

Pain related syndrome of inappropriate antidiuretic hormone secretion in a kitten

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ABSTRACT

A 2-month-old domestic shorthair kitten was presented for evaluation of weakness, gait abnormalities, and signs of pain after trauma. On admission, the patient was found laterally recumbent with obvious gait abnormalities: difficulty rising from sitting and marked unilateral left hind limb lameness. On orthopedic examination, severe pain, crepitations, and swelling of the left hind limb were detected. Results of the first diagnostic work-up were all consistent with hyponatremia, hypochloremia and a Salter-Harris type I fracture.

The kitten initially received isotonic fluids, analgesia, and antiemetic treatment. Twelve hours after admission, the analgesic plan was considered insufficient, and the general patient's condition worsened, showing severe mental depression. Blood and urine samples were collected for a more in-depth diagnostic evaluation; the patient showed worsening hyponatremia (113 mmol/L; [RR: 146,2-156,2]), severe plasma hypoosmolality (218.2 mOsm/kg; [RR: 287-307 mOsm/kg]), high natriuresis (Na: 74.9 mmol/L; [RR: <40 mmol/L]), and urinary hyperosmolality (630 mOsm/kg; [RR: <150 mOsm/kg]). Based on these new clinical findings syndrome of inappropriate antidiuretic hormone (SIADH) secretion was diagnosed.

Emergency treatment with hypertonic saline was then instituted, a constant rate infusion of 3% hypertonic saline infusion to increase plasma sodium was initiated and a loop diuretic, furosemide (1 mg/kg/IV), was administered at 12-hour intervals to induce diuresis. Discharge occurred 4 days after admission as the patient was clinically stable and the hyponatremia progressively resolved. To the author's knowledge this is the first report of a kitten developing pain related SIADH associated to orthopedic trauma.

Introduction

The syndrome of inappropriate antidiuretic hormone secretion (SIADH) is a clinical syndrome characterized by severe hyponatremia, hypoosmolality, and inappropriately concentrated urine. This syndrome is caused by the release of antidiuretic hormone (ADH) without proper stimuli but with normal renal, adrenal, and thyroid function.^{1,2} Although SIADH is the most common cause of euvoletic hyponatremia in humans,³ such a disorder is rarely reported in veterinary medicine, and its real incidence in small animals remains unknown.⁴

In normal physiological circumstances, ADH, or vasopressin (AVP), plays a crucial role in regulating the excretion of water by the kidneys and therefore maintaining the plasma sodium concentration within a relatively narrow range.⁵ Numerous stimuli, both osmotic and non-osmotic, influence ADH secretion. Dehydration, which causes an

increase in plasma osmolality, is the main osmotic stimulus that triggers the release of AVP. Additionally, low blood volume (hypovolemia) is the main non-osmotic trigger for ADH release.⁶ However, other non-osmotic stimuli, including stress, nausea, vomiting, drugs, and pain, particularly post-surgery, have been associated with an increase in ADH levels. However, the underlying mechanism remains to be elucidated.^{7,8}

This case report describes a SIADH's unique presentation in a 2-month-old domestic shorthair kitten experiencing this pain related syndrome associated with orthopedic trauma, which has not been previously described in the veterinary literature.

Case description

A 2-month-old, intact male, 0.575 kg domestic shorthair cat was presented to the emergency service of the Veterinary Teaching Hospital

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of the Universitat Autònoma of Barcelona for evaluation of progressive hyporexia, episodic vomiting, gait abnormalities, and signs of pain during the last 3 days. The patient had a previous history of hind limb lameness.

On admission, the cat was alert and responsive, laterally recumbent with obvious gait abnormalities, difficult rising from sitting, and marked unilateral left hind limb lameness. The main findings on physical examination were mild tachycardia (heart rate 260 bpm; (reference range [RR]: 140 to 200 beats/min) and moderate pale mucous membranes.

