Subjective and objective measurements of postoperative pain in cats

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Objective—To evaluate the ability of various subjective and objective measurements to determine the presence and degree of postoperative pain in cats.

Design—Randomized controlled prospective clinical study.

Animals—18 healthy client-owned cats.

Procedure—Cats were randomly assigned to 3 groups of 6: control, tenectomy, and onychectomy. Jugular catheters were placed the day prior to surgery. All surgeries were performed by the same surgeon, and all observations were made by the same blinded trained observer. One hour prior to surgery and at assigned intervals for 36 hours after surgery, heart rate, respiratory rate, and rectal temperature were measured. Scores were assigned for 3 interaction responses, including response to palpation, by use of simple descriptive scales, and to 2 pain assessment by use of visual analogue scales. Blood was collected to measure plasma β-endorphin and cortisol concentrations. Butorphanol was administered to all cats before surgery and to any cat subjectively assessed to be experiencing pain after surgery.

Results—Only visual analogue scale scores and response to palpation scores differed significantly between control and surgical groups.

Conclusions and Clinical Relevance—Determination of the presence of pain in cats can be made on the basis of observation and interaction by a trained observer. Physiologic measurements, including plasma cortisol and β-endorphin concentrations, did not differentiate between control cats and cats that underwent surgery. J Am Vet Med Assoc 2000; 217:685–690

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage; furthermore, pain in animals is an aversive sensory experience that elicits protective motor actions and results in learned avoidance.1 The detection of pain is one of the most challenging problems in medicine and biological studies. Its importance goes beyond the obvious humanitarian consideration; it can induce biological studies. Its importance goes beyond the one of the most challenging problems in medicine and is believed to be triggered by stress. In horses, concentrations of endogenous opioids can substantially modify the intensity of pain and cause generalized analgesia.9 β-Endorphins are endogenous proopiomelanocortin-derived opioids released primarily from the adenohypophysis. Their release is believed to be triggered by stress. In horses, concentrations of endogenous opioids can substantially modify the intensity of pain and cause generalized analgesia.9 β-Endorphins are endogenous proopiomelanocortin-derived opioids released primarily from the adenohypophysis. Their release is believed to be triggered by stress.

The use of pain scales to record pain intensity is well established for human patients and is becoming more common in veterinary medicine.5,11 There is, however, a fundamental difference: human patients score their own pain on the various scales,1 whereas pain assessment in animals requires an observer. A variety of scales have been used for assessing pain in humans and animals.14-15 In those used to evaluate pain in nonverbal patients such as young children and dogs, observers apply values to multiple described behaviors, the sum of which provides the final pain score. One such simple descriptive scale (SDS), the University of Melbourne Pain Scale (UMPS), is effective at assessing postoperative pain in dogs.17

An alternative to numerical rating scales such as the UMPS is the visual analogue scale (VAS). The VAS is characterized by a 100-mm line, with 0 mm representing no pain and 100 mm representing maximal pain. The observer places a mark along the line between 0 and 100 at a point that best describes the severity of pain that the patient seems to be experiencing. Visual analogue scales are most reliable in the hands of observers who are experienced or trained in interpreting the signs of pain,14 because the VAS expresses a summary of the observer’s accumulated interpretations rather than a series of scores for predefined categorized behaviors. The VAS has been widely used in clinical trials that compared the efficacy and timing of perioperative administration of analgesics in rodents, cats, and dogs.9,10 In 2 studies, VAS results were well correlated with those of objective mechanical nociceptive thresholds.10,11 The effectiveness of the VAS scale may be enhanced by complementing the standard visual perceptions of appearance and behavioral responses with physical interactions.8,10,16 The use of pain scales for evaluation of presence and severity of pain would seem appropriate, because no single readily measured physiologic measurement (e.g., heart rate, body temperature, respiratory rate) has been consistently established as the standard for pain detection in dogs or cats.17-20

Neuroendocrine assays have also been used in an attempt to identify an indicator of pain that may be applicable to research studies. Catecholamine and cortisol concentrations have been correlated with postoperative pain in cats.19-21 Release of endogenous opioids can substantially modify the intensity of pain and cause generalized analgesia.8,9 β-Endorphins are endogenous proopiomelanocortin-derived opioids released primarily from the adenohypophysis. Their release is believed to be triggered by stress. In horses, concentrations of endogenous opioids can substantially modify the intensity of pain and cause generalized analgesia.8,9 β-Endorphins are endogenous proopiomelanocortin-derived opioids released primarily from the adenohypophysis. Their release is believed to be triggered by stress.
tions of β-endorphins have been correlated with acute stress. In cats, stress has been recognized as a potent inducer of CNS analgesia, with the response mediated by opioid receptors. In cats, acute stress induces as much as an 8-fold increase in plasma β-endorphin concentrations. To the authors’ knowledge, β-endorphin release in cats has never been determined in conjunction with other modalities of pain assessment.

