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 assessments 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. 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 catabolism, impair respiration, delay wound healing, prolong periods of hospitalization, and increase morbidity and mortality.1-4 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.1-4 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.7 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,4 because the VAS expresses a summary of the observer’s accumulated interpretations rather than a series of scores for pre-defined 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.6,8-10 In 2 studies, VAS results were well correlated with those of objective mechanical nociceptive thresholds.8,9,10 The effectiveness of the VAS scale may be enhanced by complementing the standard visual perceptions of appearance and behavioral responses with physical interactions.9,10,11 The use of pain scales for evaluation of presence and severity of pain would seem appropriate, because no single readily measured physiologic measurement (eg, heart rate, body temperature, respiratory rate) has been consistently established as the standard for pain detection in dogs or cats.12-20

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.13-21 Release of endogenous opioids can substantially modify the intensity of pain and cause generalized analgesia.2 β-Endorphins are endogenous proopiomelanocortin-derived opioids released primarily from the adenohypophysis. Their release is believed to be triggered by stress. In horses, concentra-
tions of β-endorphins have been correlated with acute stress.11 In rats, stress has been recognized as a potent inducer of CNS analgesia, with the response mediated by opioid receptors.2 In cats, acute stress induces as much as an 8-fold increase in plasma β-endorphin concentrations.24 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.25,26 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.27 Pain severe enough to received analgesics for onychectomy, compared with 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.27 Pain severe enough to cause lameness or non-weightbearing of affected limbs caused by scratching.25,26 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.27 Pain severe enough to cause lameness or non-weightbearing of affected limbs caused by scratching.25,26

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 or 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 concentration of serum total protein. Cats were randomly assigned to 3 equal groups: control, tenectomy, and onychectomy.

Each cat was admitted to the hospital the day before surgery and housed separately in a secluded room throughout the period of investigation. Food was withheld for 8 to 12 hours prior to admission. Following initial examination, cats were briefly anesthetized by placing them in an anesthetic chamber and delivering oxygen (4 L/min) containing 5% isoflurane. Anesthesia was maintained with isoflurane delivered in oxygen via face mask. Indwelling jugular catheters were aseptically placed and protected by a light padded bandage. After recovery from anesthesia, cats were returned to their cages for acclimation. The same hospitalization site, holding cage, cage contents, and setup were used for each cat to minimize environmental variations.

Surgical procedures—On the day of surgery, cats were sedated 20 minutes prior to induction of general anesthesia by administration of butorphanol (0.2 mg/kg [0.09 mg/lb] of body weight, IM) and acepromazine (0.1 mg/kg [0.045 mg/lb], IM). General anesthesia was induced by administration of ketamine (5 mg/kg [2.3 mg/lb], IV). All cats were intubated, and anesthesia was maintained by administration of isoflurane in oxygen delivered by a nonrebreathing circuit. Duration of anesthesia was the same for all cats. All surgeries were performed by the same surgeon (KMT). The palmar surfaces of the front feet were shaved, and a 5-minute scrub with chlorhexidine was performed. Onychectomy was performed with nail trimming shears, and tenectomy was performed through a small incision over each deep digital flexor tendon, as described.23,24 Front feet of all cats were bandaged prior to recovery. Control cats were anesthetized, prepared for surgery, and bandaged in the same manner. Bandages were removed at the end of the study, and control cats were tenectomized or declawed as per owner's request.

Assessments—Prior to the commencement of the study, a review of the literature and survey of in-hospital clinicians and referral veterinarians regarding behavioral and postural appearance of cats with signs of various degrees of pain was performed. This allowed us to summarize guidelines regarding signs of pain in cats (Appendix 1) and provided a descriptive guide to VAS scoring. A pilot study of 2 cats was also completed to confirm the feasibility of measuring each variable and allow refinements to the protocol.

The following data were collected in the order shown: 1) SDS score based on response of the observer (Appendix 2); 2) VAS score based on observational assessment of pain; 3) SDS score based on response to a back stroke; 4) heart rate; 5) respiratory rate; 6) a 1-ml blood sample obtained from the jugular catheter for measurement of plasma β-endorphin and cortisol concentrations; 7) SDS score based on response to handling and palpation of the forelimbs; 8) an interactive VAS (IVAS) score based on assessment of the overall responses to the preceding interactions, including handling and blood sampling; and 9) rectal temperature.

