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RESEARCH ARTICLE

Perioperative Analgesic Efficacy of Yamamoto New Scalp Acupuncture for Canine Mastectomy Combined with Ovariohysterectomy: a Randomized, Controlled Clinical Trial

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Background: Yamamoto New Scalp Acupuncture (YNSA) is a therapy based on the stimulation of points on the scalp and applied to treat different states of pain.
Objectives: To investigate the analgesic efficacy of YNSA for dogs undergoing radical unilateral mastectomy with ovariohysterectomy.
Methods: Twenty-four dogs were randomly distributed into two treatments (n = 12, per group): bilateral stimulation of basic B, D, and E points (YNSA group) and no application of acupuncture (control group). All dogs were sedated with morphine; anesthesia was induced with propofol and maintained with isoflurane. Fentanyl was intraoperatively administered to control cardiovascular responses to surgical stimulation. Postoperative pain was assessed using an interactive visual analog scale (IVAS) and the short-form of the Glasgow Composite Pain Scale (CMPS-SF). Morphine was administered as rescue analgesia. Data were analyzed using t-tests, Fisher's exact test, Mann–Whitney U test, and Friedman test ($p < 0.05$).
Results: Intraoperatively, the number of dogs requiring supplemental analgesic and the number of doses of fentanyl were lower in the YNSA group than in the control group (p = 0.027-0.034). The IVAS pain scores recorded from 0.5 h to 1 h post-extubation in the YNSA group were lower than those in the control group (p = 0.021-0.023). Postoperative rescue analgesia and CMPS-SF pain scores did not differ between the groups.
Conclusion: YNSA decreases intraoperative fentanyl requirements and provides minimal postoperative analgesic benefits to dogs undergoing unilateral mastectomy with ovariohysterectomy.

Keywords: Analgesia, Antinociception, Dog, Scalp acupuncture

INTRODUCTION

Mastectomy is frequently required for small animal practice because of the high incidence of malignant mammary tumors, mainly in intact female dogs [1]. The radical unilateral resection of mammary glands is the most indicated surgical treatment [2]. As ovarian hormones play an important role in the etiology of canine mammary carcinomas, ovariohysterectomy (OHE) at the time of mastectomy has also been recommended to reduce the risks of future development of other mammary tumors [3].

Opioid-based analgesia is usually prescribed for the perioperative pain management of canine mastectomy with or without OHE [4,5]. However, negative immunomodulatory effects have been associated with some opioid agents, leading to hesitations on recommending them to patients with cancer [6].

Studies have focused on the use of nonpharmacological therapies as part of a multimodal analgesic approach, including classical acupuncture and related techniques to improve perioperative analgesia and reduce anesthetic and opioid requirements in small animals [7-9].

Yamamoto New Scalp Acupuncture (YNSA) is an acupuncture method that involves the stimulation of acupuncture points on the scalp, and they are likely associated with other anatomical regions and meridians [10,11]. This technique has been developed for application in humans [11] and small animals to treat neurologic disorders and acute and chronic pain [10]. In patients suffering from osteoarthritis [12] and migraine [13], effective analgesia after YNSA is achieved. A controlled clinical study has reported that the addition of YNSA to a standard analgesic protocol reduces postoperative pain scores in cats undergoing OHE [9]. However, information about the use of YNSA as an adjunct therapy for perioperative pain management in small animal practice is limited.

This study was performed to investigate the perioperative analgesic efficacy of YNSA as a complementary therapy for client-owned dogs undergoing radical unilateral mastectomy with OHE. The hypothesis was that YNSA could reduce perioperative opioid requirements and pain scores compared with that of the control treatment.

MATERIALS AND METHODS

1. Study design

In a prospective, parallel, blinded, and controlled trial, 24 dogs were randomized into two groups at a 1:1 ratio. A random number generator (Research Randomizer, http://www.randomizer.org/) was used to assign 12 dogs to each of the two groups through block randomization: YNSA treatment (YNSA, n = 12) and no stimulation with acupuncture (control, n = 12). The study protocol was approved by the local ethics committee (protocol 448/2018 CEUA), and informed written consent for the investigation was obtained from all owners. Acupuncture procedures were performed in accordance with the reporting guidelines for clinical studies using acupuncture (Standards for Reporting Interventions in Clinical Trials of Acupuncture: STRICTA).