Onychectomy (declaw) and tenectomy are elective procedures commonly performed on cats in North America to control property destruction and injuries caused by scratching. Many veterinarians consider onychectomy to be a moderately to severely painful surgery. In a recent survey of 470 Canadian veterinarians regarding their use of analgesics, 47% of cats received analgesics for onychectomy, compared with 16% for ovariohysterectomy. Pain severe enough to cause lameness or non-weightbearing of affected limbs has been reported to last 1 to 42 days after onychectomy. Cats undergoing flexor tenectomy may have only mild signs of pain immediately after the procedure; it is this benefit that is often highlighted when offering tenectomy as an alternative to onychectomy.

The purpose of the study reported here was to evaluate the ability of various subjective and objective measurements to determine the presence and degree of postoperative pain in cats. We hypothesized that onychectomy causes severe postsurgical pain in cats, flexor tenectomy causes less severe pain, pain induced by surgery causes substantial alterations in certain physiologic and subjective measurements, and these measurements would be useful in differentiating between the degrees of pain caused by onychectomy and tenectomy.

Materials and Methods

Cats—Eighteen client-owned cats admitted to Washington State University Veterinary Teaching Hospital for tenectomy or onychectomy were included in the study. The study was approved by the Institutional Animal Care and Use Committee. Permission was obtained from owners prior to inclusion. All cats were determined to be healthy by physical examination and measurement of PCV and concentrations of pooled cat sera provided displacement curves that best fit a compound symmetry model. The data best fit a compound symmetry model. For the categorical data, mean values for variables mea...
sured after surgery were compared among groups by use of the general linear model. All data were subjected to further analysis to compare groups for variables measured at the time when pain was considered to be greatest, termed the time of peak pain. This time was determined for each cat individually and was the time at which the highest IVAS score was recorded. If a cat had 2 identical peak IVAS scores, the peak time was determined by using the time at which the highest VAS and palpation scores were also recorded. Most identical peak IVAS scores were recorded in controls, with low or zero IVAS scores throughout the 36-hour recording period. Differences among groups were assessed by use of a logistic procedure for categoric data and a general linear model for continuously distributed data. Data were transformed to logarithms as necessary to conform to the normality assumption for parametric tests. Differences were considered significant at \( P < 0.05 \).

**Results**

In 1 control cat, 1 foot was inadvertently bandaged too tightly and became swollen and painful after bandage removal. This was the only cat in the control population to be given additional analgesics following surgery. Because the function of the control population was to serve as the pain-free standard, this cat was removed from the study.

None of the variables measured before or after surgery differed significantly among groups when compared at each assessment time point. In all groups, plasma cortisol concentrations at baseline (prior to surgery) were mildly increased (mean ± SD for all cats, 4.0 ± 0.68 µg/dl), compared with the reference range (0.5 to 3.5 µg/dl). Plasma cortisol values were lower (range for all cats, 2.6 to 3.3 µg/dl) immediately after anesthesia, compared with baseline values, and generally increased during the first hour after surgery and remained above reference range for the duration of the study (Fig 1). This increase in cortisol concentrations within each group was not significant and did not vary significantly among the 3 groups.

Plasma β-endorphin concentration did not vary significantly among the 3 groups, nor within each group as time progressed (Fig 2), and the concentration for all cats (mean, 28 pmol/L; range, 19 to 40 pmol/L) was within reference range (3.8 to 130 pmol/L).

