Correlation between subjective and objective measures used to determine severity of postoperative pain in dogs

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Objective—To determine the association between subjective and objective variables commonly used to evaluate severity of postoperative pain in dogs.

Design—Prospective double-blind study.

Animals—36 dogs with unilateral rupture of the cranial cruciate ligament that underwent surgery to stabilize the stifle.

Procedure—Each dog was assessed to determine severity of pain before and after surgery, using various subjective and objective criteria.

Results—Subjective measures of pain (scores for visual analogue and numerical rating scales) correlated poorly or were not correlated with heart rate, respiratory rate, blood pressure, and results of a pain threshold test. Scores for visual analogue and numerical rating scales correlated with each other and with the amount of vocalization at most time periods.

Clinical Implications—We detected a weak association between commonly employed subjective and objective measures of pain. This indicated that some of these measurement techniques do not predictably reflect severity of postoperative pain in dogs. Therefore, clinicians should not rely too heavily on these variables when assessing severity of postoperative pain in dogs. (*J Am Vet Med Assoc* 1997;210:1619–1622)

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage.[1-3] Empirically and logically, animals experience pain. Consequently, 1 goal of veterinarians is to manage pain in animals. Prior to this step, however, accurate recognition and assessment of severity of pain must be performed.

Limitations on physical and verbal communication leave interpretation of signs of pain in animals to observation of behavior. Quantification of these behaviors can be performed using variations of a **visual analogue scale (VAS)** or a **numerical rating scale (NRS)**. Visual analogue scales often are used by human patients to evaluate the severity of their pain.[4-6] Patients indicate the intensity of their pain by placing a mark on a line on which the left end represents no pain and the right end represents the most pain possible. When a VAS is used for interpreting pain in animals, animals are observed and the location on the line at which to place the mark is determined by an observer.[7-10] Numerical rating scales, which are used in human[1,11-14] and veterinary[10,15-18] medicine, apply numerical values to purposeful behaviors. For example, vocalization scores may range from 0 points for no vocalization to 3 points for the most vocalization possible.

Determining pain threshold requires identification of the earliest point on a continuum of increasing stimulus intensity that separates nonpainful from painful stimuli.[3,19,20] This method of pain evaluation must be carefully controlled for the procedure to yield consistent and meaningful results.[3,19,21] Because animals cannot communicate when a stimulus first becomes painful, this may be more accurately described as a stimulation threshold test in which the amount of stimulus an animal will tolerate before reacting is determined. We cannot know whether an animal is reacting before, after, or at the exact moment at which the stimulus becomes painful.

Physiologic postulates have been derived that explain ways in which a painful stimulus could alter the autonomic nervous system in a manner that could be objectively measured.[3,16,22,23] Autonomic indices such as serum cortisol[16,23] or catecholamine[24,25] concentrations, **heart rate (HR)**,[15,18,26] **respiratory rate (RR)**,[9,15,26] or blood pressure[9,15,27] have been used with varying results in previous studies of pain in animals. To our knowledge, studies correlating physiologic variables with subjective evaluations of pain have not been performed.

The goal of the study reported here was to determine the association between subjective and objective variables commonly used in clinical practice to evaluate severity of postoperative pain in dogs. In addition, we hoped to determine whether the association changed during the first 24 hours after surgery.

Materials and Methods

Thirty-six dogs with ruptured cranial cruciate ligaments that had been used in a previous study[9] were included in our prospective double-blind study in which we evaluated analgesic effectiveness of intra-articular medications. In each dog, severity of pain was evaluated by measuring changes in several variables from pre- to postoperative time periods. Heart rate was measured by auscultation, RR was determined by observation, and **mean arterial pressure (MAP)** was measured indirectly, using oscillometric monitoring.[a] To subjectively measure pain in dogs, VAS and NRS were used. The VAS involved an observer placing a mark on a line (representing no pain at the left end and the most pain possible at the other). Score (0 to 10) was determined by measuring the distance from the left end of the line to the mark. The NRS involved assigning a point score to predetermined behaviors and activities (Appendix). Pain threshold

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in both stifles was measured objectively,[9] using a load cell.[b] Steadily increasing amounts of pressure were applied via the round, blunt piston (1 cm in diameter) of the load cell, which was placed medial to the patellar tendon, until the dog had a negative response.[9] Negative responses included pulling the leg away from the load cell, turning the head toward the joint being tested, or vocalizing. When 50 N of force was applied but a pain threshold was not reached, the test was discontinued. This testing method was performed on the clinically normal and affected stifle of each dog. All evaluations and pain scores throughout the study were performed at each time interval by 1 of 2 investigators (MGC or JLS), who were not aware of the intra-articular drug received or of the group assignment of each dog. To measure consistency between observers, 20 other dogs were independently scored by both observers, using subjective criteria for VAS and NRS.