2. Animals

Between November 2018 and February 2020, 24 client-owned dogs that were of different breeds, scheduled for unilateral radical mastectomy combined with OHE, and diagnosed with mammary carcinoma through aspiration biopsy were enrolled. Healthy status was assessed through physical examination, complete blood count, serum chemistry profile, electrocardiogram, and thoracic radiography. The exclusion criteria were as follows: evidence of pulmonary metastasis and severe systemic or cardiovascular diseases. The dogs were admitted to the hospital at least 24 h prior to surgery for acclimatization. Before each experiment, the dogs were subjected to fasting overnight but were given free access to water.

3. Treatment procedures

All dogs were intramuscularly (IM) premedicated with 0.3 mg/kg morphine (Cristália, Itapira, Brazil). After 20 min, an intravenous (IV) constant rate infusion of morphine (0.1 mg/kg/h) was initiated and maintained during surgery. The dogs were placed in a quiet environment with dim lighting and no traffic of people. During this period, acupuncture was performed in the YNSA group. The basic B, D and E points of YNSA were bilaterally stimulated by perpendicularly inserting 0.20 mm × 15 mm needles (Dong Bang Acupuncture, Seoul, Korea) to a depth of approximately 10 mm. A single acupuncture procedure was performed by the same veterinarian who has worked with acupuncture for 16 years. The locations of these points were determined in accordance with the following anatomical references: the basic B point is located 1-1.5 cm lateral to the midline and at the frontal line on the frontalis muscle; the D point is located on the junction between the upper line of the zygomaticus muscle and its insertion in the scutiform cartilage in the temporal region, approximately 0.5-1 cm above the zygomatic arch and 1 cm in front of the ear over the frontalis muscle; and the basic E point is located above the superior orbit approximately 1 cm lateral to the midline and laterally follows the curve of the orbicular muscle of the eye (Fig. 1) [10]. The needles were retained from 20 min prior to anesthetic induction until the end of the surgery. The acupuncture points were stimulated by manually rotating the needles to the right and left for approximately 2-3 s until *de qi* was achieved, as evidenced by twitching the muscle and skin. The needles were then maintained in place without rotation

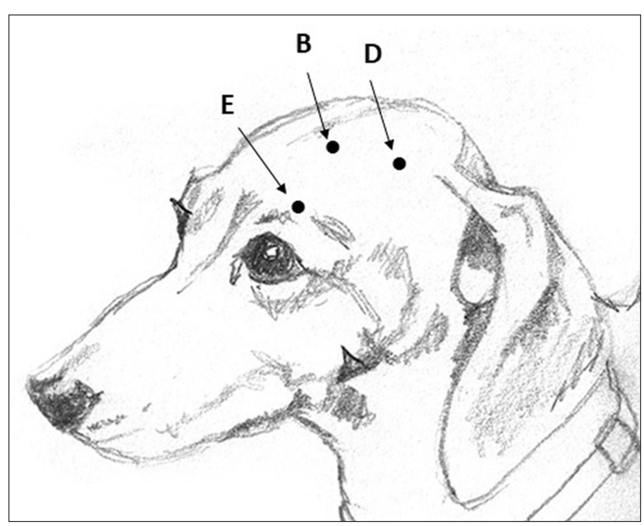

Fig. 1. Anatomical location of basic B, D, and E acupuncture points according to YNSA in a dog [10].

until the end of the surgery. The dogs in the control group were subjected to the same procedures except acupuncture application.

