Effects of anesthesia, surgery, and intravenous administration of fluids on plasma antidiuretic hormone concentrations in healthy dogs

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Objective—To evaluate effects of anesthesia, surgery, and intravenous administration of fluids on plasma concentrations of antidiuretic hormone (ADH), concentration of total solids (TS), PCV, arterial blood pressure (BP), plasma osmolality, and urine output in healthy dogs.

Animals—22 healthy Beagles.

Procedure—11 dogs did not receive fluids, and 11 received 20 ml of lactated Ringer’s solution/kg of body weight/h. Plasma ADH and TS concentrations, PCV, osmolality, and arterial BP were measured before anesthesia (T0) and after administration of preanesthetic agents (T1), induction of anesthesia (T2), and 1 and 2 hours of surgery (T3 and T4, respectively). Urine output was measured at T3 and T4.

Results—ADH concentrations increased at T1, T3, and T4, compared with concentrations at T0. Concentration of TS and PCV decreased at all times after administration of preanesthetic drugs. Plasma ADH concentration was less at T3 in dogs that received fluids, compared with those that did not. Blood pressure did not differ between groups, and osmolality did not increase >1% from T0 value at any time. At T4, rate of urine production was less in dogs that did not receive fluids, compared with those that did.

Conclusions and Clinical Relevance—Plasma ADH concentration increased and PCV and TS concentration decreased in response to anesthesia and surgery. Intravenous administration of fluids resulted in increased urine output but had no effect on ADH concentration or arterial BP. The causes and effects of increased plasma ADH concentrations may affect efficacious administration of fluids during the perioperative period in dogs. (Am J Vet Res 2000;61: 1273–1276)

Antidiuretic hormone (ADH; also known as arginine vasopressin or vasopressin) is a 9-amino acid peptide; its sequence is the same throughout most mammals. Antidiuretic hormone is secreted from the posterior pituitary, primarily in response to an increase in osmotic pressure. A 1% increase in plasma osmolality will stimulate the secretion of ADH. Hypovolemia and hypotension are potent, but less sensitive, stimuli for release of ADH, requiring a 10% reduction in blood volume or pressure. Other stimuli for release of ADH include body temperature, pain, stress, trauma, anesthesia, and surgery. The primary action of ADH is to increase free water absorption in the distal tubules of the kidney; the principal function of ADH is to regulate serum osmolality and blood volume.

A syndrome of inappropriate release of ADH (SIADH) was initially described in humans with bronchogenic carcinoma. This syndrome is characterized by hyponatremia and plasma hyposmolality, continued renal excretion of sodium with inappropriately high urine osmolality, absence of clinical evidence of volume depletion or edema, and normal renal and adrenal function. An increase in plasma ADH concentration in association with trauma, pain, and surgery has been described as a SIADH; high concentrations of ADH reportedly persist for 1 to 5 days after surgery. Moreover, a SIADH, diagnosed on the basis of low serum and high urine sodium concentrations, reportedly develops in 6 to 21% of human surgical patients. Persistently high concentrations of ADH, associated with SIADH, would result in fluid retention, oliguria, and a decrease in PCV and total solids (TS) concentration. However, results of other studies indicate that SIADH rarely develops in association with surgery, and the secretion of ADH is simply a physiologic response to hypovolemia, anesthesia, or pain.

There is a limited discussion of ADH in the perioperative period in the veterinary literature. One author speculated that the SIADH that develops in veterinary surgical patients may result in fluid retention, and that author recommended restriction of fluid administration to such patients during the perioperative period. There are no measurements of ADH in the perioperative period reported in the veterinary literature. The purpose of the study reported here was to evaluate the effects of anesthesia, surgery, and intravenous administration of fluids on plasma concentrations of ADH and TS, PCV, arterial blood pressure (BP), plasma osmolality, and urine output in healthy dogs. The null hypothesis was that ADH concentration would not be affected by surgery or fluid administration.

