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Postoperative serum potassium concentration in dogs that underwent ovariohysterectomy

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Abstract...

Introduction: To evaluate the postoperative potassium concentration in dogs after ovariohysterectomy.

Methods: Eleven adult, healthy female dogs took part in the present report. Dogs underwent elective ovariohysterectomy. Three samples were taken in order to assess serum potassium levels as well as sodium, blood glucose, blood osmolality and to perform arterial blood gas analysis. The first sample was taken before surgery, the second one right after surgery and before the dog was extubated and the third sample 6 hours postoperatively.

Discussion: A mild elevation of serum potassium concentration was noted right after the surgical procedure. In addition, a reduction of blood pH, blood osmolality and serum HCO_3^- was observed. At the same time point, blood glucose was increased as well as arterial CO_2 however, hypercapnia was not observed. Six hours postoperatively, there was a statistically significant reduction of serum potassium levels. Even so, hypokalemia was not observed in any of the participating dogs. All other examined variables returned to the preoperative values.

Conclusion: This is the first report of significant postoperative serum potassium decrease in dogs after ovariohysterectomy. Even though no hypokalemia was observed in any of the dogs, more studies need to be done in order to further evaluate postoperative potassium concentrations changes.

Keywords: Dog; Potassium; Postoperative; Ovariohysterectomy; Hypokalemia.

Introduction

Perioperative potassium abnormalities have been noticed in a few veterinary studies. More specifically, mild to severe increase of potassium has been noticed to occur in dogs during anaesthesia or shortly after the surgical procedure. The definite cause of this phenomenon has not been defined [1,2]. On the other hand, in human studies, postoperative decrease in serum of potassium concentrations have been described which is usually noted the first postoperative day [3,4]. Due to this fact, close monitoring of potassium concentrations perioperatively has been suggested in order to avoid hypokalemia and in some instances, potassium supplementation might be warranted [5]. To the authors' knowledge, there are no published studies that present postoperative drop of serum potassium concentration in dogs.

The aim of this report is to present changes in serum potassium concertation in dogs, postoperatively which, to the authors' knowledge have not been described previously. In the cases presented, arterial blood gas analysis as well as glucose, blood osmolality and sodium serum concentrations were assessed in order to further evaluate serum potassium changes. The primary hypothesis of the authors was that there will be no significant alterations of serum potassium in dogs after elective ovariohysterectomy.

In addition, we hypothesized that both acid base balance and serum electrolytes changes would not be significantly altered after surgery.

Materials and methods

All dogs were privately owned and had a thorough physical examination, routine blood screening tests and urinalysis before undergoing elective ovariohysterectomy. Dogs that had any underlying pathology noted from the owners or found during the pre- anaesthetic routine tests and dogs that were on any medication were excluded from the study. Written informed owner consent was obtained for all dogs included in the study which was approved by Research and Ethical Committee (clinical study approval N. 611/2-7-2019). All dogs that participated in this study were included in the control group of another experimental study so as they would not receive any further treatment. The preanaesthetic medication consisted of dexmedetomidine (180 μg m^{-2}) (Dexdomitor, Orion Pharma, Finland) and methadone (0.2 mg kg^{-1}) (Synthadon, Animalcare Ltd, UK) Intramuscularly (IM). An intravenous catheter was inserted at the cephalic vein approximately 20 minutes later and the induction of anaesthesia was achieved via propofol (1-2 mg kg^{-1}) (Propofol MCT/LCT 1%, Fresenius Kabi Hellas, Greece) Intravenously (IV) to allow endotracheal intubation. The dogs were connected to a rebreathing anaesthetic circuit and anaesthesia was maintained with isoflurane (Iso-Vet, Piramal Critical Care Ltd, Longford, UK) in oxygen. Intraoperatively, Lactated Ringer's solution(Baxter, Athens, Greece) was administered at 5 mL kg^{-1} $hour^{-1}$. Standard monitoring was applied (Datex-Ohmeda S/5, GE Healthcare, Datex- Ohmeda, Finland). Specifically, pulse oximetry, capnography, indirect measurement of arterial blood pressure and electrocardiography were used to monitor vital signs. At the end of the surgery, tramadol (2 mg kg^{-1}) (Tramal, Vianex A.E., Hellas) and atipamezole (0.5% solution at a volume of a quarter of the initial dexmedetomidine volume) (Antisedan, Orion Pharma, Finland) were administered IM. Postoperative pain was evaluated hourly using the short form of the Glasgow Composite Measure Pain Scale (score ranging from 0^- no signs of pain to 24^- maximum pain score) [6]. Rescue analgesia consisted of pethidine (3 mg kg^{-1}) (pethidine cloridato, Molteni, Italy) IM, which would be administered if pain score was above 6/20 [6] and the dog would be excluded from the study.