4. Anesthesia and surgery

All anesthetic procedures were performed by a single anesthesiologist. Anesthesia was induced with IV propofol (Cristália, Itapira, Brazil) at the dose necessary to achieve endotracheal intubation. Isoflurane (Cristália, Itapira, Brazil), vaporized in 100% oxygen, was administered to maintain the surgical depth of anesthesia by using a small animal rebreathing circuit (Takaoka, São Paulo, Brazil). Lactated Ringer's solution was administered at 5 ml/kg/h until extubation. Meloxicam (0.2 mg/kg, IV; Cristália, Itapira, Brazil) was administered to all dogs after intubation. Heart rate (HR), oxygen saturation of hemoglobin, and esophageal temperature were continuously measured using a multiparametric monitor (Dixtal Biomédica, São Paulo, Brazil); respiratory rate, end-tidal carbon dioxide concentration ($P_{ET}CO_2$), and end-tidal isoflurane concentration (FE'ISO) were measured using an infrared gas analyzer (Dräger Barueri, Brazil). The dogs were permitted to breathe spontaneously throughout the procedure unless $P_{ET}CO_2$ exceeded 45 mmHg at which point mechanical ventilation was used to maintain eucapnia. Systolic arterial blood pressure (SAP) was monitored indirectly with a Doppler sphygmomanometer (Parks Medical Electronics, Aloha, USA) by using an appropriately sized cuff between 30% and 40% of the circumference of the thoracic limb; in this procedure, the probe was placed over the digital artery. Body temperature was maintained between 37℃ and 38℃ by using an electrical heating pad (Brasmed, São Paulo, Brazil).

Vaporizer settings were adjusted on the basis of the conventional signs of anesthesia (rotation of the eyeball, loss of palpebral reflex, and loss of jaw tone) and autonomic responses to surgical stimulation. If SAP or HR increased by more than 20% of previously recorded values, additional analgesia was provided using fentanyl (2.5 μg/kg, IV, Cristália, Itapira, Brazil). The number of dogs requiring fentanyl and the number of fentanyl rescue doses were recorded. Surgical procedures were performed by the same experienced surgeon using standard techniques for OHE and unilateral radical mastectomy [14].

The anesthesia time (time elapsed from propofol administration to isoflurane discontinuation), surgery time (time elapsed from the first incision until the placement of the last suture), time to extubation (time elapsed from isoflurane termination until orotracheal tube removal upon swallowing reflex recovery), and recovery time (time elapsed from the time of isoflurane discontinuation to voluntary movement into a sternal position) were recorded for each dog.

5. Postoperative assessments

The same single observer, who was a graduate student with experience in the assessment of pain in dogs through behavioral indices, was unaware of the treatment groups and responsible for the pain and sedation assessments, which were performed 2 h prior to surgery and 0.5, 1, 2, 4, 6, 8, 12, 18, and 24 h after extubation. Pain was assessed by two different means: interactive visual analog scale (IVAS, from 0 mm = no pain to 100 mm = maximum pain) and the short form of the Glasgow composite pain scores (CMPS-SF, from 0 = no pain to 24 = maximum pain) [15]. At each pain assessment, sedation was scored according to an abbreviated numerical rating scale that ranged from 0 to 12 [16].

Morphine was administered (0.5 mg/kg, IM) as rescue analgesia if CMPS-SF scores were ≥ 6. The number of dogs requiring rescue analgesia and the number of additional doses of morphine were recorded.

Anesthetic protocol-related adverse events, including nausea, vomiting, bradycardia, and hypotension, were monitored. Bradycardia and hypotension were defined as an HR < 60 beats/min and SAP < 90 mmHg, respectively, for longer than 5 min consecutively. In addition, acupuncture procedure-related adverse events, such as bleeding, allergic reactions, infections, and peripheral nerve injuries at the site of the needle insertion, were recorded.

6. Outcome measures

Primary outcome measures were the assessment of pain (IVAS and CMPS-SF) and the requirement for rescue perioperative analgesia. Secondary outcome measures included sedation scores and adverse events.