Materials and Methods

Animals—Twenty-two healthy adult Beagles (21 females, 1 male), used in a nonsurvival surgery laboratory for veterinary students, were acquired from the University Laboratory Animal Resources of Michigan State University. Mean (± SD) body weight was 9.2 ± 2.5 kg.

Anesthetic and surgical protocols—Dogs were randomly assigned to 2 groups of 11 dogs each. Dogs in group 1 did not receive fluids intravenously, whereas those in group 2 received lactated Ringer’s solution at a rate of 20 ml/kg/h beginning after induction of anesthesia and approximately 30 minutes prior to surgery. A soft tissue or orthopedic procedure was performed on each dog. Numbers of dogs receiving...
In both groups, ADH concentrations increased at T1, groups in ADH concentration at any other time point.

\[ P \pm 0.004 \] less in dogs that received fluids (76.7 \pm 11.4 pmol/L), compared with dogs that did not (128.9 \pm 10.8 pmol/L). There were no differences between groups in ADH concentration at any other time point. In both groups, ADH concentrations increased at T1, T3, and T4, compared with T0 concentrations (Fig 1).

Figure 1—Mean (± SEM) plasma concentrations of antidiuretic hormone (ADH) in 21 healthy adult Beagles before (T0) and at 4 times during anesthesia and surgery (T1, after acepromazine administration; T2, after induction of anesthesia; T3, after 1 hour of surgery; T4, after 2 hours of surgery). Dogs did not receive fluids (n = 10; white bars) or received lactated Ringer’s solution IV after induction of anesthesia (20 ml/kg/h; 11; black bars). *Value significantly different from T0 for same group. #Value significantly different from value for the other group.

Figure 2—Mean (± SEM) PCV in 21 healthy adult Beagles before (T0) and at 4 times during anesthesia and surgery (T1, after acepromazine administration; T2, after induction of anesthesia; T3, after 1 hour of surgery; T4, after 2 hours of surgery). See Figure 1 for key.

Figure 3—Mean (± SEM) plasma concentration of total solids in 21 healthy adult Beagles before (T0) and at 4 times during anesthesia and surgery (T1, after acepromazine administration; T2, after induction of anesthesia; T3, after 1 hour of surgery; T4, after 2 hours of surgery). See Figure 1 for key.

Results

Measurements were not obtained from 1 dog in group 1 at T4. Therefore, that dog was excluded from the study. Mean (± SD) body weight did not differ between groups (group 1, 9.9 ± 0.9 kg; group 2, 8.4 ± 0.6 kg).

Plasma ADH concentrations—At T3 (after 1 hour of surgery), ADH concentration was significantly (\( P = 0.004 \)) less in dogs that received fluids (76.7 ± 11.4 pmol/L), compared with dogs that did not (128.9 ± 10.8 pmol/L). There were no differences between groups in ADH concentration at any other time point. In both groups, ADH concentrations increased at T1, T3, and T4, compared with T0 concentrations (Fig 1).
**Discussion**

Concentrations of ADH increased in association with surgery and anesthesia. Plasma ADH concentrations in both groups increased significantly after administration of acepromazine (T1) but then decreased to T0 values within approximately 30 minutes, coinciding with induction of anesthesia (T2). The exact reasons for these fluctuations in ADH concentrations are not known. It is theorized that administration of acepromazine and other preanesthetic medications induces vasodilatation.

Vasodilatation would result in relative hypovolemia, fluid shifts to the plasma volume, and a release of ADH. We also detected a concurrent 20% decrease in PCV from T0 to T1 in both groups combined, which is in agreement with observations that anesthesia results in decreased PCV and increased plasma volume attributable to fluid shifts to the plasma space. The rapid decrease in plasma concentrations of ADH that we detected after the initial increase was compatible with the 5- to 10-minute circulating half-life of ADH. It is also conceivable that other factors may have contributed to the increased ADH concentrations at T1 (eg, stress).

