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RESEARCH PAPER

The influence of demeanor on scores from two validated feline pain assessment scales during the perioperative period

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Abstract

Objective To evaluate the effects of demeanor on validated pain assessment scales.

Study design Prospective, blind, clinical trial.

Animal population Thirty three adult domestic cats scheduled for orchiectomy.

Methods Cats were assessed for pain pre (baseline) and 1, 2, 4 hours postoperatively using two validated pain scales [Composite Measures Pain Scale-Feline (rCMPS-F) and UNESP-Botucatu multidimensional composite pain scale (psychomotor and pain expression subscales; U-B MCPS-psych and -painex)], and a demeanor scale. Return of sternal recumbency and postoperative feeding were recorded. Anesthesia consisted of a single intramuscular injection of dexmedetomidine-ketamine-hydromorphone with intratesticular lidocaine and atipamezole and meloxicam postoperatively. Following data collection, cats were assigned to two groups based on baseline demeanor scores (LO $\leq$ 5/21, 18 cats; HI $\geq$ 6/21, 15 cats) and data from each group compared.

Results Baseline demeanor predicted pain scores with the U-B MCPS-psych scale: baseline [LO 0 (0–0), HI 2 (0–6), $p = 0.0005$], 1 hour [LO 1 (0–5), HI 3 (1–5), $p = 0.02$], and 4 hours [LO 0 (0–2), HI 1 (0–6), $p = 0.01$]. A similar pattern was observed with the rCMPS-F. This resulted in more crossings of the analgesic intervention threshold in the HI group: U-B UNESP-psych (9 *versus* 1, $p = 0.005$) and rCMPS-F (23 *versus* 3, $p < 0.0001$). In contrast, U-B MCPS-painex scores did not differ between LO/HI groups: baseline ($p > 0.99$), 1 hour ($p = 0.34$), 2 hours ($p > 0.99$) and 4 hours ($p = 0.31$). LO cats ate sooner (61% *versus* 33% by 1 hour, $p < 0.0001$) despite similar times to sternal recumbency ($p = 0.48$).

Conclusions and clinical relevance Demeanor affected pain assessment with U-B UNESP-psych and rCMPS-F scales, but not U-B UNESP-painex scale. Demeanor had a significant effect on postoperative feeding. These data highlight the potential for demeanor to confound pain assessment.

Keywords behavior, castration, enhanced recovery after surgery, feline, temperament.

Introduction

Pain in cats is under-recognized and under-treated (Watson et al. 1996; Lascelles et al. 1999; Joubert 2001, 2006; Hugonnard et al. 2004; Williams et al. 2005; Hewson et al. 2006a, b). Though analgesic administration rates by veterinarians, for providing analgesia at any time perioperatively, for feline castration appear to have increased substantially over time, from 16% of respondents (958 respondents in total) surveyed in 1996 to 88% of respondents (326 respondents in total) surveyed in 2001, this still leaves a large number of castration procedures performed without analgesia (Lascelles et al. 1999; Hewson et al. 2006a).

Several international surveys have identified the use of analgesics perioperatively for common procedures (e.g. ovariohysterectomy, castration, fracture repair, dentistry) to be influenced by multiple factors (Watson et al. 1996; Lascelles et al. 1999; Hugonnard et al. 2004; Hewson et al. 2006b; Joubert 2006). These include the perception of pain associated with surgical procedures, a limited appreciation of pharmacology of analgesic drugs, year of graduation, the influence of animal health technicians, and the ability to assess pain. Regarding the latter, validated feline-specific pain scales have only recently become available (Brondani et al. 2013; Calvo et al. 2014). This represents an important advancement in our ability to accurately, reliably and sensitively assess pain in cats, and the application of a validated scale has recently been used to successfully apply the principle of Enhanced Recovery After Surgery (ERAS) to feline ovariohysterectomy surgery (Hasiuk et al. 2015). ERAS aims to improve post-surgical recovery by optimizing perioperative care. Through a multi-disciplinary, evidence-based approach, substantial improvements in recovery have been achieved, resulting in, for example, reduced complication rates and decreased hospital stay (Kehlet & Wilmore 2008; Varadhan et al. 2010; Spanjersberg et al. 2011; Lu et al. 2012).

The generalizability of these pain scales to a wide range of situations cannot be assumed. Scale validation is specific to the environment in which it was performed and may therefore be influenced by animal behavior, procedure, drugs and observers. As a result, the application of scales in a range of heterogenous settings is essential to assess generalizability of published scales (Streiner & Norman 2008; Oliver et al. 2014; Zeiler et al. 2014; Buisman et al. 2016).