7. Statistical analysis

A sample size of at least 11 dogs per group was estimated to achieve an 80% statistical power for detecting a difference of 3 points in the CMPS-SF between the YNSA and control groups and obtain a standard deviation (SD) of 2.5 at an overall alpha level of 0.05. SD was estimated from a pilot study. A Shapiro–Wilk test was performed to assess the normality of variables. Data were expressed as mean ± SD (parametric variables) or median (range; nonparametric variables) as appropriate. Body weight, age, propofol dose, FE'ISO, procedural times, and nodule size were compared between the groups via an unpaired t-test. A Mann–Whitney U test was used to compare pain and sedation scores between the groups and the number of fentanyl and morphine doses administered to them. A Friedman test was conducted to compare differences in pain and sedation scores over time within each group. Fisher's exact test was performed to compare the number of dogs requiring perioperative rescue analgesia and the histopathological classification of mammary tumors between the groups. All analyses were performed using GraphPad Prism 7.0. Differences were considered significant when $p < 0.05$.

RESULTS

In this study, 33 dogs were screened for enrolment, but 9 of them did not meet the inclusion criteria (2 dogs with renal insufficiency, 1 with pyometra, 2 with pulmonary metastasis, and 4 with castration). The following dog breeds were included: poodle (5), Lhasa Apso (1), dachshund (1), Basset Hound (1), Schnauzer (1), Maltese (1) pinscher (2), and mixed breed (12).

Age, procedural times, and characteristics of the mammary tumors had no significant differences between the groups. Body weight was significantly higher in the YNSA group than in the control group ($p = 0.0004$; Table 1). The mean (SD) duration of acupuncture was 95 ± 15 min.

The mean dose (mg/kg) of propofol (YNSA = 5.38 ± 1.9; control = 4.4 ± 1.2, $p = 0.22$) and overall mean of FE'ISO did not differ between the groups (YNSA = 1.36 ± 0.2; control = 1.42 ± 0.1, $p = 0.88$). The number of dogs requiring intraoperative analgesic supplementation and the number of rescue fentanyl doses were lower in the YNSA group than in the control group ($p = 0.027$-0.034). Fentanyl was given in 41.6% (5/12) and 91.7% (11/12) of the dogs in the YNSA and control groups, respectively (Table 2). In the YNSA group, three dogs received one dose of fentanyl, and two dogs received two doses of fentanyl. In the control group, eight dogs received one dose of fentanyl, one dog received two doses of fentanyl, and two dogs received three doses of fentanyl.

The IVAS pain scores were lower from 0.5 h to 1 h in the YNSA group than in the control group ($p = 0.021$-0.023). The CMPS-SF scores did not differ significantly between the

Table 1. Demographic data, procedural times, and characteristics of the mammary tumors in the YNSA (n = 12) and control (n = 12) groups

Variables	YNSA	Control	p-value
Body weight (kg)	10.7 ± 6.8†	5.7 ± 2	0.0004
Age (years)	9.5 ± 3.4	9.2 ± 2	0.81
Anesthesia time (minutes)[a]	87 ± 14	83 ± 14	0.63
Surgery time (minutes)[b]	75 ± 16	65 ± 12	0.14
Extubation time (minutes)[c]	4 ± 2	5 ± 3	0.46
Recovery time (minutes)[d]	18 ± 12	20 ± 8	0.17
Characteristics of mammary tumors			
Size of nodules (cm)	3.5 ± 0.8	3.2 ± 1	0.82
Complex carcinoma (%)	58.3 (7/12)	50 (6/12)	1.00
Simple carcinoma (%)	8.4 (1/12)	8.3 (1/12)	1.00
Malignant mixed tumor (%)	33.3 (4/12)	41.7 (5/12)	1.00

Procedural times: [a]Time elapsed from propofol administration to isoflurane discontinuation; [b]time elapsed from the first incision until the placement of the last suture; [c]time elapsed from isoflurane termination until orotracheal tube removal upon swallowing reflex recovery; and [d]time elapsed from the time of isoflurane discontinuation to voluntary movement into a sternal position.
Data shown as mean ± standard deviation or percentage (number of dogs) as appropriate.
†Significantly different from the control group (Student's t-test, $p < 0.05$).