An arterial blood sample was collected from the right femoral artery at three time points: before the premedication (T0), immediately after extubation and before atipamezole administration (T1) and 6 hours postoperatively (T2). Blood osmolality, glucose, potassium and sodium concentrations were also included in the results of the blood gas analysis using a calibrated blood gas analyzer (ABL 700; Radiometer Medical A/S, Brønshøj, Denmark).

Statistical analysis

Data were analyzed with Friedman's test and Wilcoxon's signed-rank test for pairwise comparisons. All statistical calculations were carried out using a statistical software (IBM SPSS Statistics 24.0, New York, USA). Significance level was set to 0.05.

Results

A total of 11 female, American Society of Anesthesiologists Physical Status Score (ASA) I dogs, aged 1-6 years and weighed 17-30 kg that underwent elective ovariohysterectomy enrolled in the study. Mean duration of the surgery was 75 minutes. All dogs recovered uneventfully. Six hours postoperatively, the mean pain score was 2/20. At no time point pain score exceeded 6/20 and no dog received rescue analgesia.

A mild statistically insignificant increase (p=0.29) in serum potassium concentration was noted in the blood sample collected immediately after the extubation (T1), compared to T0. In addition, arterial blood pH decreased at values below the Reference Intervals (RI) (7.35- 7.45) *(p*<0.05) with a concurrent increase of arterial partial pressure of carbon dioxide ($PaCO_2$) (p<0.05) and a decrease of bicarbonate ($HCO3^-$) levels at T1 compared to T0. However, HCO_3^- and $PaCO_2$ levels did not exceed RI (19- 23 mEq L^{-1} and 35- 45 mmHg respectively). Furthermore, sodium levels decreased as well as blood's osmolality (p< 0.05). A marked elevation of blood's glucose was noticed at T1 (p< 0.05).

A statistically significant decrease of serum potassium levels was noted at T2 compared to T1 and T0 (p< 0.05). In addition, arterial blood pH reached the pre- operative levels as well as the $PaCO_2$, glucose, serum sodium levels and osmolality (p<0.05). HCO_3^- concentration was not significantly changed during the three time points. In brief, there was no statistically significant difference of the recorded variables between T0 and T2 except from the reduction of potassium levels (p<0.05). All the above changes are presented at Table 1.

Figure 1: Arterial blood gases and biochemistry values preoperatively (T0), after extubation (T1) and 6 hours postoperatively (T2) in the 11 dogs (mean ± standard deviation).

Variable (normal values)	T0	T1	T2
pH (7.35- 7.45)	7.41 ± 0.36*	7.31 ± 0.64*†	7.40 ± 0.04†
Glucose (4.16 – 6.44 mmol L^{-1})	5.87 ± 0.46*	9.54 ± 2.16*†	6.46 ± 0.54†
$PaCO_2$ (35-45 mmHg, 4.67- 6 kPa)	35.23 ± 3.96 mmHg*	44.80 ± 8.84 mmHg*†	36.82 ± 5.43 mmHg†
	4.7 ± 0.53 kPa	5.97 ± 1.18 kPa	4.91 ± 0.72 kPa
Potassium (4- 4.5 mmol L^{-1})	4.26 ± 0.32‡	4.48 ± 0.55†	3.84 ± 0.25†‡
Osmolality (290-310 mOsm kg^{-1})	295.35 ± 5.30*	290.45 ± 5.65*†	295.85 ± 5.43†
Sodium (142- 149.3 mmol L^{-1})	144.74 ± 2.68*	140.46 ± 2.77*†	144.69 ± 2.65†
HCO3-(19- 23 mEq L^{-1})	22.73 ± 1.29*	20.81 ± 1,66*†	22.54 ± 2.31†

*Statistically significant changes within T0-T1. † Statistically significant changes within T1-T2
‡ Statistically significant changes within T0-T2

Discussion

In our study, a sharp and significant decrease of serum potassium concentration was noticed 6 hours after elective ovariohysterectomy in dogs. In human medicine, hypokalemia is frequently encountered after surgery and strategies have been developed in order to prevent and control postoperative potassium decrease [7], however such incidences have not been reported in canine postoperative patients. On the other hand, a mild but statistical insignificant elevation of potassium concentration just after extubation comes in relative agreement with the results of other studies that noted a significant increase in inra- and postoperative potassium concentration in dogs [1,2].

In the present study, two postoperative time points have been selected in order to assess potassium concentration. The immediate post- extubation time point was selected in order to assess the immediate effects of surgery on serum potassium while the 6 hours postoperative sample was selected because it was the time point where a decrease of potassium concentration was first observed in the study of Kim et al (2011) [3].