Recently, the role of demeanor (temperament) in pain assessment has been raised as a potential confounding factor (Zeiler et al. 2013; Calvo et al. 2014). Both of the available feline pain scales include multiple behavioral assessments, with the potential that they could be affected by factors other than pain (Brondani et al. 2013; Calvo et al. 2014; Buisman et al. 2016).

The primary objective of this study was to evaluate the effects of demeanor on pain assessment. We hypothesized that when assessing pain with available validated feline-specific pain scales, cats with high demeanor scale scores (described as shy or aggressive) would generate higher pain scale scores as a result of the confounding effect of behavior. A secondary objective was to investigate the influence of demeanor on recovery by recording the time to return of sternal recumbency and time to eating.

Material and methods

The study was performed at the City of Calgary Animal Services Centre Clinic following institutional ethics approval from the University of Calgary Veterinary Sciences Animal Care Committee, operating under the auspices of the Canadian Council on Animal Care. Cats scheduled for orchiectomy were enrolled through the clinic shelter (consent provided by supervising veterinarian and shelter manager) or through the clinic's no cost spay-neuter program (informed owner consent).

A physical examination was performed on all cats before anesthesia. Age or approximate age, breed, weight and American Society of Anesthesiologists (ASA) physical status classification were recorded (Anon 2014). Exclusion criteria were aggressive behavior that would prevent safe application of behavior scales, body mass < 1.5 kg, ASA status > 1, postoperative hypothermia (< 36.0°C), postoperative hyperthermia (> 39°C), incomplete administration of intramuscular (IM) premedication, cryptorchidism and cats scheduled to undergo any additional procedure during the same anesthetic episode. Food and water were withheld for approximately 11 and 2 hours, respectively. Cats were housed individually throughout their stay in the clinic. Housing included a litter box, igloo shelter, towel, food and water.

Investigators performed baseline assessments of sedation, demeanor and pain after a 10-15 minute adjustment period to the kennel environment. All assessments were performed by one of two trained veterinary students (MB, MMMH): inter-rater agreement, assessed following a training period, for both pain scales and the demeanor scale was ‘very good’ [intra-class correlation coefficient (ICC) $\geq$ 0.81: Universidade Estadual Paulista-Botucatu (UNESP-Botucatu) multidimensional composite pain scale; ICC_{single} = 0.85, revised Composite Measures Pain Scale-Feline; ICC_{single} = 0.85, demeanor; ICC_{single} = 0.94] (Altman 1999). Sedation was scored using a numerical rating scale which ranged from 0 to 4, with increasing score indicating increased sedation (Slingsby et al. 1998). Demeanor was scored with a demeanor scale (Zeiler et al. 2013). The original scale was modified, as two of the original 8 items required assessments of the specific behaviors of

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eating and litter tray use over the previous 24 hours prior to procedure, which were unavailable (Buisman et al. 2016). The assessment period for hiding behavior was assessed over the time in the clinic rather than a 24 hour period. The modified scale ranged from 0−21 with increasing scores indicating a deterioration in demeanor from friendly to aggressive.

Pain assessment was performed with two scales, the UNESP-Botucatu multidimensional composite pain scale (U-B MCPS) and the revised Composite Measures Pain Scale-Feline for acute pain in cats (rCMPS-F) (Brondani et al. 2013; Calvo et al. 2014). Use of the U-B MCPS was restricted to the psychomotor (U-B MCPS-psych) and pain expression (U-B MCPS-painex) subscales, for which intervention thresholds for rescue analgesia have been identified (psychomotor score > 3, scale range 0-12; pain expression > 2, scale range 0−12). The rCMPS-F threshold for intervention is ≥ 4, with the scale ranging from 0−16.

As a result of concerns for the potential for ketamine to confound the psychomotor subscale of the U-B MCPS (Buisman et al. 2016), the pain expression subscale score was used to trigger assessment of a cat for rescue analgesia by the supervising veterinarian (MG). Rescue analgesia was oral transmucosal buprenorphine (0.02 mg kg^{-1}; Vetergesic, 0.3 mg mL^{-1}; Champion Alstoe Animal Health Inc., ON, Canada). Cats that crossed the intervention threshold were assigned that score for the remaining time points and that score was used for statistical analyses.