Table 2. Number of intraoperative fentanyl doses and number of the rescued dogs in the YNSA (n = 12) and control (n = 12) groups

Group	Intraoperative time points									Sum of rescued doses	Number of rescued dogs
	T0	T1	T2	T3	T4	T5	T6	T7	T8		
YNSA	0	0	1	3	1	1	1	0	0	7†	5/12†
Control	0	0	4	5	4	0	2	1	0	16	11/12

T0 = baseline, 10 min of 1.2% FE'ISO, before surgical stimulation; T1 = midline incision; T2/T3 = clamping of first/second ovarian pedicles; T4 = clamping of the uterine body; T5 = closure of the abdominal cavity; T6 = skin incision from the first to the fifth mammary gland; T7 = removal of the mammary chain; T8 = skin suture.
†Significantly different from the control group (Mann–Whitney U test, $p = 0.034$; Fisher's exact test, $p = 0.027$).

Table 3. Pain and sedation scores in the YNSA (n = 12) and control (n = 12) groups

Time	CMPS-SF (0-24 points)		IVAS (0-100 mm)		Sedation (0-12 points)	
	YNSA	Control	YNSA	Control	YNSA	Control
BL	0 (0-1)	0 (0-0)	0 (0-0)	0 (0-30)	1 (1-1)	1 (1-1)
0.5 h	4 (1-9)*	4 (2-5)*	18 (0-65)†	31 (12-55)*	4 (1-6)*	4 (1-6)*
1 h	4 (1-7)*	3.5 (1-6)*	27 (0-60)†	33 (10-65)*	4 (1-4)*	3 (1-5)*
2 h	3 (1-4)*	2 (1-6)*	19 (0-45)	36.5 (5-65)*	3 (1-4)	3 (1-4)
4 h	2 (0-7)	1.5 (1-5)	20 (0-70)	22.5 (0-60)	2 (1-4)	1 (1-6)
6 h	1 (0-4)	2 (1-8)	23 (0-50)	17.5 (0-45)	1 (1-3)	1 (1-3)
8 h	1 (0-5)	2 (0-7)	15 (0-60)	10 (0-55)	1 (1-3)	1 (1-3)
12 h	1.5 (0-8)	1.5 (0-3)	13 (0-65)	7.5 (0-40)	1 (1-1)	1 (1-3)
18 h	1 (0-2)	0.5 (0-3)	10 (0-25)	5 (0-30)	1 (1-1)	1 (1-1)
24 h	0.5 (0-2)	0.5 (0-1)	4 (0-25)	5 (0-30)	1 (1-1)	1 (1-1)

Data were presented as median (range). Pain and sedation assessments were performed prior to the surgery (BL) and 0.5, 1, 2, 4, 6, 8, 18, and 24 h after extubation.
IVAS = Interactive Visual Analog Scale (IVAS); CMPS-SF = short form of the Glasgow composite pain scores.
*Significantly different from the baseline values (Friedman test, p < 0.0001); †significantly different from the control group (Mann–Whitney U-test, p = 0.021-0.023).

Table 4. Number of postoperative morphine rescue doses and number of rescued dogs on the YNSA (n = 12) and control (n = 12) groups

Group	Postoperative time (h)									Sum of rescue doses	Number of rescued dogs
	0.5	1	2	4	6	8	12	18	24		
YNSA	1	1	0	2	0	0	1	0	0	5	5/12
Control	0	2	1	0	2	1	0	0	0	6	6/12

groups. However, the CMPS-SF scores recorded from 0.5 h to 2 h were higher than the baseline values in both groups (p < 0.0001), while the IVAS scores increased at the same time points in the control group (p < 0.0001) and did not change over time in the YNSA group (Table 3). Morphine was given in 41.6% (5/12) and 50% (6/12) of the dogs in the YNSA and control groups, respectively (p = 1.00). All dogs received only one dose of morphine at different time points (Table 4).

Sedation scores did not differ between the groups at any time point. The scores from 0.5 h to 1 h were significantly higher than the baseline in both treatment groups (p < 0.0001).

Hypotension was detected during the surgical procedure in 41.6% (5/12) of the dogs in both groups. In 70% of the cases, hypotension was successfully reversed by decreasing the isoflurane concentration, while in 30% of the cases, an IV bolus of 5 ml/kg crystalloid solution was required and administered for 10 min.

DISCUSSION

The hypothesis of this study was partially supported by the results, showing that the application of YNSA concurrently with systemic analgesics reduced intraoperative opioid requirements and provided minimal additional benefits to alleviating postoperative pain in dogs undergoing radical unilateral mastectomy with OHE.