An orthopedic examination revealed severe pain, crepitations, and swelling in the left hind limb, along with an edematous area over the ventral abdominal wall and left inguinal region. Given these signs, thoracic radiographs and abdominal ultrasound were conducted to investigate the suspicion of underlying trauma, despite unremarkable results. A complete radiographic study of the pelvis revealed a Salter-Harris type I fracture of the left femoral head and distal epiphysis of the femur, with cranial and lateral displacement of the femur. Moderate thickening of the adjacent soft tissues and popliteal lymphadenomegaly were also present, probably secondary to trauma (Fig. 1).

An intravenous cephalic catheter was placed, and fluid therapy was initially instituted with an isotonic crystalloid solution (Sterovet, B. Braun Medical S.A., Barcelona, Spain) at a maintenance volume (rate of 3.6 ml/h). Buprenorphine (Buprex, Indivior Europe Limited, Dublin, Ireland) and maropitant (Cerenia, Zoetis, Louvain-la-Neuve, Belgium) were administered to provide analgesia and antiemetic support, respectively.

A complete blood count and blood smear showed a mild normocytic, normochromic, nonregenerative anemia, a moderate inflammatory leukogram with neutrophilic leukocytosis, a regenerative left shift, and moderately toxic changes in the neutrophils (Table 1). Serum biochemistry revealed severe hyponatremia and mild hypochloremia (Table 2). Testing for thyroid function was also performed, resulting in normal values (Table 2), but serum basal cortisol concentration to rule out hypoadrenocorticism was not determined because clinical findings did not support any dysfunction. Venous blood gases revealed metabolic acidosis (pH 7.27; [RR]: 7.26-7.42; HCO₃- 11.1 mmol/L; [RR]: 20-29;

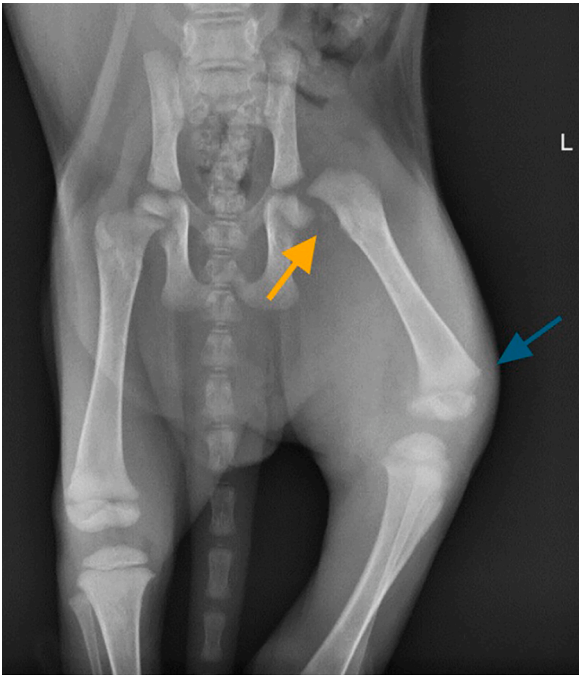


Fig. 1. The radiographic findings reveal a Salter-Harris type I fracture involving the left femoral head (yellow arrow) and distal epiphysis of the femur (blue arrow), with cranial and lateral displacement of the femur. Adjacent soft tissue thickening and popliteal lymphadenomegaly are also observed.

Table 1
Complete blood cell count results.

Complete Blood Cell Count	Results	Reference Range
RBC (x10 ⁶ /μL)	5,33	6 - 10,2
Hemoglobin (g/dL)	7,3	9 - 15
Hematocrit (%)	21	29 - 48
MCV (fL)	37,5	41 - 53
MCHC (pg)	36,5	30 - 34
MCH (g/dL)	13,7	13 - 17
White cell Count (x/μl)	5930	5000 - 15000
Leukocyte Count	% (x/μl)	Reference Range
Lymphocytes	20 1186	1400 - 6100
Monocytes	10 593	100 - 600
Bands	18 1067	0 - 300
Segmented neutrophils	52 3084	2500 - 11300
Eosinophils	0 0	0 - 1500
Basophils	0 0	0 - 100
Platelet count (x10 ³ μl)		200 - 600
Reticulocytes count	Adequates	0 - 50000
	0,4 22919	

Abbreviations: MCV, mean corpuscular volume; MCHC, mean corpuscular hemoglobin concentration; MCH, mean corpuscular hemoglobin; RBC, red blood cell count.