Anesthesia was induced by administration of a single IM injection into the lumbar epaxial muscle of hydromorphone (0.05 mg kg^{-1}; hydromorphone hydrochloride, 2 mg mL^{-1}; Sandoz Canada, QC, Canada), ketamine (5 mg kg^{-1}; Vetalar, 100 mg mL^{-1}; Bioniche Animal Health Inc., ON, Canada) and dexmedetomidine (15 μg kg^{-1}; Dexdomitor, 0.5 mg mL^{-1}; Zoetis, QC, Canada). Time of administration was recorded and sedation was scored 10 minutes after drug administration (time PM10). Immediately following completion of sedation scoring, the cat was moved to the adjacent surgery suite and administered oxygen (1 L $minute^{-1}$) delivered through a face mask attached to a Bain breathing system. The following procedures were performed before surgery: eye lubrication, placement of monitoring equipment, trimming of nails, subcutaneous microchip placement and preparation of testes for surgery. Pulse rate and haemoglobin oxygen saturation (SpO_2) with the pulse oximeter probe placed on the tongue or digital pad were monitored with a multiparametric physiologic monitor (SurgiVet Advisor Vital Signs Monitor; Smiths Medical, OH, USA). Respiratory rate was monitored by direct observation of thoracic excursions. The cat was placed in lateral recumbency for surgery. Lidocaine (2 mg kg^{-1} divided equally between testes; Lidocaine Neat 2%; Pfizer Canada Inc., QC, Canada) was injected through a 25 gauge, 16 mm needle into each testicle, and the surgical site swabbed with iodine immediately prior to surgery. Surgery was performed by the same veterinarian (MG) using a closed castration method. Scrotal incisions were made with a scalpel blade and the spermatic cord and associated vessels ligated using the figure of eight method with a pair of mosquito hemostats. If movement (such as a limb twitch or tongue curl) was observed in response to surgery, isoflurane was added to the oxygen being delivered by face mask, beginning with a vaporizer setting of 0.5−1.0%. Surgery duration, from the start of the initial incision until the release and return of the second spermatic cord into the scrotal sac was recorded.

Immediately following the end of surgery, a rectal temperature was taken with a single digital thermometer and meloxicam (0.2 mg kg^{-1}; Metacam, 5 mg mL^{-1}; Boehringer Ingelheim (Canada) Ltd., ON, Canada) was administered subcutaneously and atipamezole (75 μg kg^{-1}; Antisedan, 5 mg mL^{-1}; Zoetis, QC, Canada) was administered IM. The cat was then returned to its kennel and placed in lateral recumbency on top of a heated disc wrapped in a towel for recovery. The cat was observed every 15 minutes to identify the time from the end of surgery to return of sternal recumbency. Sternal recumbency was defined as the position where all four limbs were tucked under the body. At this point, a litter tray, igloo shelter, wet food and water were placed in the kennel. The food was approximately 45 g (50% Purina Veterinary Diets Essential Care Adult Formula for Cats and 50% Purina Veterinary Diets Essential Care Senior Formula for Cats, ON, Canada).

Pain, demeanor and sedation were assessed postoperatively at 1, 2, 4 and 24 hours after surgery using the end of surgery as T0. Only animals enrolled from the shelter were available for a 24 hour time point assessment. Appetite (any indication that food had been eaten) was recorded at 1, 2, 3 and 4 hours postoperatively.

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When data collection was completed, > 24 hours after surgery, the baseline demeanor scores were used to separate cats into two demeanor groups (Zeiler et al. 2013). Group LO consisted of cats with baseline scores of 0−5 and were classified as friendly and group HI comprised cats with baseline scores of 6−21 and were classified as shy or aggressive. Data assigned to the two demeanor groups were analysed.

Statistical analyses

Continuous data were assessed for normality with a D'Agostino Pearson omnibus normality test. Normally distributed data were analysed with an unpaired t test (time to sternal recumbency, surgery duration, anesthesia duration, weight, postoperative temperature) and non-normally distributed data were analysed with a Mann-Whitney test (age, isoflurane requirement). Ordinal scale data (pain assessment, sedation and demeanor scales) were analysed with Friedman (with group comparison to baseline) and Kruskal Wallis tests (between group comparison at each time point) followed by Dunn's *post hoc* test.

The proportion of cats eating postoperatively was compared with a Chi-squared test and the numbers of crossings of the analgesic intervention threshold for each pain scale for all time points combined was compared between groups with a Fisher's Exact test. The 95% CI for the difference in proportions between cats crossing the analgesic intervention threshold was calculated using the method described by Gardner & Altman (1986).

In cases where a cat had a U-B MCPS-painex score crossing the intervention threshold, that score was carried forward for any remaining time points and included in the analysis. For the other pain assessment scales (U-B MCPS-psych and rCMPS-F), where an intervention threshold was crossed pain scores assigned at remaining time points were included in subsequent analysis.