A mild increase in potassium was observed immediately postoperatively. It was not consistent in all dogs and was approximately 0.22 mmol L^{-1}. More specifically, potassium was increased in only 5 dogs and the elevation of potassium concentration ranged from 0.53 to 1.33 mmol L^{-1}. An increase in serum potassium perioperatively has been previously documented in dogs. In the cases presented by Hampton et al., and Tong et al severe hyperkalemia was documented in diabetic dogs that underwent surgery [2,8]. In both cases, the exact reason for the development of hyperkalemia was not found however, the authors mentioned that metabolic acidosis, reduced renal excretion, potassium distribution disturbances possibly due to insulin resistance and hyperglycemia and acute lysis syndrome may have contributed to potassium disturbance [2,8]. In addition, intraoperative increase in serum potassium was also noted in the study of West et al. and hyperkalemia also developed in some cases, two hours after induction of anesthesia. The reason of these potassium disturbances was not explained by the authors [1]. In the present study, serum potassium elevation, as it was already mentioned, was not significant, and hyperkalemia did not occur in any of the presenting cases. However, more studies need to be done in order to assess the cause of the increase in potassium concentration postoperatively in some cases.

On the other hand, 6 hours postoperatively, a significant decline of potassium was noted. In the perioperative period of human surgical and laparoscopic procedures hypokalemia has been previously reported. The majority of the patients developed mild hypokalemia (potassium levels between 3.0 to 3.5 mmol L^{-1}) but severe hypokalemia (< 2.5 mmol L^{-1}) was also noted in some patients [5]. The disturbance in potassium levels may lead to gastrointestinal disorders and arrhythmias in the perioperative period thus its close monitoring is described in the "Enhanced Recovery After Surgery" protocol [5]. In the results presented in this study, a statistically significant decrease was noted at potassium levels 6 hours postoperatively but did not lead to hypokalemia. Thus, no symptoms of gastrointestinal hypomotility or cardiac arrhythmias were noted. The use of Lactated Ringer's perioperatively may have contributed to the lesser reduction of potassium compared to that observed in human studies. However, it's is still questioned whether its small amount of potassium could prevent hypokalemia in these dogs [4].

Possible factors that can contribute to postoperative hypokalemia is reduced potassium intake or increased potassium loss. Thus, undetected preoperative hypokalemia may be one factor that leads to severe postoperative hypokalemia [7]; however, serum potassium levels were examined in all dogs preoperatively and no abnormalities were found. Potassium loss through the gastrointestinal track is also a possible factor that leads to hypokalemia [4] however none of the dogs in this study had any gastrointestinal symptom thus, the reduction of potassium levels is unlikely to be contributed to that factor.

Neuroendocrine stress response may also contribute to perioperative hypokalemia observed in human patients. More specifically, the release of catecholamine and stress hormones due to preoperative anxiety has been linked with the transportation of the extracellular potassium into the hepatic cells and the skeletal muscles. In the study of Kim et al. (2011), decreased potassium levels were noted in patients from the day of the surgery until the first postoperative day. In addition, stress from the perioperative pain was also associated with hypokalemia [3]. In the present study, pain scores of all dogs indicated that postoperative pain possibly did not alter the stress response of these animals. Nevertheless, any surgical procedure may provoke endocrinological and metabolic alternations and lead to stress response [9]. Thus, stress response to the surgical procedure may have led to the decreased postoperative potassium levels.

Other possible factors that may have contributed to the reduction of potassium levels 6 hours postoperatively is respiratory or metabolic alkalosis [3]. In the dogs presented in this study, blood gas analysis revealed no alkalosis. More specifically, pH, $PaCO_2$ and HCO_3 values returned to preoperative levels. Other causes of hypokalemia are renal diseases, administration of diuretics and preoperative bowel preparation in human patients [3,5]. The dogs that were included in this study had no concurrent diseases, did not received any medication preoperatively and no bowel preparation was performed. However, a possible limitation is that urinary potassium excretion was not assessed in the dogs that participated in this study.

Conclusion

In conclusion, a significant potassium decrease, 6 hours postoperatively was noted. Even though the changes presented in this study were statistically significant, none of the values examined exceeded the RIs. However, more compromised dogs or dogs with pre-existed potassium imbalances might experience more pronounced disturbances. We believe that this clinical observation should be the beginning of further studies to be done assessing potassium's homeostasis perioperatively in a larger population of dogs and in compromised animals. Furthermore, the evaluation of the impact of the postoperative stress response to the potassium's homeostasis, among other factors, should be assessed in future studies.

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