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# Primary polydipsia in a cat

**Jihyun Kim[1,2], Sooa Yoon[2], Miryeng Kim[2], Seungjin Lee[2], Woojin Song[1] and Youngmin Yun[1]**

## Abstract

*Case summary* In cats, polyuria (PU) and polydipsia (PD) are defined as a urine specific gravity (USG) consistently <1.035 and water consumption >100 ml/kg/day. A 2-year-old castrated male domestic shorthair cat with PU/PD was brought to our hospital. Diagnostic tests for PU/PD included physical examination, blood analyses (complete blood count, serum chemistry profile, electrolytes, ionised calcium, symmetric dimethylarginine and thyroxine concentration), thoracic radiography, abdominal ultrasound examination, urinalysis, urine cortisol:creatinine ratio, urine protein:creatinine ratio and urine culture. A modified water deprivation test resulted in a USG >1.036 and cranial MRI did not identify any abnormalities. Therefore, the cat was administered desmopressin, which failed to decrease water consumption or increase the USG above the untreated level; thus, primary PD was confirmed.

*Relevance and novel information* This rare case of feline primary PD is the first reported that did not identify evidence of structural pathology of the pituitary gland.

**Keywords:** Domestic shorthair; modified water deprivation test; polyuria; primary polydipsia

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## Introduction

Polyuria (PU) and polydipsia (PD) in cats are defined as a urine specific gravity (USG) of <1.035 and water consumption of >100 ml/kg/day, respectively.[1–3] Diagnostic tests for PU/PD in animals include the following: medical history taking; physical examination; blood analyses, including complete blood count (CBC), serum chemistry profile, bile acid, electrolytes, ionised calcium, symmetric dimethylarginine (SDMA) and thyroxine (T4) concentration analyses; thoracic radiography; abdominal ultrasound examinations; and urinalysis, urine cortisol:creatinine (UCC) ratio, urine protein:creatinine (UPC) ratio and urine culture.[1–4] PU/PD in cats can result from various conditions, including chronic kidney disease (CKD), urinary tract infections, hepatic dysfunctions, such as portosystemic shunts, and endocrine disorders including hyperthyroidism, hyperadrenocorticism and hypoadrenocorticism. When these common causes are excluded, differentiation between central diabetes insipidus (CDI), nephrogenic diabetes insipidus (NDI) and primary polydipsia (PP) is required. Here, the authors report on a rare case of PP in a domestic shorthair cat, including indications for CDI and NDI through a modified water deprivation test (MWDT), MRI examination and desmopressin treatment.

## Case description

A 2-year-old castrated male domestic shorthair cat was brought to our animal hospital owing to significantly increased water intake and urination over the past month. One month before the visit, another cat in the home was diagnosed with hypertrophic cardiomyopathy and prescribed diuretics. Consequently, the owner

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increased the number of water bowls and the opportunities to access the bowls. The cat exhibited an average consumption of 135 ml/kg/day with free access to water, without medication. The cat was consistently fed a commercial feline kibble diet.

Physical examination revealed no abnormalities. The results of the blood analyses, including CBC, serum chemistry profile, electrolytes, ionised calcium, SDMA and T4 concentration analyses, were within normal limits. Bile acid testing was not performed in this cat. Urine samples were obtained via cystocentesis in the hospital; analyses of the samples yielded normal results, except for persistent hyposthenuria (USG: 1.004).[5] The UCC and UPC ratios were within normal limits (7.79 [reference interval (RI) <34] and 0 [RI <0.2], respectively) (Table 1).[6,7] The UCC and UPC ratios were performed using a single urine sample. Urine culture revealed no aerobic or anaerobic bacterial growth and fungal growth after 7 and 14 days, respectively. Thoracic radiography and abdominal ultrasound examinations revealed no significant abnormalities.

A plasma osmolality level >300 mOsm/kg indicates CDI, NDI or PP, while levels <280 mOsm/kg indicate PP alone.[1–4] In this case, since the plasma osmolality was measured at >300 mOsm/kg upon the initial visit, three differential diagnoses for PU/PD remained: CDI, NDI and PP.