Data are presented as mean ± standard deviation (SD) (95% CI) and median (range), as appropriate. Plotted data reflect actual scores collected in all cases. p-values < 0.05 were considered significant. Commercial software was used for data analyses (Prism Version 6.0f, GraphPad Software Inc., CA, USA).

Results

Forty-four cats were recruited. From these, 11 cats were excluded for the following reasons: drug protocol deviation ($n = 6$), misinjection ($n = 1$), cryptorchid ($n = 1$), additional procedure ($n = 1$), suspected seizure during recovery ($n = 1$), elevated pain score at baseline ($n = 1$). Data from 33 cats were analysed (LO; $n = 18$, HI; $n = 15$). The sources of cats assigned to the LO and HI groups were: LO, 7 client-owned, 11 shelter; HI, 11 client-owned, 4 shelter. All cats were either domestic short- or long-haired. Data collected at 24 hours were not included in the statistical analyses owing to the small number of animals available for assessment (nine LO; two HI).

Age, procedure duration and isoflurane requirement did not differ between demeanor groups (Table 1). The HI group was on average 1.2 kg heavier than the LO group ($p = 0.004$, 95% CI 0.4−1.9) and had a slightly higher postoperative temperature (difference of 0.6°C, 95% CI 0.1−1.1, $p = 0.01$, Table 1). There were no significant differences between groups in the time to sternal recumbency (LO, 42.2 ± 15.7 minutes; HI, 46.0 ± 15.4 minutes, $p = 0.48$, 95% CI −7.0-14.6). Hypoxaemia ($SpO_2 < 90\%$) was not observed during the procedure and all cats were discharged from the clinic, or made available for adoption, without complication.

With the exception of the 1hour time point, where there was some convergence of scores, demeanor

Table 1 Demographic data and procedure parameters for cats undergoing orchiectomy divided into two demeanor groups: LO, preoperative demeanor scores ≤ 5/21, friendly, $n = 18$, and HI, preoperative demeanor scores ≥ 6/21, shy/aggressive, $n = 15$

Parameter	LO	HI	p-value (95% CI)
Age (years)	0.79 (0.2−2.0)	1.0 (0.5−5.0)	0.19
Weight (kg)	3.5 ± 1.2	4.7 ± 0.9	0.004 [0.4−1.9]
Surgery duration (minutes)	2.1 ± 0.4	2.1 ± 0.6	0.68 [−0.3−0.5]
Anesthesia duration (minutes)	19.6 ± 2.1	21.1 ± 2.4	0.07 [−0.1−3.1]
Isoflurane (%)	0 (0−0)	0 (0−1.3)*	0.45
Postoperative temperature (°C)	37.7 ± 0.7	38.3 ± 0.6	0.01 [0.1−1.1]

*One cat required isoflurane to facilitate surgery. Data are mean ± standard deviation or median (range).

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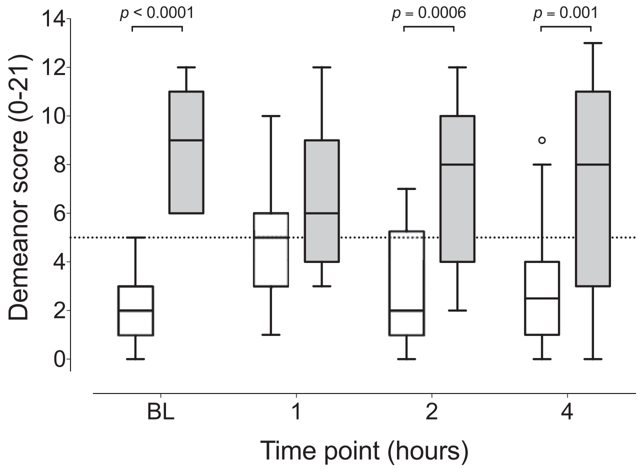

Figure 1. Demeanor scores in cats before (baseline, BL) and 1, 2, and 4 hours after orchidectomy. Clear box, 18 cats with baseline demeanor scores ≤ 5/21 (group LO). Grey box, 15 cats with baseline demeanor scores ≥ 6/21 (group HI). Dotted horizontal line represents the demeanor score that separated cats into LO and HI. Box and whisker plots (horizontal line within box is median, boundaries represent interquartile ranges). Circles are data points with a distance from the median exceeding 1.5 × interquartile range.

scores assigned at baseline were maintained postoperatively (Fig. 1). In LO, demeanor scores increased from baseline [2 (0−5)] at 1 hour postoperatively [5 (1−10)] ($p = 0.04$, Fig. 1). No differences were found at 2 and 4 hours compared with baseline ($p > 0.99$). At 24 hours, demeanor scores were 1.5 (0−5). In HI, postoperative demeanor scores were not significantly different from baseline (Fig. 1). In the between group comparisons, demeanor scores for HI were higher at baseline ($p < 0.0001$), 2 ($p = 0.0006$) and 4 hours ($p = 0.001$) (Fig. 1).