Subjective evaluations of pain were made prior to the objective measurement of the pain threshold. Heart rate, RR, MAP, VAS and NRS scores, and pain threshold on each stifle were recorded prior to surgery, at the time of extubation (time 0), and at 1, 2, 3, 4, 5, 6, and 24 hours after surgery. All measurements for a given dog were made by the same investigator.

Association between percentage change from preoperative values in HR, RR, MAP, pain threshold, VAS and NRS scores, amount of vocalization (a component of the NRS), and duration of surgery and anesthesia for each dog was calculated at each time period, using Pearson's product-moment correlation coefficient. This method produced a unitless correlation coefficient (r) with a value between –1 and 1, reflecting the intensity of the association among measured variables. A value of 0 indicated that there was no association, whereas values of –1 and 1 indicated perfect inverse or direct correlations, respectively. A value of $P \leq 0.05$ was considered significant. A kappa test was performed to evaluate extent of agreement between observers.

Results

Agreement was high (κ value > 0.90) between the 2 observers for independently assigned subjective scores (VAS and NRS) of the 20 other dogs.

A variable-based correlation matrix was generated from data for each time period. A significant correlation ($r = 0.84$; $P < 0.0001$) existed between duration of surgery and duration of anesthesia.

The VAS scores correlated significantly with NRS scores at every time period and correlated significantly with vocalization at every time period except 24 hours after surgery, when none of the dogs vocalized. The VAS scores correlated significantly with increases in RR at 1, 3, 4, 5, and 6 hours after surgery, did not correlate significantly with HR, MAP, or duration of surgery at any time period, and correlated significantly with duration of anesthesia and inversely with results of the pain threshold test at only 1 of 8 time periods.

The NRS scores correlated significantly with vocalization at every time period except 24 hours after surgery, correlated significantly with increases in RR at 1, 4, 5, and 6 hours after surgery, but did not correlate significantly with the pain threshold, HR, MAP, or duration of surgery or anesthesia at any time period. Amount of vocalization correlated significantly with RR at 1, 4, 5, and 6 hours after surgery.

Results of the pain threshold test had a significant inverse correlation with duration of surgery at 2, 3, 4, and 5 hours after surgery and with duration of anesthesia at 2, 3, and 4 hours after surgery. Results of the pain threshold test also had a significant inverse correlation with VAS at 6 hours after surgery.

In addition, RR correlated significantly with MAP 1 hour after surgery. Heart rate correlated significantly with MAP at every time period, but only correlated significantly with duration of surgery at 5 hours after surgery. Mean arterial pressure correlated significantly with duration of surgery at 2 and 3 hours after surgery.

Discussion

Successful management of pain in animals must begin with an accurate assessment of the degree of pain. Recognizing and classifying severity of pain starts with observing the animal. This subjective investigation is complicated by many factors. First, animals cannot verbally communicate about pain. Second, observed behavior may not accurately reflect intensity of pain.[5,23] Degree of domestication and socialization of an animal will influence the animal's perception of whether it is advantageous to display overt behavior.[23] Third, the function of a particular behavior may vary among animals. A dog vocalizing during the postoperative period may be expressing pain; however, vocalization also may represent anxiety, fear, or anesthesia-induced delirium. Fourth, philosophic differences of observers, clinicians, and investigators can result in multiple interpretations of the same observation.[5,23]

Visual analogue and numerical rating scales have been used to evaluate pain in human infants, laboratory animals, and dogs and cats in veterinary clinics. Results of a previous investigation[10] support our finding that VAS and NRS give reproducible results, even when used by multiple observers. In pediatric medicine, a strong correlation exists between ratings provided by patients and ratings of their caregivers, using either scale.[5] Although the scales appear to be similarly precise and accurate, they are not interchangeable; the VAS is reportedly more sensitive.[5,10]

The VAS scores were significantly and consistently correlated with increases in vocalization and RR. This can be explained by the fact that vocalization and respiration are easily detected and, thus, have a greater influence on observers than other measured variables. When increases in vocalization and RR are attributable to increases in pain, VAS is potentially a good technique for measuring severity of pain. Intuitively, other factors, such as anxiety and delirium, affect vocalization and RR. Unless these other factors are identified and controlled, use of a VAS to measure severity of pain often will be misleading.