Significant differences among groups were, however, detected for data recorded at the time of peak pain (Table 1). The time when pain appeared to be greatest ranged from 0 to 24 hours after surgery and was recorded at 8 hours after surgery for 9 of the 17 cats. There were significant differences among groups for VAS, IVAS, and response to palpation SDS scores at the peak pain time, with scores being higher for onychectomy and tenectomy groups than for the control group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control (mean ± SE)</th>
<th>Tenectomy (mean ± SE)</th>
<th>Onychectomy (mean ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>241 (15.9)</td>
<td>223 (7.3)</td>
<td>217 (13.4)</td>
</tr>
<tr>
<td>Respiratory rate (breath/min)</td>
<td>38.8 (4.5)</td>
<td>40.3 (3.4)</td>
<td>41.6 (5.5)</td>
</tr>
<tr>
<td>Rectal temperature (°C)</td>
<td>38.3 (0.2)</td>
<td>38.3 (0.2)</td>
<td>39.1 (0.4)</td>
</tr>
<tr>
<td>Response to approach</td>
<td>1.4 (0.4)</td>
<td>2.8 (0.5)</td>
<td>2.5 (0.2)</td>
</tr>
<tr>
<td>Response to stroke</td>
<td>1.6 (0.2)</td>
<td>1.6 (0.3)</td>
<td>2.1 (0.4)</td>
</tr>
<tr>
<td>Response to palpation</td>
<td>2.6 (0.2)</td>
<td>3.5* (0.2)</td>
<td>3.7* (0.2)</td>
</tr>
<tr>
<td>Visual analogue scale</td>
<td>0 (0)</td>
<td>2.8* (0.3)</td>
<td>2.3* (1.0)</td>
</tr>
<tr>
<td>Interactive visual analogue scale</td>
<td>1.0 (0.5)</td>
<td>4.8* (0.6)</td>
<td>5.3* (0.8)</td>
</tr>
<tr>
<td>Plasma β-endorphin (pmol/L)</td>
<td>25 (7)</td>
<td>22 (2.1)</td>
<td>27.7 (2.8)</td>
</tr>
<tr>
<td>Plasma cortisol (µg/dl)</td>
<td>4.8 (0.6)</td>
<td>5.4 (0.8)</td>
<td>6.6 (0.2)</td>
</tr>
</tbody>
</table>

*Significant (\( P < 0.05 \)) difference from control values.

To convert degrees C to F, multiply by 9/5 and add 32.

See Appendix 2 for descriptions of variables.
The SDS scores for response to the approach of the observer were greater for surgically treated cats, compared with control cats, but not significantly ($P = 0.08$). The use of butorphanol after surgery was greater in surgically treated cats, compared with control cats, but not significantly ($P = 0.053$). Additional butorphanol was administered at least once to 4 onychectomized cats and 4 tenectomized cats but not to control cats. Significant differences between tenectomy and onychectomy groups were not detected for any variable.

**Discussion**

Accurate detection of pain in animals is notoriously difficult. Detection of pain in cats is a particular challenge, because signs of pain in cats are often subtle. Recognition of pain will likely result in its treatment; results of surveys of the veterinary community indicate, however, that analgesia is most often withheld for fear of adverse consequences, despite a paucity of clinical reports suggesting such a risk. A review of analgesic administration in one institution revealed that, after 238 major surgical procedures, only 40% of patients received an analgesic in the postoperative period, and only 28% received an analgesic after recovery from general anesthesia. In this study, only 1 of 15 cats was given an analgesic after surgery. Two recent reviews of analgesic administration have identified increased use by veterinarians who have recently graduated. This may reflect a trend in increased awareness of, and education in, analgesic principles and use at teaching institutions.

An ideal method for determining the presence of pain should be highly sensitive, and the assessment criteria should be as simple as possible, requiring minimal training of veterinary staff. Personnel who authorize the administration of analgesics should have a certain degree of expertise in assessing pain, although pain assessment is a subjective analysis even when SDS are used. Minimizing variability among veterinary personnel in pain assessment is desirable for recording changes in the pain status in a patient and comparing analgesic regimens between patients.

In the study reported here, differences in heart rate, respiratory rate, and rectal temperature were not detected among groups. These variables are poor indicators of postoperative pain in cats. In our study, time was allowed before surgery for the cats to acclimatize to their surroundings, but it is unlikely that they acclimatized fully or that they would do so in a typical clinical situation. Thus, stress likely caused changes in these variables in control cats that were similar to changes in the surgically treated cats and reduced the usefulness of these variables as indicators of pain.

In our study, plasma $\beta$-endorphin concentration did not differ significantly among groups. Results of a previous study in cats indicate that $\beta$-endorphin concentrations increase after hypoxia, ether-induced stress, or acute tight limb restraint. In studies of humans, plasma $\beta$-endorphin concentrations are not correlated directly with pain, which is consistent with our findings.