This division based on demeanor was reflected in the U-B UNESP-psych and rCMPS-F pain scale scores, but not the U-B UNESP-painex scale scores (Figs. 2 & 3). The U-B MCPS-psych scores were higher in HI than in LO at all but one time point, reflecting the greater number of crossings of the intervention threshold in HI (9 crossings, Fig. 2). Six cats were responsible for these crossings, with one cat exceeding the intervention threshold at every time point. The number of crossings of the intervention threshold was significantly higher in HI than in LO

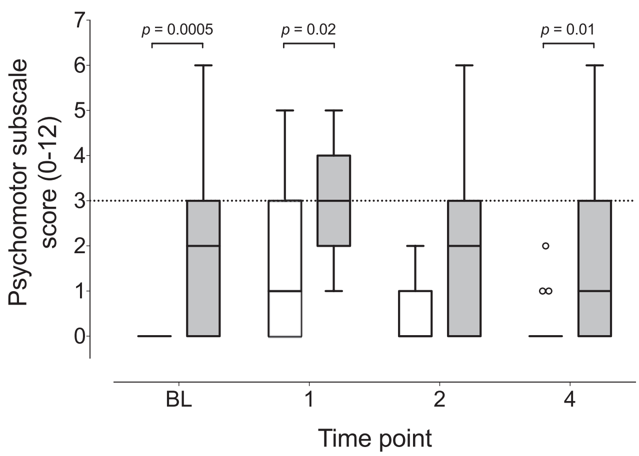

Figure 2. U-B UNESP-psychomotor subscale scores in cats before (baseline, BL) and 1, 2, and 4 hours after orchiectomy. Clear box, 18 cats with baseline demeanor scores ≤ 5/21 (group LO). Grey box, 15 cats with baseline demeanor scores ≥ 6/21 (group HI). Dotted horizontal line indicates intervention threshold for analgesia. Box and whisker plots (horizontal line within box is median, boundaries represent interquartile ranges). Circles are data points with a distance from the median exceeding 1.5 × interquartile range.

(one cat at 1 hour postoperatively, $p = 0.005$, proportion difference 0.14, 95% CI 0.05−0.23).

The U-B MCPS-psych scores increased in LO from baseline to 1 hour postoperatively ($p = 0.004$, Fig. 2). No differences were observed between baseline and 2 ($p = 0.74$) or 4 hours ($p > 0.99$), where scores for all cats remained below the intervention threshold. At 24 hours, U-B MCPS-psych score was 0 in nine cats in LO available for assessment. In HI, there were no differences in the U-B MCPS-psych scores between baseline and postoperatively (Fig. 2). The two cats in HI available for assessment at 24 hours had U-B MCPS-psych scores of 1 and 2.

The U-B MCPS-painex scores did not differ between groups at baseline [LO, 0 (0−0); HI, 0 (0−1), $p > 0.99$], at 1 hour [LO, 0 (0−1); HI, 0 (0−0), $p = 0.34$], 2 hours [LO, 0 (0−2); HI, 0 (0−3), $p > 0.99$] and 4 hours [LO, 0 (0−2); HI, 0 (0−6), $p = 0.31$]. The total number of crossings of the analgesic intervention threshold did not differ (LO, 0; HI, 3, $p = 0.09$, proportion difference 0.05, 95% CI −0.01-0.12). Two cats were responsible for the 3 crossings in HI.

There were no changes over time in U-B MCPS-painex scores in LO (baseline *versus* 1 hour, $p = 0.99$; baseline *versus* 2 hours, $p = 0.59$; baseline *versus* 4 hours, $p > 0.99$) and no cats exceeded the intervention threshold. At 24 hours, LO U-B MCPS-painex scores were 0 (0-1). Similar results were observed in HI for the U-B MCPS-painex scores (baseline *versus* 1 hour, $p > 0.99$; baseline *versus* 2 hours, $p > 0.99$; baseline *versus* 4 hours, $p > 0.99$), with one cat crossing the intervention threshold at 2 hours and one at 4 hours. At 24 hours both cats received U-B MCPS-painex scores of 1.