Diuretic hormone concentration again increased, compared with the T0 value, in association with surgery (T3, T4). Coincident with increased ADH concentrations was a decrease in mean arterial BP. Arterial hypotension may have been the stimulus for ADH release during the operative period; stimuli associated with surgical manipulations may have also contributed to release of ADH.

Intraoperative plasma ADH concentrations were in the range of 50 to 100 pmol/L. Mean concentration of ADH at T0 was 6.9 pmol/L (median, 4.5 pmol/L). Plasma ADH concentrations that reportedly result in maximal urine concentration are approximately 11 pmol/L. Therefore, ADH concentrations that we recorded during surgery were clinically relevant and capable of causing antidiuresis. A 1% increase in plasma osmolality is a potent stimulus for the release of ADH. At no time did serum osmolality increase to > 1% of the T0 value in either group. Thus, serum osmolality did not cause the observed increase in plasma ADH concentrations. In group 1, osmolality decreased at 2 times (T1 and T2) after induction of anesthesia and after 1 hour of surgery, respectively, compared with the T0 value. The reasons for this decrease are unclear. It is conceivable that fluid shifts from the intracellular to the extracellular space developed to compensate for a relative hypovolemia that developed secondary to drug-induced vasodilatation.

The effect of IV administration of fluids on ADH concentrations was not extensive. After 1 hour of surgery (T1), ADH concentration in dogs that received fluids (group 2) was less than in dogs that did not (group 1). This could be because fluid administration (27.6 ml/kg/h) ameliorated any volume deficit. After 2 hours of surgery (T4), the difference in ADH concentration between groups was less and not significant. Between T1 and T4, fluids were given at a slower mean rate (17.4 ml/kg/h) than before T1. The degree that hypotension and various other factors affected ADH concentrations at T1 and T4 are not known; additional factors that may influence concentrations of ADH include temperature, Po2, Pc02, and anesthetic depth.

The 2 rates of fluid administration were selected, because they were considered to be less than and greater than the standard rates used during elective surgery in healthy dogs. Median rates of urine production in dogs that did not receive fluids at T1 and T4 were 0.0 and 0.0 ml/kg/h, respectively, whereas median rates of urine production in group 2 at T1 and T4 were 0.0 and 3.1 ml/kg/h, respectively. From these results, we concluded that IV administration of fluids is an important factor for maintenance of urine production.
and urine is produced in the presence of plasma ADH concentrations in excess of those associated with maximal antidiuresis (ie, 50 to 100 pm/L). Intravenous administration of fluids had no significant effect on arterial blood pressure in this study.

The causes of increased plasma concentrations of ADH during anesthesia and surgery are not known nor have the effects of increased ADH concentrations been completely determined. It is apparent from results of our study that urine can be produced even when ADH concentrations are high, if adequate amounts of fluids are administered. It has been reported that urine production during surgery is determined mainly by osmolar load, and there is no relationship between ADH concentrations and urine volume. Results of our study are in agreement with these observations. Plasma ADH concentration and urine volume were correlated (Pearson correlation, r = 0.33). The squared correlation coefficient (r^2) between ADH concentration and urine volume was, therefore, only 0.11, implying that 11% of the variation in ADH concentration could be accounted for by urine volume. We did not evaluate the effects of high plasma ADH concentrations in dogs given fluids (eg, water retention and vascular expansion). Packed cell volume did not decrease further after the initial decrease at T1. Therefore, we believed that changes in blood volume at T3 and T4 associated with intravenous administration of fluids were not clinically relevant. On the other hand, concentration of TS further decreased by 15 to 20% after the initial decrease at T1. This further decrease would argue that blood volume increased in association with IV administration of fluids and increased plasma ADH concentrations at T3 and T4. Further studies are needed to address the effects of increased ADH concentration on actual blood volume.

In this study, data were obtained from dogs that were used in a nonsurvival surgery laboratory for veterinary students. Consequently, postoperative data were not obtained. Some authors have suggested that plasma ADH concentration remains high for 1 to 5 days after surgery. We were not able to address that issue in this study.

References

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