Table 2
Serum biochemistry blood results.

Parameter	Result	Reference Range
Creatinine (mg/dL)	<0,1	0,6 - 1,6
Total Bilirubin (mg/dL)	0.2	0,0 - 0,9
Albumin (g/dL)	2.7	2,2 - 3,9
ALT (U/L)	42	12 - 115
Glucose (mg/dL)	209	77 - 153
Sodium (mmol/L)	118	150 - 165
Potassium (mmol/L)	4.7	3,7 - 5,9
Chloride (mmol/L)	93	115 - 126
Thyroxine T ₄ (μg/dL)	3.41	1.3 - 3.7

Abbreviations: ALT, alanine aminotransferase

standardized base excess -13.6 mmol/L; [RR]: -4 to +1 mmol/L) and respiratory alkalosis (pCO₂ 23.8 mmHg, [RR]: 33.6-47.3) (Table 3).

Additional plasma and urine samples were obtained for electrolyte analysis and plasma/urine osmolality calculation. Effective plasma osmolality was determined resulting in severe hypoosmolality (218.2 mOsm/kg; [RR]: 287 - 307 mOsm/kg). Urine sodium concentration was 74.9 mmol/L (adequate amount, <40 mmol/L), urine specific gravity was 1.018 ([RR] for kittens 4-24 weeks old: 1.035-1.060 g/L), and urine osmolality was 630 mOsm/kg (adequate amount < 150 mOsm/Kg).

Table 3
Venous blood gas results at admission.

		Reference Range
pH	7.274	7.265 - 7.424
pCO ₂ (mmHg)	23.8	33.6 - 47.3
HCO ₃ (mmol/L)	11.1	20 - 29
BE-b (mmol/L)	-13.6	-4 - +1
Na (mmol/L)	113.9	146.2 - 156.2
K (mmol/L)	4.30	3.42 - 4.71
Cl (mmol/L)	96.0	117.0 - 125.0
iMG (mmol/L)	0.58	0.33 - 0.49
Lactate (mmol/L)	1.3	1.1 - 3.5
Creat (mg/dL)	0.88	0.70 - 1.90
PCV (%)	34	36 - 50
Total plasma protein (g/dL)	7	5.4 - 7.1

Abbreviations: pCO₂, partial pressure of carbon dioxide; HCO₃, bicarbonate anion; BE-b, base excess; Na, sodium; K, potassium; Cl, chloride; iMG, ionized magnesium; Creat, creatinine; PCV, packed cell volume.

Urine osmolality was determined based on urine-specific gravity.⁹

At this point, a presumptive diagnosis of SIADH was strongly suggested as the cause of the hyponatremia. Therefore, the treatment goal was focused on restoring electrolyte disturbances and pain management. Immediately, the patient was transferred to the intensive care unit (ICU). Packed cell volume, serum total protein, plasma electrolytes, acid-base balance, glucose and lactate controls were scheduled every 1-8 hours throughout the ICU stay. Despite initial fluid therapy and intensive monitoring, 12 hours after admission, hyponatremia persisted (Table 4) and the patient's mental status worsened progressively to severe dull mentation, which was considered a sign of acute hyponatremic encephalopathy. Emergency treatment with a constant rate infusion (CRI) of -2 ml/kg/h- of 7.5% hypertonic saline (Hypertonic NaCl solution (7.5g/100 ml), B. Braun Medical S.A., Barcelona, Spain) diluted to a 3% solution was initiated to reach an initial increase in plasma sodium of 4-6 mmol/L during the first two hours of treatment. Once the target was achieved, the goal of the fluid therapy plan was to achieve a controlled rise in plasma sodium concentration (up to 10 mmol/L/d). Therefore, the flow rate of the 3% hypertonic saline was conveniently modified to a lower rate (1.2 ml/h) for the first day of therapy. Additionally, to promote excess plasma water excretion, 2 bolus of furosemide (Furosemida, Sanofi-Aventis S.A., Paris, France) at 1 mg/kg IV were administered 12 hours apart. Buprenorphine was also discontinued according to individual reports of severe hyponatremia due to opioid-induced SIADH in human beings;¹⁰ instead, metamizole (25 mg/kg IV q8h) was started as a monomodal analgesic therapy. Given the kitten's age of only 8 weeks, using a nonsteroidal anti-inflammatory (NSAID) was avoided due to the potential for severe adverse effects, particularly gastrointestinal and renal toxicity.