The pattern of rCMPS-F scores in LO and HI was similar to that of the U-B MCPS-psych scores (Fig. 3). Scores were significantly higher in HI at baseline ($p = 0.0003$) and at 4 hours ($p = 0.04$). Scores were not different at 1 hour ($p = 0.07$) and 2 hours ($p = 0.09$). A *post hoc* power analysis of rCMPS-F data indicated that study sample size was sufficient to detect a difference in scores between groups of 3 or greater at hours 1 and 2 (alpha at 0.05, 80% power). The total number of crossings of the analgesic intervention threshold was greater in HI (23 *versus* 3, $p < 0.0001$, proportion difference 0.34, 95% CI 0.21−0.47). Eight cats made 23 crossings in HI (five cats at baseline, two cats at 1 hour, one cat at 2 hours) and the 3 crossings in LO were different cats (two cats at 1 hour and one cat at 4 hours) (Fig. 3).

The rCMPS-F scores in LO increased from baseline to the 1 hour time point ($p = 0.01$) (Fig. 3). Scores between baseline and 2 or 4 hours did not differ (both $p > 0.99$) and all cats had a score of 0 at 24 hours. rCMPS-F scores in HI did not differ between baseline and the postoperative time points, and scores in two cats at 24 hours were 3 and 4.

Cats in LO began eating earlier postoperatively than in HI ($p < 0.0001$) (Fig. 4). Within 1 hour of achieving sternal recumbency, 61% of cats in LO began to eat, in contrast to 33% of cats in HI. By 4

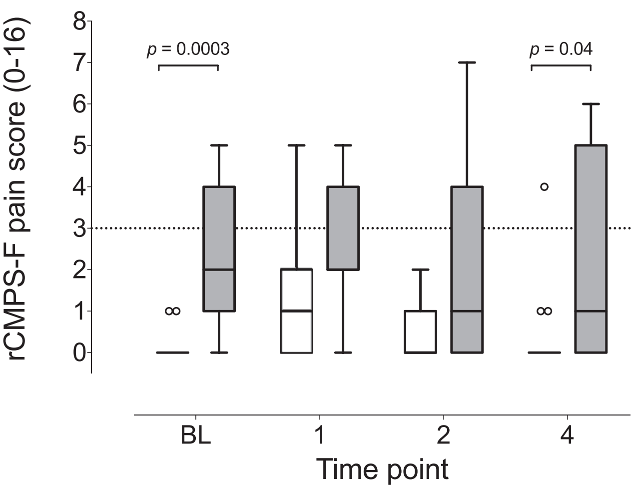

Figure 3. rCMPS-F scale scores in cats before (baseline, BL) and 1, 2, and 4 hours after orchiectomy. Clear box, 18 cats with baseline demeanor scores ≤ 5/21 (group LO). Grey box, 15 cats with baseline demeanor scores ≥ 6/21 (group HI). Dotted horizontal line indicates intervention threshold for analgesia. Box and whisker plots (horizontal line within box is median, boundaries represent interquartile ranges). Circles are data points with a distance from the median exceeding 1.5 × interquartile range.

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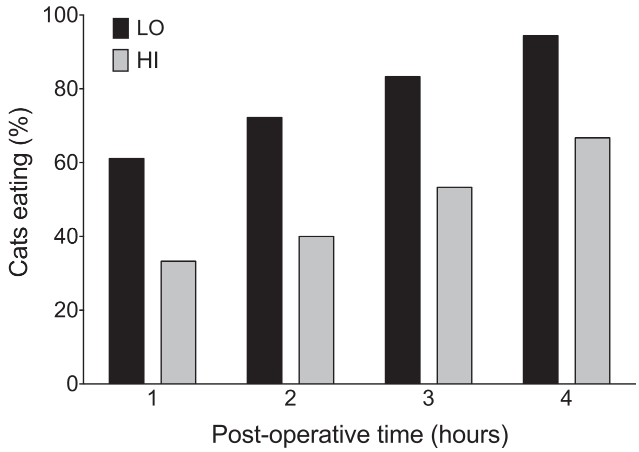

Figure 4. Number of cats (%) that were eating at 1−4 hours after anesthesia for orchiectomy. Group LO, 18 cats with preoperative demeanor scores ≤ 5/21; group HI, 15 cats with preoperative demeanor scores ≥ 6/21. Cats in the LO group began eating earlier ($p < 0.0001$).

hours postoperatively, 94% of cats in LO were eating and 67% of cats in HI.

Sedation scores increased in both LO and HI between baseline and PM10 ($p < 0.0001$, both groups), with all cats assigned a score of 0 at baseline and 4 at PM10. A similar proportion of cats in both groups remained sedated (sedation score greater than 0) at 1 hour postoperatively [LO, 13/18, 1 (0−1); HI, 10/15, 1 (0−2)]. Compared with baseline, this represented a significant increase in sedation in LO ($p = 0.02$), but not in HI ($p = 0.06$). Recovery progressed rapidly thereafter with four cats in LO and three cats in HI assigned a score of 1 at 2 hours. All cats were scored 0 at 4 hours. Sedation scores at 2 and 4 hours did not differ from baseline (both $p > 0.99$). There were no significant differences between groups for sedation scores at each time point ($p > 0.99$).