The MWDT was planned to differentiate between CDI, NDI and PP. Gradual water restriction was instituted at home for 3 days before the MWDT to help minimise medullary washout from longstanding PU/PD.[1–3,8] During the MWDT, the cat's mentation and hydration status were assessed every hour, and its body weight and USG were measured every 2 h. To assess kidney damage caused by the MWDT and to calculate plasma osmolality, blood urea nitrogen, creatinine, glucose, sodium, potassium and chloride levels were measured before the MWDT, at the beginning and at the end stage. Four hours after initiating the MWDT, the USG was 1.030; therefore, CDI and NDI could be excluded. Although CDI and NDI were excluded, the literature indicates that the confirmation of PP corresponds to normal renal function in cats, which is characterised by a USG above 1.035 during the water deprivation test. As the cat's mental state and vital signs remained stable, monitoring was continued to observe if the USG would rise above 1.035. At 14 h after initiating the MWDT, the cat lost 3.2% of its body weight and the USG measured 1.036; the MWDT was stopped (Table 2; Figure 1). These results indicated PP.

Cranial MRI findings were normal (Figure 2). A cranial MRI system (1.5 Tesla unit, Vantage Elan; Canon Medical Systems) was used with a 16-channel, medium-size coil (1.5 T Receive-Only 16-channel Flex SPEEDER Medium; Canon Medical Systems). The T1-weighted, T2-weighted and T2-weighted fluid-attenuated inversion recovery (T2-FLAIR), and contrast-enhanced T1-weighted images after intravenous administration of contrast medium (Dotarem; Guerbet) were obtained.

**Table 1** Complete blood count, serum chemistry, electrolyte, plasma osmolality, ionised calcium, symmetric dimethylarginine (SDMA), thyroxine (T4), N-terminal pro-B-type natriuretic peptide (NT-proBNP), urinalysis, urine cortisol:creatinine (UCC) ratio and urine protein:creatinine (UPC) ratio of the cat

| Index | Results | Reference interval |
|---|---|---|
| Red blood cell (106/ul) | 10.31 | 6.54–12.2 |
| Haematocrit (%) | 48 | 30.3–52.3 |
| Haemoglobin (g/dl) | 16.2 | 9.8–16.2 |
| Mean cell volume (fl) | 46.6 | 35.9–53.1 |
| Mean cell haemoglobin (pg) | 15.7 | 11.8–17.3 |
| Mean cell haemoglobin concentration (g/dl) | 33.8 | 28.1–35.8 |
| Reticulocyte (103/µl) | 34 | 3–50 |
| White blood cell (103/µl) | 8.43 | 2.87–17.02 |
| White blood cell-neutrophil (103/µl) | 3.9 | 1.48–10.29 |
| White blood cell-lymphocyte (103/µl) | 3.58 | 0.92–6.88 |
| White blood cell-monocyte (103/µl) | 0.22 | 0.05–0.67 |
| Platelet (103/µl) | 451 | 151–600 |
| Blood urea nitrogen (mg/dl) | 29.4 | 16.0–36.0 |
| Creatinine (mg/dl) | 2.03 | 0.8–2.4 |
| Alkaline phosphatase (U/l) | 70 | 9–109 |
| Glutamic pyruvic transaminase (U/l) | 54 | 12–130 |
| Glucose (mg/dl) | 112 | 74–152 |
| Albumin (g/dl) | 3.9 | 2.2–4.1 |
| Total bilirubin (mg/dl) | 0 | 0–1.0 |
| Globulin (g/dl) | 4 | 2.5–4.5 |
| Total protein (g/dl) | 7.9 | 5.8–9.1 |
| Sodium (mmol/l) | 150 | 147–156 |
| Potassium (mmol/l) | 4.3 | 3.4–4.6 |
| Chloride (mmol/l) | 111 | 107–120 |
| Plasma osmolality (mOsm/kg) | 325.32 | 308–335 |
| Ionised calcium (mmol/l) | 1.34 | 1.11–1.38 |
| SDMA (µg/dl) | 6 | 0–14 |
| T4 (µg/dl) | 2.3 | 0.8–4.7 |
| NT-proBNP (pmol/l) | 50 | 0–100 |
| Urine glucose (mg/dl) | 0 | 0–50 |
| Urine ketone (mg/dl) | 0 | 0 |
| Urine protein (mg/dl) | 0 | 0–100 |
| UPC ratio (%) | 0 | <0.2 |
| UCC ratio (%) | 7.79 | <34 |