Assessments were made 1 hour before surgery to establish a baseline and 0, 0.5, 1, 2, 4, 8, 12, 24, and 36 hours after stopping anesthesia. During the study, the same observer (AJC), blinded to the treatment, made all observations.

Butorphanol (0.2 mg/kg, IM) was given when pain was subjectively assessed by the observer to be substantial (≥3 on the IVAS scale), with a minimum interval of 3 hours between administration of each dose. Fresh food was offered 12, 24, and 36 hours after surgery. Blood samples were collected into cold heparinized glass tubes containing 50 μg of bacitracin and 1,000 units of trasylool to prevent peptide degradation.30 Samples were placed on ice and centrifuged at 5,000 X g at 4 C for 10 minutes, separated, and stored at −80°C until assays were performed. Plasma cortisol and β-endorphin concentrations were assayed by radioimmunoassay (RIA). The cortisol assay has been described.31 The β-endorphin assay used a human β-endorphin antiserum that cross-reacted with ovine β-endorphin (100%) and ovine β-lipotropin (15 to 20%) on a molar basis. The minimum detectable amount of β-endorphin was 3 pg/tube at 1:28,000 antiserum dilution. Gel chromatography from plasma extracts revealed a major β-endorphin component and a small β-lipotropin component, suggesting that the values obtained by this RIA represented mostly β-endorphin. The reliability of the β-endorphin RIA used in this study was supported by finding that serial dilutions of pooled cat sera provided displacement curves that were parallel to the curve generated by the β-endorphin standard. Therefore, it is likely that feline β-endorphin has a peptide sequence similar to that reported for other species, as has been suggested.32

Statistical analyses—Each continuously distributed variable was evaluated for the effect of treatment, time after surgery, and their interaction by use of a mixed procedure with time as the repeated measure and cat within treatment as the subject. The data best fit a compound symmetry model. For the categoric 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 receive 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 \( \pm \) SD for all cats, 4.0 \( \pm \) 0.68 \( \mu \)g/dl), compared with the reference range (0.5 to 3.5 \( \mu \)g/dl). Plasma cortisol values were lower (range for all cats, 2.6 to 3.3 \( \mu \)g/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 \( \beta \)-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</th>
<th>Tenectomy</th>
<th>Onychectomy</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 (breaths/min)</td>
<td>36.8 (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 (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 ( \beta )-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 \( \frac{9}{5} \) 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 any analgesic in the postoperative period, and only 28% received an analgesic after recovery from general anesthesia. In that 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 allowed before surgery for the cats to acclimatize was 4 hours. In other pain assessment studies, opioid analgesics were not administered until after extubation. 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, predominantly 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 stimulus 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. 19–22 In rodents, subjective observation of signs of pain induced by noxious stimuli and inflammation permitted differentiation between effects of only 3 or 4 doses of morphine. 23–24 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 care of our patients, 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.

<table>
<thead>
<tr>
<th>Signs of minimal pain</th>
<th>Signs of maximal pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stops interacting</td>
<td>Calls</td>
</tr>
<tr>
<td>Avoidance of eye contact</td>
<td></td>
</tr>
<tr>
<td>Ungroomed appearance</td>
<td></td>
</tr>
<tr>
<td>Reluctance to stretch or lie laterally</td>
<td></td>
</tr>
<tr>
<td>Hunched or retracted posture</td>
<td></td>
</tr>
<tr>
<td>Withdraws when approached</td>
<td></td>
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<tr>
<td>Salvation</td>
<td></td>
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<tr>
<td>Dilated pupils</td>
<td></td>
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<tr>
<td>Incessant licking</td>
<td></td>
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<tr>
<td>Vocalization</td>
<td></td>
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<tr>
<td>Growls or hisses when approached</td>
<td></td>
</tr>
<tr>
<td>Attacks when approached</td>
<td></td>
</tr>
<tr>
<td>Rigid and nonresponsive</td>
<td></td>
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</tbody>
</table>

### 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>
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</thead>
<tbody>
<tr>
<td>Observer approaches</td>
<td>Approaches observer</td>
<td>1</td>
</tr>
<tr>
<td>Does not approach observer but raises head</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No movement</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Withdrawal of head or body</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Avoidance; stands up to move away</td>
<td>5</td>
<td></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>No movement</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Withdraws head or body</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Avoidance; stands up to move away</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Response to foot palpation</td>
<td>Approaches observer</td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Withdrawal of foot</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Violent avoidance or struggle</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>