Clinical reports have demonstrated a significant decrease in opioid consumption when different acupuncture modalities are applied to human surgical patients compared with those of control therapy [17,18]. Similarly, significant reductions in intraoperative fentanyl requirements in the YNSA-treated dogs were observed in this study, suggesting that the stimulation of basic B, D and E points potentiated the antinociceptive effects of morphine. In animal models, the IV injection of pethidine and fentanyl increases acupuncture analgesia, indicating a synergistic effect between μ-agonist opioids and acupuncture therapy [19]. Acupuncture needling triggers complex somatosensory responses, thereby activating spinal mechanisms and opioidergic and serotoninergic descending inhibitory pathways that can modulate pain perception [20]. Although information on the neurophysiologic effects of YNSA is limited, an imaging study on humans has shown that YNSA reduces pain scores and simultaneously increases neural activities in some brain areas, including the thalamus, insula, periaqueductal gray, and prefrontal cortex, which are involved in nociceptive processing [21].

The three basic points of YNSA stimulated in the current study are recommended for trauma and postoperative pain relief [10]. Surgical incision for radical unilateral mastectomy is extensive; that is, it involves thoracic and abdominal mammary glands, which are innervated by lateral and ventral cutaneous branches derived from the third thoracic vertebrae (T3) to the third lumbar vertebrae (L3) [22]. The basic E point is connected to anatomical structures innervated by afferent fibers originating from T1 to T12 and associated with thoracic analgesia [10]. Although the surgical removal of axillar lymph nodes was unnecessary in the current study, the stimulation of the basic B point is also included as preventive care in the acupuncture procedure if this additional surgical procedure is required because this acupoint is related to different conditions of pain affecting the forelimbs [10]. In addition, the basic D point is stimulated because OHE is performed below the umbilicus, whose innervation involves emerging dermatomes from T10 to the fourth lumbar vertebra (L4), resulting in somatic and visceral pathway stimulation [23]. Basic D point needling can activate the microregions of the cerebral cortex, triggering an analgesic effect on the lower abdominal region [10]. In this way, the decision to perform the simultaneous stimulation of the three points is made to activate different areas of the cerebral cortex and obtain an effective neural response.

With respect to the duration of acupuncture analgesia, some studies have demonstrated decreased pain intensity in the early postoperative period [9,24], while other studies have not shown significant analgesic benefits [25,26]. A previous clinical controlled study reported significant reduction in pain scores 4 h after OHE in YNSA-treated cats and indicated that none of them required postoperative rescue analgesia [9]. Conversely, in the current study, lower IVAS pain scores were found in the G-YNSA only in the first hour after extubation without significant intergroup differences in CMPS-SF pain scores and postoperative analgesic requirements. Although these results could not be directly compared because the species vary, the main variation might be related to different surgical traumas experienced by animals in each study. Ribeiro et al. [9] demonstrated that the degree of incisional pain experienced by cats is lower than that suffered by the dogs in the current study; in addition to somatovisceral stimulation induced by OHE, the large incision required around the skin and subcutaneous tissues is extensively sensitized by somatic afferent fibers to remove the mammary channel [14]. Clinical reports have shown that the incisional component of pain is more dominant than the visceral component in the early postoperative period [24,27]. This finding can partly explain the different findings in the two studies. Furthermore, the peculiarities of each species, as well as different anesthetic protocols and pain scales used in each study, may support the variations between results. Moreover, the application of YNSA only until the end of surgery may have been insufficient to control postoperative pain. A previous study reported a significant reduction in opioid requirements in the first 2 h after lower abdominal surgeries in women treated with electrical acupuncture (EA) applied immediately after a surgical procedure [28]; conversely, no significant analgesic benefits are found when EA is applied pre- and intraoperatively [25]. Animal studies have demonstrated that acupuncture stimulation provides a gradual increase in pain threshold, resulting in a maximum effect between 15 and 30 min after needle insertion, and such effect persists from 30 min to 60 min after the interruption of acupuncture application [29,30]. Therefore, the maximum acupuncture analgesia was likely achieved throughout the surgery; a residual effect occurred in the first hour after extubation as indicated by the IVAS pain scores detected in the YNSA group were lower than those in the control group. Moreover, anesthesia-related central depression possibly reduced the acupuncture analgesic response. Previous human clinical studies failed to demonstrate significant analgesic benefits after EA application to patients under general anesthesia [25,26]; conversely, EA application in anesthetized dogs decreases analgesic requirements after OHE and mastectomy [7,8]. Further studies are needed to investigate the possible effect of general anesthesia on YNSA-mediated analgesic effects.