**Table 2** Summary of body weight (kg), urine specific gravity (USG) and plasma osmolality during the 14 h modified water deprivation test

| Time point (h) | Body weight (kg) | USG | Plasma osmolality (mOsm/kg) |
|---|---|---|---|
| Preparation phase | 7.18 | 1.006 | 325.51 |
| 0 | 7.07 | 1.025 | 327.87 |
| 2 | 7.07 | 1.025 | – |
| 4 | 7.05 | 1.030 | – |
| 6 | 7.05 | 1.030 | – |
| 8 | 7.03 | 1.031 | – |
| 10 | 6.99 | 1.031 | – |
| 12 | 6.96 | 1.033 | – |
| 14 | 6.95 | 1.036 | 331.98 |

Plasma osmolality obtained as calculated values

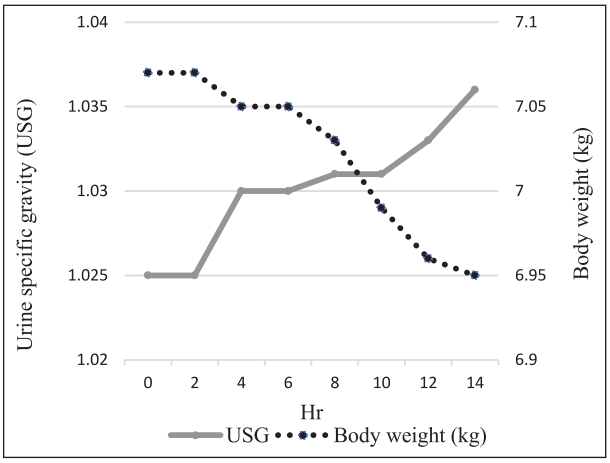


**Figure 1** Body weight (dotted line) and urine specific gravity (solid line) during the 14 h modified water deprivation test

Since PP is very rare, a desmopressin trial was conducted, although ideally, it should have been performed before the MWDT. The cat was administered desmopressin acetate tablets 0.04 mg q12h for 14 days. After 14 days, the USG was 1.003. Desmopressin did not decrease water consumption nor increase the USG above the untreated level.

Psychological anxiety has been considered as a potential cause of PP in humans. The cat was treated with anti-anxiety medications. Gabapentin (10 mg/kg q12h) and fluoxetine (0.5 mg/kg q24h PO) were administered for 6 weeks. However, the cat still exhibited an average consumption of 135 ml/kg/day with free access to water and the USG remained in the range of 1.003–1.006; the anti-anxiety drugs did not effectively treat PP. The owner made environmental-enrichment changes and restricted the cat's water intake to 80 ml/kg/day, which increased the USG to 1.025. The cat has maintained a low USG and normal osmolality and has remained healthy 18 months after the PP diagnosis.

## Discussion

This case report describes a cat with PU/PD and hyposthenuria diagnosed with PP after initial and advanced diagnostic tests.

Bile acid testing is a valuable diagnostic tool for assessing liver failure as a potential cause of PU/PD in cats. The omission of bile acid testing in this case is recognised as a limitation; however, during an 18-month follow-up period, no clinical signs, haematological abnormalities or ultrasonographic findings indicative of liver failure were identified, making liver failure an unlikely contributing factor.

Plasma osmolality >300 mOsm/kg suggests CDI, NDI or PP, while a value <280 mOsm/kg indicates PP alone. Highlighting plasma osmolality as an initial diagnostic tool is particularly useful for cases where PP is the main differential diagnosis, as it facilitates a quick and straightforward diagnosis.

The MWDT causes stress and discomfort to the animal and poses a risk of dehydration and complications due to prolonged water restriction. Therefore, when differentiating between CDI, NDI and PP, it is recommended that a desmopressin trial is performed before conducting the MWDT. This approach addresses the ethical concerns and minimises the risks associated with the MWDT. However, in this case, the likelihood of CDI was considered very low, which justified the decision to proceed with the MWDT as the initial diagnostic step. In addition, 4 h after initiating the MWDT, the USG was 1.030, which allowed the exclusion of CDI and NDI. Therefore, continuing the MWDT until the USG reached 1.036 could be considered controversial and deemed unnecessary.