Serial venous blood gas tests and electrolyte determinations every 4 hours were performed to control the progression of sodium concentration (Table 4). For the first 24 hours, the plasma sodium concentration rose from 113.9 mmol/L [RR: 146.2 – 156.2] to 124.4 mmol/L [RR: 146.2 – 156.2]. On the third day, sodium plasma values reached the reference range and the patient remained clinically stable. Therefore, fluid therapy was changed to achieve maintenance requirement with hypotonic saline (0.45% NaCl) supplemented with potassium chloride (KCL 2M; B. Braun S.A., Barcelona, Spain) and 2.5% dextrose (Glucosa 40%, B. Braun S.A., Barcelona, Spain).

The patient did not show any neurologic clinical signs, and his mental level of consciousness and normal attitude were progressively re-established.

On the fourth day after admission the cat was discharged pending surgery. A follow-up blood work was performed 20 days after discharged, and sodium plasma values remained within normal range. Finally, arthroplasty was performed, but postoperative complications during convalescent period required limb amputation.

Discussion

SIADH is an unusual hormonal disorder seldom reported in small animals, particularly in feline species. In contrast to canine species where such syndrome has been reported to be associated with general anesthesia,¹¹ aspiration pneumonia,^{12,13} liver disease,¹⁴ dirofilariasis,¹⁵ or some neurological disorders such as meningoencephalitis,¹⁶ hydrocephalus,¹⁷ or hypothalamic neoplasia. Only three documented cases of SIADH in cats have been reported in the veterinary literature. In the first case, SIADH was described as associated with a craniopharyngeal duct cyst, potentially leading to hypothalamic degeneration.¹⁸ In the second case, this hormonal disorder was linked to an accidental overdose of vinblastine during lymphoma chemotherapy, suggesting chemotherapy induced SIADH.¹⁹ Finally, in the third case, a cat with liver disease developed severe, unresponsive hyponatremia during anesthesia and laparoscopy, suspected to result from multiple factors, including anesthesia, surgery, and metoclopramide administration.²⁰

To the author's knowledge, this is the first case report of SIADH presumably associated with trauma-related pain in a cat, as well as in small animals overall. Although previous medical research has extensively characterized the predominant causes of SIADH in hospitalized patients (Table 5), such a hormonal disorder has also been associated with some physiological conditions such as stress, nausea, or pain.^{3,21,22} Nowadays, the exact link between pain and SIADH remains unknown, but several potential pathways of pain related SIADH have been described in the human literature. According to Blackburn-Munro et al,²³ severe pain can stimulate the hypothalamus, leading to the release of corticotropin-releasing hormone (CRH), which in turn stimulates the release of AVP from the posterior pituitary gland, potentially resulting in SIADH. Additionally, pain related sympathetic nervous system activation has also been described as a potential mechanism that could explain the increase in AVP levels, thus leading to increased release of norepinephrine (NA), and hence AVP secretion stimulation. Following this line, a recent study observed that NA, in addition to its role as a neurotransmitter, also played a role in AVP secretion.²⁴