Although CMPS-SF and IVAS are sensitive and reliable methods for pain assessment in dogs, these scoring systems may be biased in terms of postoperative analgesic supplementation because lower pain scores are expected in dogs given rescue analgesia. This bias could have been avoided by excluding rescued animals from the statistical analysis of pain assessment. However, given the similarity between the number of rescued dogs and the number of rescue morphine doses required in each group, the rescued dogs were included in the statistical analysis in this study. In addition, behavioral responses can be influenced by postoperative sedation, impairing pain recognition [15]. In the current study, the degree of sedation was comparable between the groups and did not apparently interfere with pain assessments; the scores peaked from 0.5 h to 1 h after extubation. As mastectomy is considered a moderate to severely painful surgical procedure and may induce pro-inflammatory cytokine production, meloxicam was given preoperatively to all dogs, but it might influence pain assessments and decrease intergroup differences. However, previous studies reported long-lasting postoperative analgesia when opioids are combined with meloxicam in dogs undergoing mastectomy with or without OHE [4,5].

Minimal perioperative complications were recorded in both groups. During anesthesia, transitory hypotension was the most frequent adverse event observed in both groups, and it might be attributed mainly to the cardiovascular depressant effects induced by general anesthesia. The overall mean FE'ISO was 1.4%, which might have decreased myocardial contractility and systemic vascular resistance, resulting in hypotension [31]. Consistent with previous reports on cats [9], our results showed no local adverse effects related to YNSA application.

This study had some limitations. For example, it included a small sample size, which was estimated considering a difference of at least 3 points in the CMPS-SF pain scores between the groups. However, the intergroup differences were smaller than this, limiting the statistical power of our study. Additionally, the current study did not include a placebo acupuncture group (sham group). Neuroimaging studies have demonstrated that the needling of nonacupuncture points may induce analgesic effects due to the activation of cortical and subcortical brain areas involved in nociception [20]. However, clinical reports have found that analgesic effects following real acupuncture are greater than those following sham acupuncture in human surgical patients [17,24]. Similarly, the stimulation of the basic D point of YNSA is more effective than placebo acupuncture in reducing pain induced by experimental stimuli in humans [32]. In view of these results and for ethical reasons, a placebo acupuncture group was not included in the present study. Furthermore, somatic pain could be more accurately measured by the inclusion of objective methods in our study design. Among the objective validated tools to assess postoperative pain, von Frey filaments are the most widely used to measure the severity of incisional pain under clinical and experimental conditions [33,34]; they are probably helpful for distinguishing intergroup differences. Additionally, neuroimaging techniques, such as electroencephalography and functional magnetic resonance imaging, would have provided more data to clarify YNSA-triggered neurophysiological mechanisms.

CONCLUSIONS

As a complementary therapy, YNSA decreased intraoperative fentanyl requirements and provided minimal postoperative analgesic benefits to dogs undergoing radical unilateral mastectomy with OHE. However, additional larger sham-acupuncture studies are needed to support these results.

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AUTHORS' CONTRIBUTIONS

Carolina C. Bacarin: recruitment and enrolment of study animals, behavior scoring, rescue analgesia, and drafting of manuscript; Luíza G. Perucchi: perioperative care, data acquisition, and data management; Gabriel M. Nicácio: surgical procedure; Letícia M. L. Cerazo: anesthesiologist and postoperative care; and Renata N. Cassu: study design, acupuncture treatment, data analysis, statistical analysis, and writing of manuscript. All authors approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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