Pain threshold tests on animals, when well controlled, are considered to be excellent measures of severity of pain and are commonly used in laboratories.[19,20,28] We controlled for variation in our pain threshold test by comparing preoperative with postoperative examinations in the same animal and by comparing the affected stifle with the clinically normal stifle at each time period. In the study reported here, 35 of 36 (97%) dogs reached the maximum of 50 N in the clinically normal stifle before and after surgery. In contrast, only 2 of 36 (6%) reached the maximum force in the affected stifle after surgery. We concluded that decreases in amount of force applied to the affected stifle after surgery necessary to elicit a response were attributable to heightened sensitivity of the dog (ie, an increase in pain in that stifle). It is unlikely that the degree of anesthetic recovery caused this heightened sensitivity, because changes were not detected in the contralateral clinically normal stifle. Empirically, we believed this measuring technique was the most accurate means of measuring pain in dogs. We often found dogs that would vocalize as if in pain, but they were not sensitive to the pain threshold test (ie, correlations were not significant between the affected and clinically normal stifle). Likewise, some dogs would be resting quietly and would allow the maximum of 50 N to be applied to their clinically normal stifle, but had decreased thresholds in the affected stifle. We believed that these dogs had pain in that stifle. Surprisingly, results of the pain threshold test rarely correlated with VAS scores and never correlated with increases in NRS scores, vocalization, HR, RR, or MAP. If the pain threshold test we performed was an accurate measure of pain, all other variables we measured were not. Results of the pain threshold test for the affected stifle did have a weak, but significant, inverse correlation with duration of surgery at 4 of the 8 postoperative evaluations. Theoretically, as surgery time increases, tissue damage may increase, predisposing for more pain after surgery. In human beings, however, the amount of tissue damage does not necessarily equate to the amount of postoperative pain.[3]

Heart rate and MAP are physiologic variables that have been used to monitor severity of pain in animals in laboratory situations and in veterinary and human hospitals. Pain may increase HR and MAP; however, these are complex physiologic variables that can also be altered by fear,[29,30] stress,[29,30] degree of anesthesia,[27,29-33] and vascular volume. In our study, except for significant correlations between each other at all time periods, HR and MAP did not correlate with other variables. We attributed this to the probable confounding effects of fear, stress, or anesthesia; therefore, we cannot recommend measuring HR and MAP to determine whether an animal is in pain. If degree of stress in an animal can be decreased by use of an antianxiety drug, it is possible that correlations between HR and MAP and other variables could become evident. In addition, blood concentrations of cortisol, epinephrine, and norepinephrine might be more meaningful.[25,29]

Degree of recovery from anesthesia did not appear to play a role in the association among variables. We hypothesized that as dogs recovered from anesthesia, subjective evaluations would be more strongly correlated with physical variables as a result of decreased confusion between signs related to pain and those related to anesthetic recovery. However, this was not the case. A pattern of correlations among variables did not develop over time. It is possible that the evaluators of pain in this study were aware of this potential problem and developed internal guidelines to overcome it. In addition, postoperative analgesics were given to 8 dogs in this study, which could have affected variables that were measured (ie, MAP or vocalization may have increased or decreased in response to a drug rather than in response to pain), further complicating interpretations of severity of pain. Given the poor correlations between subjective and objective variables for determining severity of pain, it is unlikely that the supplemental analgesics used in this study substantially altered the results.

Fundamentally, signs of pain are a subjective behavior unique for each animal. Given the complexity of perception of pain, it is unlikely that a single, reliable, objective measure of pain exists. We found surprisingly few correlations existed between subjective and objective measures of severity of pain. Analysis of our results, unfortunately, did not enable us to suggest any guidelines for measuring severity of pain in animals. In fact, analysis of our results revealed that when some of these measures were related to pain, others clearly could not be. However, as misleading and challenging as pain evaluation may be, it is an essential part of animal care. We recommend that clinicians consider the likelihood for a specific procedure to cause postoperative pain. When the likelihood is high, as with arthrotomies and thoracotomies, we recommend that analgesics be used, regardless of an animal's behavior. Additionally, when risk from the use of analgesics is low, we recommend use of analgesics, especially when uncertainty exists regarding the postoperative pain status of an animal.

[a]Dinamap vital signs monitor 8100, Critikon Inc, Tampa, Fla.
[b]Pain Diagnostics and Thermography Inc, Great Neck, NY.

Appendix

Numerical rating scale used to assess severity of pain in dogs

Observation	Score	Criteria
Vocalization	0	No vocalizing.
	1	Vocalizing, responds to calm voice and stroking.
	2	Vocalizing, does not respond to calm voice and stroking.
Movement	0	None.
	1	Frequent position changes.
	2	Thrashing.
Agitation	0	Asleep or calm.
	1	Mild agitation.
	2	Moderate agitation.
	3	Severe agitation.

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