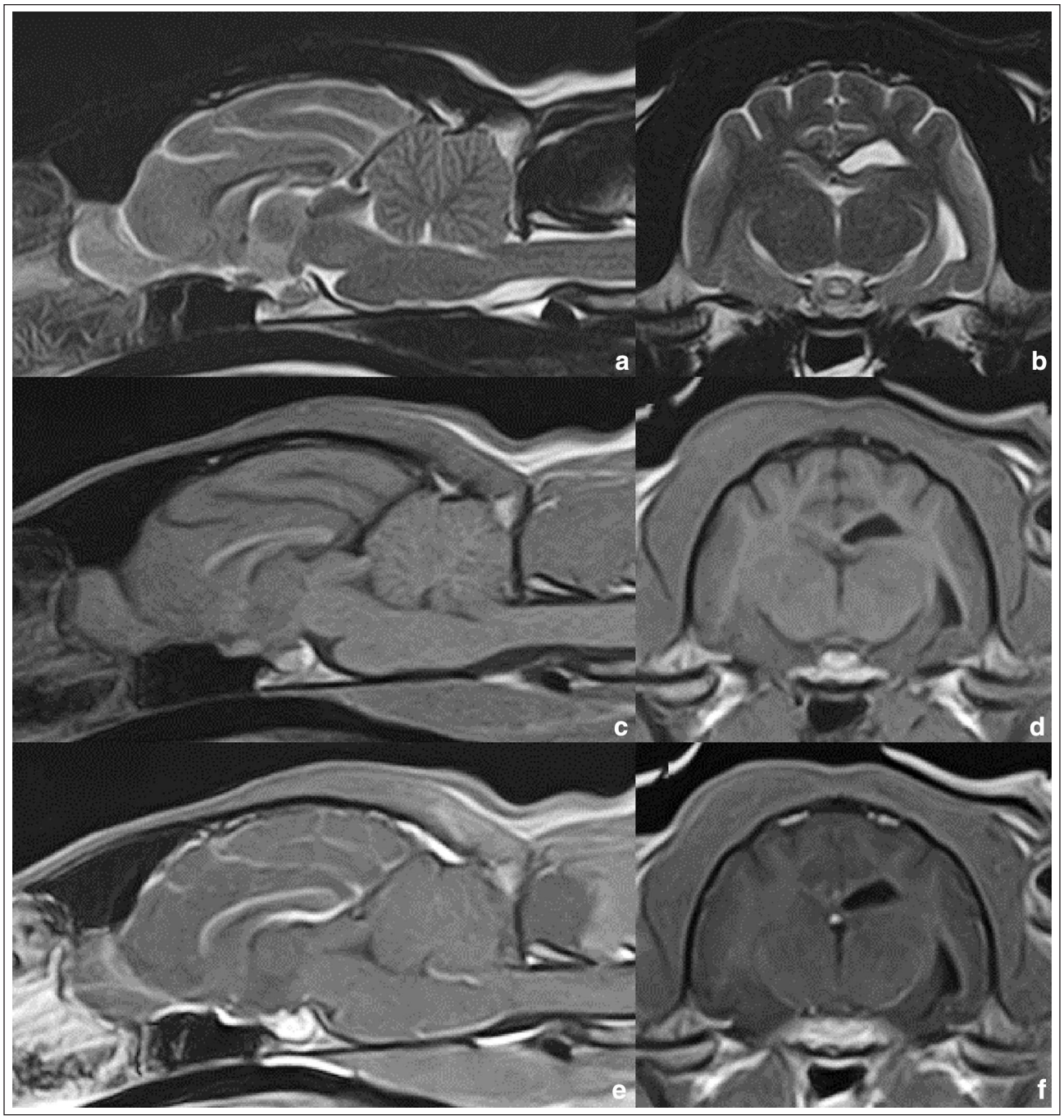


**Figure 2** (a,b) Sagittal and transverse T2-weighted; (c,d) T1-weighted precontrast; and (e,f) T1-weighted postcontrast images of the pituitary gland. The pituitary gland shows a hyperintense region within the caudal third of the gland on T1-weighted and T2-weighted images as well as uniform contrast enhancement on T1-weighted postcontrast images. This is consistent with a normal feline pituitary gland

