to interfamily relationships -- if the dog has interfered, for example, with interactions between family members, the priority should be for family members to sit/interact in proximity.

e. Reduction of physical freedom; increased leash control. On-leash exercise should be increased, while free time in the yard should be reduced or, ideally, eliminated.

2. Active behavior modification

a. Head collar (Gentle Leader®) with leash control. A head collar allows most owners to control their dogs better than they previously did. The collar is fitted intentionally on the muzzle in a way that asserts the handler's control (or "dominance"). Collars should be used sensibly for this purpose: for some dogs, the collar is used only during walks, while for others it is suggested for all times the dog is awake (and the owners home).

b. Obedience training. Although obedience training alone will not solve aggressive behavior problems, it is an important tool in treatment protocols. The purpose is threefold: first, owners appreciate assistance in regaining (or gaining for the first time) voice control over their dogs. Second is the use of obedience commands to change the dog's motivation for the moment, or to interrupt aggression. Third, using the "sit-stay" or "down-stay" commands produces a submissive posture -- if used repeatedly the dog learns to relax its vigilance. The training program takes advantage of such relaxation by then introducing desensitization (see below). A structured program is recommended, in which owners practice for a prescribed period once or twice daily. Positive reinforcement is important and may be accomplished with food,

toys, or anything for which the dog will "work". The most successful owners are those who work for brief periods consistently, end each session on a positive note, and do not ask the dog to perform beyond its ability.

c. Desensitization and counter-conditioning. After the above suggestions have been applied for at least one month and the owner has demonstrated reliable control in "stay" commands, the dog may be ready for exposure to the specific stimuli that historically had provoked aggression. The stimulus is controlled and gradually increased in intensity, while the dog is "counter-conditioned" to relax and await reward for his tolerance. For dominant-aggressive dogs, this would include physical control, petting, hugging and other manipulations. For territorially aggressive dogs this would include approaches by strangers both indoors and outdoors. Exercises may (and often do) require use of a wire muzzle. It is very important to remind owners that, in spite of such efforts, the dog will probably never be completely reliable in these situations. Startle responses (such as snapping when woken) are unlikely to change.

Prognosis

Success in the treatment of aggression depends on several factors, which can be divided into those involving the owner and family, and those involving the dog.

Owner factors : Dogs with a history of biting will always have the tendency to bite. First, then, is a willingness to accept (and to deal with) risk. Households with small children (residents, relatives or visitors) are at increased risk, as are those with physically compromised or elderly people. In addition, there should be a willingness to follow through with recommendations. Many aspects of treatment, including drug therapy in some cases, are intended to be long-term or permanent. If risk factors are high, euthanasia may be the only safe treatment option.

Dog factors : In a retrospective study of dominant-aggressive dogs euthanized because of their behavior [45], risk factors included lack of predictability of aggression, relatively larger size of the dog, and aggression disproportionate to the stimulus (specifically, a greater tendency to bite in response to benign circumstances such as petting). These might be extrapolated to other classifications of aggression as well. Further prediction of response to treatment is either speculative or anecdotal. The behavior of dogs that fail to inhibit aggression (for example, those that bite rather than simply warn, or those that bite several times in one episode) may be more difficult to change. "Rage"-like behavior (still poorly defined but probably a range of behaviors including unpredictability and impulsivity, poor inhibition, or sudden behavior changes2) is likely to have a poor prognosis.

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