Additionally, although specific pathways are still not well defined, several studies have also demonstrated that AVP could also play a role in pain modulation, in both humans and animal models. According to such studies, AVP secretion also influences pain perception through V1a and V1b receptors, impacting on various brain regions.^{25,26} Hyponatremia due to pain-induced ADH secretion in the post-op period of orthopedic surgery has been previously reported in human beings.²⁷⁻³⁰ In fact, recent research suggests that even intranasal AVP administration may alleviate such orthopedic pain, revealing a potential role of ADH in central pain modulation.^{31,32} In the author's opinion, the evidence observed in previous medical literature provides valuable insights into the link-up between acute pain, excessive vasopressin secretion, and the

Table 4
Daily venous blood gas results.

	Day 1		Day 2				Day 3			Day 4	Reference Range
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	T ₁₀	
pH	7.351	7.333	7.253	7.306	7.306	7.309	7.231	7.405	7.443	7.390	7.265 - 7.424
pCO ₂ (mmHg)	23.2	19.6	31.6	27.3	23.1	22.3	28.3	22.4	19.8	24.3	33.6 - 47.3
HCO ₃ (mmol/L)	13.0	10.5	14.1	13.8	11.7	11.3	12.0	14.2	13.7	14.9	20 - 29
BE-b (mmol/L)	-10.7	-13.3	-11.3	-10.7	-12.7	-12.9	-13.5	-9.0	-8.4	-8.5	-4 - +1
Na (mmol/L)	115.0	115.7	117.9	124.4	136.8	140.8	149.8	146.8	145.3	144.1	146.2 - 156.2
K (mmol/L)	4.04	3.92	3.78	3.38	2.80	2.45	3.51	4.46	4.43	4.64	3.42 - 4.71
Cl (mmol/L)	97.3	97.5	96.0	98.1	113.7	111.8	121.1	124.8	123.0	118.6	117.0 - 125.0
iMG (mmol/L)	0.53	0.56	0.56	0.54	0.64	0.63	0.68	0.59	0.49	0.51	0.33 - 0.49
Lactate (mmol/L)	1.3	1.3	2.1	3.2	0.7	0.9	1.6	1.0	0.9	0.7	1.1 - 3.5
Creat (mg/dL)	0.79	0.72	0.87	0.73	0.46	0.48	0.59	0.56	0.59	0.52	0.70 - 1.90
PCV (%)	29	30	30	31	26	27	24	22	24	23	36 - 50
Total plasma protein (g/dL)		7					8			8	5.4 - 7.1

Abbreviations: pCO₂, partial pressure of carbon dioxide; HCO₃, bicarbonate anion; BE-b, base excess; Na, sodium; K, potassium; Cl, chloride; iMG, ionized magnesium; Creat, creatinine; PCV, packed cell volume.

Table 5

Common causes of syndrome of inappropriate antidiuretic hormone secretion (SIADH) in humans[2,23,37].

Tumors
- Small cell lung cancer
- Nasopharyngeal cancer
- Mesothelioma
- Lymphoma
- Sarcoma
Pulmonary disorders
- Pneumonia, especially <i>Legionella</i> and <i>Mycoplasma</i>
- Tuberculosis
- Abscess
- Vasculitis
- Positive pressure ventilation
- COPD, asthma
- Cystic fibrosis
Central nervous system disorders
- Tumors
- Infection: meningitis, encephalitis, abscess
- Intracranial bleeding: subdural hemorrhage, subarachnoid hemorrhage
- Inflammatory disease: vasculitis, myelitis, multiple sclerosis
- Traumatic brain injury
Drug-induced
- Antidepressants: SSRIs, TCAs, MAOIs
- Antipsychotics: phenothiazines, haloperidol
- Antiepileptics: carbamazepine, levetiracetam, valproate
- NSAIDs
- Opiates
- Cytotoxic agents: vincristine, vinblastine, cyclophosphamide, cisplatin, carboplatin
Miscellaneous
- Guillain-Barré syndrome
- Idiopathic
- Postoperative
- Pain, nausea and vomiting
- HIV disease
- Endurance exercise
- General anesthesia
- Hereditary (gain-of-function mutations in the vasopressin V2 receptor)
Malignant disease
- GI tract malignancy (Pancreatic)
- Genitourinary tract malignancy