Discussion

These data show that feline demeanor influences feline-specific pain scales. Specifically, both the U-B MCPS-psych subscale (assessing posture, comfort, activity, attitude) and rCMPS-F scale (assessing posture, vocalization, response to stroking and wound palpation and general impression) generated consistently elevated scores in the HI but not the LO group. In contrast, the U-B MCPS-painex subscale, which includes responses to palpation (“miscellaneous behaviours”, “reaction to palpation of the surgical wound”, “reaction to palpation of the abdomen/flank”, “vocalization”), reflected no differences in pain scores between the LO and HI groups.

In the context of recent work by Zeiler et al. (2013), showing the negative effects of a clinic environment on feline demeanor, it is perhaps unsurprising that pain assessment is confounded by high demeanor scores in non-painful cats. Interestingly, Calvo et al. (2014) and Zeiler et al. (2013) both commented on the possible interaction between demeanor and pain assessment. Calvo et al. (2014), during development and validation of the rCMPS-F, observed high rCMPS-F scores associated with elevated “general impression” (demeanor) scores (Calvo et al. 2014). They suggested that demeanor contributed to a misclassification of cats as painful compared with their criterion standard (a numerical rating scale). The results of the study presented here support this observation. In contrast to the pain expression subscale assessment, where no animals crossed threshold at baseline, these results show that the behavioral assessment components of both the U-B UNESP-psych and rCMPS-F are susceptible to demeanor.

This creates a dilemma: how to approach the assessment of pain in cats with high demeanor scores that may have artificially elevated the pain scores? One approach is to administer analgesics, with the view that it is better to provide pain relief than assume the pain scale score has been artificially elevated. Given that pain in cats remains under-recognised and under-treated this seems reasonable (Hugonnard et al. 2004; Williams et al. 2005; Hewson et al. 2006a; Joubert 2006). However, analgesia drugs may have undesirable side effects, such as sedation and ileus, that slow recovery and

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return to normal function. Promoting a rapid, complete recovery and return to normal function through optimal perioperative management is the foundation of ERAS, a key component of which is appropriate analgesia management, based on accurate pain assessment. ERAS has been successfully applied to veterinary medicine (Hasiuk et al. 2015) and has made significant contributions to human medicine (Varadhan et al. 2010; Spanjersberg et al. 2011; Lu et al. 2012; Zhu et al. 2012). An alternative approach, supported by these data, would be to account for demeanor when applying the preferred validated pain scale. The recent publication of a demeanor scale provides a mechanism to achieve this (Zeiler et al. 2013). In the case of an elevated demeanor scale score, the U-B UNESP-painex subscale differentiates demeanor and acute pain. This combined assessment has the advantage of avoiding unnecessary administration of analgesics. Although assessing demeanor concurrently with pain is potentially more labor intensive, this is balanced against applying a "one size fits all" approach to perioperative management. In recognition that validated pain scales serve as a guide and are not infallible, regular assessment of patients is essential (Reid et al. 2007).

The presence of measurable sedation at 1 hour postoperatively was associated with a temporary convergence of demeanor scores. Scores of the HI group decreased and those of the LO group increased so that the median score difference between groups reduced to 1 at 1 hour compared to 5−7 at other time points. This highlights difficulties associated with behavioral and pain assessments during the early postoperative period and has been noted in several studies (Calvo et al. 2014; Zeiler et al. 2014; Buisman et al. 2016). Using an earlier version of the U-B UNESP pain scale, Zeiler et al. (2014) noted that sedation was associated with an increase in pain scores and an experimental study of ketamine showed the greatest inflation of the U-B UNESP-psych occurring during the first 2 hours of recovery from general anesthesia (Zeiler et al. 2014; Buisman et al. 2016). Together, these studies provide evidence that pain assessment early in the recovery period (up to 1−2 hours after termination of general anesthesia) is prone to interference by drug effects. Therefore the approach of Calvo et al. (2014) to not perform a pain assessment when sedation is present appears prudent. In a clinical context, when pain assessment is necessary in the presence of sedation, our data support the use of the U-B UNESP-painex subscale.