In our study, plasma cortisol concentrations were not significantly different among groups, in contrast with results of a recent study in which significant differences in plasma cortisol concentrations were detected between cats that underwent ovariohysterectomy and cats in a control group; these differences may reflect variations in methodology. All cats in our study had their front feet bandaged, which alone increases plasma cortisol concentrations in cats. Also, all cats in our study received analgesics before anesthesia. In other pain assessment studies, opioid analgesics were not administered until after extubation.

Analgesics administered prior to the onset of a painful stimulus prevent central hypersensitivity, a phenomenon that results in an increased sensitivity to afferent stimuli when a nociceptive stimulus is transmitted to the spinal cord. Changes are induced in the CNS that result in a 10- to 200-fold prolongation in response to subsequent afferent stimuli. Although the exact mechanism is still under investigation, the changes are thought to be mediated by excitatory amino acids and neuropeptides, predominately in the dorsal horn. Once induced, the neural and behavioral responses to the noxious stimuli persist, even when the afferent nerves from the inciting site are blocked or sectioned. Administration of opioids prior to delivery of a noxious stimuli is believed to result in presynaptic and postsynaptic blockade of nociceptive stimuli, reducing the chemical changes that result in dorsal horn wind-up or central hypersensitivity. Use of analgesics in dogs before ovariohysterectomy results in lower pain scores, compared with scores in dogs administered analgesics after ovariohysterectomy is performed.

In the study reported here, significant differences for peak pain scores assigned by use of VAS and IVAS techniques were detected when comparing control cats with surgically treated cats. In comparison, the difference between peak SDS scores for response to palpation in surgically treated cats and control cats, although significant, was small. Identifying pain consistently by use of this measurement alone would be difficult.

The use of analgesics before anesthesia has been cited as the reason for lack of significant differences between study groups in some human pain studies. The importance of such use of analgesics in human clinical procedures has been difficult to establish because of the inability to eliminate effects of anesthetic agents and other drugs administered concurrently.

In the study reported here, we can only speculate that VAS and IVAS scores, as well as plasma cortisol concentrations, may have been higher in surgically treated groups if opioids had not been administered before anesthesia. Furthermore, differences between the 2 surgical groups may also have been significant if analgesics had not been administered.

A further explanation for lack of significant differences between the 2 surgically treated groups is that these pain scales may not be sensitive enough to detect small to moderate variances of pain. Adult humans can distinguish between 11 and 21 degrees of pain, whereas children using pictorial scales can distinguish only 6 degrees of pain.

In cattle and sheep, 3 to 4 degrees of pain may be
distinguished. In rodents, subjective observation of signs of pain induced by nociceptive stimuli and inflammation permitted differentiation between effects of only 3 or 4 doses of morphine. A pain-assessment tool that reliably allowed differentiation between 3 or 4 degrees of pain in cats would certainly be clinically acceptable, although it may not have the sensitivity to distinguish subtle differences that may be required for experimental studies. Although our sample size was small, we did not detect strong evidence that onychectomy was more painful than tenectomy.

As we strive to develop pain scales to permit improved pain assessment, we should remember that no scale will be 100% sensitive. The adverse consequences of pain are clear, so our goal should be to anticipate pain on the basis of previous experience and intuition and preempt its development, rather than wait for it to become evident. Scales can then be used to detect failed or insufficient analgesia or unexpected pain.

References

40. Woolf CJ, Wall PD. Relative effectiveness of C primary


Appendix 1
Signs indicative of pain in cats. Arrow indicates progression of signs associated with increasing severity of pain

Appendix 2
Criteria used to determine simple descriptive scores for assessment of pain in cats

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Cat’s response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer approaches</td>
<td>Approaches observer</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Does not approach observer but raises head</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No movement</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Withdrawal of head or body</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Avoidance; stands up to move away</td>
<td>5</td>
</tr>
<tr>
<td>Back is stroked</td>
<td>Does not approach observer but raises head and arches back</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No movement</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Withdraws head or body</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Avoidance; stands up to move away</td>
<td>4</td>
</tr>
<tr>
<td>Response to foot palpation</td>
<td>Approaches observer</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No response</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Withdrawal of foot</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Violent avoidance or struggle</td>
<td>4</td>
</tr>
</tbody>
</table>