Abbreviations: COPD, chronic obstructive pulmonary disease; SSRIs: selective serotonin reuptake inhibitors; TCA: tricyclic antidepressants; MAOI: monoamine oxidase inhibitors; HIV: human immunodeficiency virus infection.

future development of SIADH and hyponatremia in many clinical scenarios. It is predicted that the most severely ill or injured patients could present elevated ADH and consequently be at risk for developing this hormonal disorder throughout their ICU stay.

In veterinary medicine, despite the absence of established consensus guidelines, there is a widespread acceptance of specific diagnostic criteria for SIADH in animals, which aid in excluding other potential causes of hyponatremia.^{4,11,33} Increased urinary osmolality (>100 mOsm/kg), elevated natriuresis (> 20 mmol/L), normal renal, adrenal, and thyroid function, and no recent use of diuretic drugs are all together diagnostic criteria compatible with such a hormonal disorder.

In the present case, at the time of examination, the kitten showed no medical history indicative of dehydration and was considered normovolemic. The presumed diagnosis of SIADH was based on laboratory test results that consistently demonstrated persistent hyponatremia, inappropriate urine hyperosmolality despite serum hypoosmolality, evidence of natriuresis, and the absence of renal disease. Additionally, confirmation of normal thyroid function was obtained by testing the total T4 hormone. In the reported case, adrenal function testing to rule out hypoadrenocorticism was not performed because it was considered unlikely, based on the patient's age, clinical signs, and laboratory results.

Regarding the management of the patient, the clinical approach was focused on resolving the primary cause (pain) and managing the symptomatic severe hyponatremia. Treatment primarily involved water intake restriction, fluid therapy with hypertonic solutions, and diuretic administration to promote free water clearance.¹¹ The optimal way to correct hyponatremia depends on various aspects, including onset

(acute or chronic), severity grade, and clinical signs. In our case, the initial diagnosis and treatment plan assumed a chronic hyponatremia, that is, one that had developed in 48 hours or more. Infusion of 3% hypertonic saline is highly recommended in acute situations but also in chronic and severe hyponatremia with neurological signs.^{34,35} In such situations, 3% hypertonic solution should be infused at 12–42 ml/kg/d (0.5–3 ml/kg/h) to progressively increase sodium plasma concentration. In the present case, the total amount of hypertonic solution to be administered was calculated based on the Adrogue–Madias formula,³⁶ which takes potassium supplementation into account. In that scenario, treatment aims to raise plasma sodium at a correction rate of 0.5–2 mEq/kg/h for 2–3 hours or until the neurological signs are resolved, but no more than 10 mEq/L during the first 24 hours or 18 mEq/L during each following 24-hour period to avoid the risk of permanent brain damage because of osmotic demyelination syndrome (ODS).^{4,37}

This therapy was combined with loop diuretic agents (furosemide) to facilitate water excretion and reduce extracellular space volume expansion. Furosemide binds to and then inhibits the Na-K-2Cl cotransporter on the apical membrane of epithelial cells of the thick ascending limb of the loop of Henle. The decreased sodium and chloride reabsorption results in marked natriuresis and diuresis. This can be a very effective treatment for hospitalized patients in conjunction with appropriate monitoring of hydration and electrolytes to restore plasma sodium concentration. According to several reports, even low doses of furosemide (0.1–0.5 mg/kg IV) are sufficient to produce diuresis in dogs with SIADH.¹¹ In the reported case, higher doses of loop diuretics were used until therapeutic goals were achieved. Although cats are reportedly more sensitive than other species to the diuretic effects of furosemide,

the suboptimal effect could be attributed, in the author's opinion, to the immaturity of the patient.