The influence of demeanor on the U-B UNESP-psych was similar to the reported effect of ketamine in an experimental (non-surgical) study comparing the combination of ketamine or alfaxalone with hydromorphone and dexmedetomidine (Buisman et al. 2016). As ketamine was included in this study it was not possible to separate the relative contributions of ketamine or demeanor, though the influence of demeanor on the pain scale was also apparent at baseline, prior to drug administration.

The benefit of habituation to the environment was reflected by the distribution of cats within the two study populations, where the ratio of shelter cats in the LO and HI groups was over 2:1. Zeiler et al (2013) showed that several days were required (under the conditions studied) for habituation. The majority of cats in the HI group were experiencing the clinic environment for the first time.

The decision to administer the dexmedetomidine antagonist, atipamezole, to all cats was based on evidence that recovery to sternal recumbency was four times faster (median difference of 45 minutes), without compromising analgesia (Hasiuk et al. 2015). Similar feline castration studies showed that recovery to standing was approximately ten times faster when atipamezole was administered (Ko et al. 2011) and the absence of pharmacological antagonism was associated with long recoveries, taking over two hours to return to standing (Zeiler et al. 2014). Ko et al. (2011) reported a similar duration of anaesthesia to that reported here, but a shorter time to regain sternal recumbency (approximately 12 minutes *versus* 42−46 minutes in the present study). There are several factors which may contribute to this difference, including drug doses, definition of sternal recumbency and role of environmental factors. Ko et al. (2011) administered atipamezole at a ratio of 10:1 for the dexmedetomidine dose *versus* 5:1 in this study. It is unknown if our definition of sternal recumbency was stricter, as the time for all four paws to be tucked under the body could take longer, and differences in environmental factors such as noise can be considerable between clinics (Fullagar et al. 2015). Nevertheless, speed of recovery, without compromising analgesia, is an important consideration given that 61% of feline perioperative mortality occurs during recovery (Brodbelt et al. 2008). Though contributing factors have not been identified, decreased surveillance and physiological monitoring, and continuing effects of anaesthetic and analgesic drugs are potential culprits.

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An unexpected finding was the difference in eating behavior observed between demeanor groups. Though it may be expected that cats with lower demeanour scores are more likely to eat in a clinic environment, the magnitude of this difference was surprising. This supports the anecdotal observation that cats are often inappetent in a clinic environment. However, the contribution of stress to inappetence, *versus* underlying disease or pain, or both, may be underestimated. Whether the improvement of the clinic experience for cats can result in lower demeanor scale scores at subsequent visits and easier pain assessment remains to be studied.

The use of a modified demeanor scale and unvalidated sedation scale were limitations of this study. The modified demeanor scale was necessitated by a limited ability to collect information on appetite and litter tray use from all cats. Omitting these sections allowed the scale to be applied consistently to all cats. To our knowledge, no validated sedation scale is available for cats. Repeat assessments of individual cats by the same observer was fundamental to our study design and it is possible that prior observations influenced future observations. The study was not designed to address this potential confound and the validation process used in both pain scales suggests that this is not an important limitation.

The methodology of carrying forward the score an animal receives when it meets criteria for rescue analgesia is commonly employed in clinical pain assessment studies (Slingsby & Waterman-Pearson 1998). The rationale for this approach is: 1) underestimating pain if animals were excluded after administration of rescue analgesia; 2) underestimating pain if post-rescue scores were included instead, and 3) protecting against loss of data if animals are excluded after administration of rescue analgesia.

Absence of a negative control group and the low number of cats crossing the intervention threshold ($n = 2$) for U-B MCPS-painex in this study limited the assessment of the ability of the U-B MCPS-painex to identify painful animals. However, this has previously been examined during scale validation in a feline ovariohysterectomy model, where analgesic administration was delayed for a short time postoperatively (Brondani et al. 2013) and the low number of potentially painful animals agrees with the findings of studies using similar multimodal, pre-emptive anaesthetic-analgesic protocols (Ko et al. 2011; Zeiler et al. 2014).

Pain assessment in cats remains challenging. The recent publication of feline-specific pain scales has greatly advanced our ability to accurately quantify and track changes in comfort, allowing optimisation of patient management (Brondani et al. 2013; Calvo et al. 2014; Hasiuk et al. 2015). However, further work is necessary to elucidate factors which may alter interpretation of these scales (Buisman et al. 2016). The reported study shows that cats with high preoperative demeanor scores (shy/aggressive) may be misidentified as painful postoperatively if demeanor is not accounted for during pain assessment.

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Authors' contributions

MB, MMMH: study design, data collection and interpretation, preparation of manuscript. MG: data collection and critical revision of manuscript. DSJP: study design, data interpretation and statistical analyses, preparation of manuscript.

Conflict of interest statement

Authors declare no conflict of interest.

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