CDI is a polyuric syndrome resulting from insufficient arginine vasopressin (AVP) secretion, which prompts urine concentration for water conservation. In complete CDI, there is an absolute deficiency of AVP, resulting in persistent hyposthenuria (USG <1.005) even with severe dehydration. In partial CDI, the USG may increase to the isosthenuric range (1.008–1.015) during water restriction, but typically does not exceed 1.015–1.020.[9–12] CDI can be caused by any condition that damages the neurohypophyseal system. Most cases are idiopathic; identifiable causes in dogs and cats include head trauma, neoplasia and hypothalamic–pituitary malformations.[11–17] In this cat, CDI was ruled out through the MWDT, desmopressin trial and MRI examination.

NDI is a polyuric disorder caused by impaired nephron responsiveness to AVP, with plasma AVP levels

being normal or elevated. Several diseases, such as hyperadrenocorticism, pyometra, pyelonephritis and hyperthyroidism, can cause secondary NDI in cats.[4,18–21] Animals with NDI show minimal to no antidiuretic response to high doses of synthetic vasopressin (desmopressin) and the MWDT. The MWDT result ruled out primary and secondary NDI in this case because the urine was concentrated above 1.036.

PP is defined as a marked increase in water intake that cannot be explained as a compensatory mechanism for excessive fluid loss.[2,22–25] Animals with PP have an intact hypothalamic–pituitary–renal axis that controls fluid balance; because the AVP production and renal tubular response to AVP are normal, such animals show urine concentrated above 1.030 during water deprivation.

In human medicine, PP can be further categorised into dipsogenic diabetes insipidus and psychogenic polydipsia. Dipsogenic diabetes insipidus is characterised by an unusually low osmotic threshold for thirst. In affected individuals, the osmotic threshold for AVP release tends to be at the upper end of the normal range. This results in plasma osmolality remaining at a level that is sufficient to suppress thirst but not high enough to trigger AVP release. Consequently, patients with this condition often consume excessive amounts of water, leading to water diuresis. The pathogenesis of dipsogenic diabetes insipidus is unknown but is hypothesised to be due to a disruption of one or more afferent pathways that regulate the thirst and AVP osmostats. Lesions of the hypothalamic thirst centre leading to compulsive water drinking have yet to be reported in dogs or cats. Psychogenic PD is abnormal water intake and an underlying psychiatric disorder. The terms 'primary' and 'psychogenic' PD are often used interchangeably, especially in veterinary medicine.

PP has been described in dogs (typically young, hyperactive dogs).[1,4,25] Only one case of confirmed PP in a cat has been reported.[2] In that case, MRI was not performed, leaving structural problems in the pituitary gland unconfirmed. A rare case of feline PP is reported here, with structural pathology in the pituitary gland excluded based on cranial MRI results.

Psychological anxiety is a potential cause of PP in humans; based on relevant literature in human medicine, gabapentin and fluoxetine were administered.[26,27] The cat still exhibited PU/PD, and the USG remained between 1.003 and 1.006. Anti-anxiety drugs were not effective for PP treatment in this case. Because the response to anti-anxiety drugs varies in human patients with PP, further research on the response to these drugs in cats with PP is needed. Environmental enrichment and restriction of the cat's water intake to 80 ml/kg/day increased the USG to 1.025.

## Conclusions

This case report describes the identification of the underlying disease in a cat with PU/PD, exploring three primary differential diagnoses: CDI, NDI and PP. An MWDT confirmed that although the cat's urine could be concentrated above a USG of 1.036, urine concentration did not occur after desmopressin treatment, confirming PP as the underlying cause of PU/PD. Only one case of feline PP has been reported previously, and the cat in that case did not undergo cranial MRI, limiting the ability to identify structural pathology with the pituitary gland. To our knowledge, this rare case of feline PP is the first reported case wherein the structural pathology of the pituitary gland was completely excluded based on MRI and the response to anti-anxiety drugs was studied.

**Conflict of interest** The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**Ethical approval** The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS Open Reports*. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

**Informed consent** Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers, tissues and samples) for all procedure(s) undertaken (prospective or retrospective studies). For any animals or people individually identifiable within this publication, informed consent (verbal or written) for their use in the publication was obtained from the people involved.

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