In human medicine, the treatment of SIADH typically includes fluid restriction and the use of various agents that may be approved for different indications, such as demeclocycline, urea, or lithium.³⁸ However, these drugs have shown limited effectiveness and have raised concerns regarding side effects and efficacy.³⁹

Recently, arginine vasopressin antagonists, like vaptans (e.g., conivaptan and tolvaptan), have been used as a part of SIADH treatment. Vaptans work by disrupting the binding of AVP to its receptors, preventing the insertion of water channels into the apical membrane of renal distal convoluted tubules and collecting ducts, which leads to the excretion of solute-free urine and the generation of concentrated urine.⁴⁰ However, a direct comparison of the effects of vaptans vs other therapies and the optimal role for these drugs regarding SIADH diagnosis remains to be elucidated, not only in human but also in veterinary medicine.

It must be acknowledged that this case report presents certain limitations. Firstly, the patient was diagnosed with SIADH based on the main analytical diagnostic criteria, but there are additional parameters that were not assessed in this case. Adrenal function testing was not performed to rule out hypoadrenocorticism due to its unlikelihood, considering the patient's young age, lack of clinical signs, and the absence of other associated laboratory abnormalities. The reported signs from the owner, clinical findings, and diagnostic work-up during the initial examination did not align with the typical manifestations of hypoadrenocorticism. Notably, a recent study identified hyponatremia, hyperkalemia, and azotemia as the most common laboratory abnormalities in cats with hypoadrenocorticism. However, in our patient, only hyponatremia was observed.⁴¹ An abdominal ultrasound was conducted by a board-certified radiologist, who concluded that the adrenal glands were within normal limits. However, it's important to note that in cats with suspected primary hypoadrenocorticism, having normal-sized adrenal glands does not rule out the disease. A recent study found that 54% of cats with hypoadrenocorticism had adrenal glands with a smaller width than normal.^{42,43} Finally, the resolution of clinical and laboratory signs without treatment for this condition makes it unlikely that this endocrinopathy was present. Secondly, urine osmolality (UOsm), considered the most accurate method to determine urine solute concentration in humans, is currently determined through direct measurement by an osmometer, which is the gold standard in clinical practice.⁹ However, osmometers are expensive and they are not easy to use in clinical practice. Therefore, in our case, urinary osmolality was calculated based on the urine-specific gravity (USG) measured with a refractometer. Results from various studies suggest a significant relationship between urine osmolality and urine specific gravity (USG) in healthy cats. In one of them, researchers described the presence of a direct correlation between urine osmolality, measured using freezing point depression, and USG, measured by refractometry.⁴⁴ Specifically, in that study, an indirect calculation of UOsm was obtained by multiplying the last two digits of USG by 35. This method has also been validated in human medicine throughout the initial evaluation and follow-up of the patient.⁴⁵

Consequently, it should be mentioned that urine osmolality was measured after the patient received a total dose of 2 mg/kg of furosemide. Nonetheless, urine osmolality remained excessively elevated relative to serum hypoosmolality, indicating a significant physiological response aimed at water conservation.

Furthermore, this case report raises interesting questions about the potential consequences of excessive AVP secretion, particularly in traumatic injuries. In this sense, studying the relationship between acute pain and SIADH, the role of AVP in pain modulation, and the incidence of such hormonal disorders in the water and electrolyte imbalances found in critically ill patients may be a vital area of study. Thus, it might lead not only to improved pain management strategies in veterinary medicine but also to a timely diagnosis of such a hormonal disorder and

an early treatment that could have a great impact on the prognosis of patients suffering from this rare and challenging condition.

CRedit authorship contribution statement

Patricia Prat: Writing – original draft, Visualization, Conceptualization. **Patricia Bou:** Writing – review & editing, Conceptualization. **Luis Bosch:** Writing – review & editing. **Carlos Torrente:** Writing – review & editing, Visualization, Supervision.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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