Effects of dexamethasone and isoflupredone acetate on plasma potassium concentrations and other biochemical measurements in dairy cows in early lactation

Natalie J. Coffer, BVetMed; Nicholas Frank, DVM, PhD; Sarah B. Elliott, BSc; Charles D. Young, MSc; Sarel R. van Amstel, BVSc, MMedVet

Objective—To determine whether administration of isoflupredone acetate (ISO) to healthy cows increases the frequency of severe hypokalemia and whether dexamethasone (DEX) has detectable mineralocorticoid properties.

Animals—33 cows at 20 to 25 days of lactation.

Procedures—Cows were randomly allocated to 5 treatment groups and received 2 intramuscular (IM) injections on days 0 and 2 of sterile saline (0.9% NaCl) solution (10 mL each), an injection of ISO (20 mg) or DEX (20 mg) followed by 10 mL of saline solution, or 2 injections of ISO or DEX. Milk production was measured, physical examinations were performed, and blood and urine samples were collected daily on days 0 through 7.

Results—Physical examination parameters did not differ among groups; however, 1 cow developed atrial fibrillation on day 4. Both corticosteroids significantly increased plasma glucose concentrations, and ISO significantly decreased plasma potassium concentrations and increased total carbon dioxide concentrations with time. One dose of ISO decreased mean plasma potassium concentration by 25% on day 2, compared with day 0, and severe hypokalemia (serum potassium concentration < 2.3 mEq/L) developed in 1 of 6 cows. Mean plasma potassium concentration was 46% lower on day 3 than on day 0 in cows receiving 2 doses of ISO, and 5 of 7 cows became severely hypokalemic. Mean urinary fractional excretion of potassium significantly increased from that on day 0 in cows receiving 2 doses of ISO.

Conclusions and Clinical Relevance—Both corticosteroids had glucocorticoid activity; however, only ISO had mineralocorticoid activity. Compared with saline solution, administration of 2 doses of ISO significantly increased the frequency of severe hypokalemia. (Am J Vet Res 2006;67:1244–1251)

Corticosteroids are commonly administered to dairy cows with ketosis to enhance gluconeogenesis and lower milk production, but their use has also been associated with development of BHKS. This syndrome is characterized by severe hypokalemia (defined as a serum potassium concentration < 2.3 mEq/L), weakness or recumbency, cardiac arrhythmias, and myofiber degeneration. An association between ISO use and BHKS was first reported in 1997 when Sielman et al identified 10 cows that were weak or recumbent and severely hypokalemic. Each cow had been treated with ISO prior to admission; however, information regarding the dosages used and timing of injections was not provided. In another retrospective study, 4 of 14 cows with BHKS received ISO prior to admission, whereas 5 cows did not receive corticosteroids, and information regarding treatments was not provided for the 5 remaining cows. Peek et al also reported that 10 of 15 cows with BHKS received ISO, 4 cows were treated with DEX, and 1 cow received both corticosteroids prior to examination.

Results of those retrospective studies suggest that corticosteroid administration is an important risk factor for severe hypokalemia, and this conclusion is supported by results of a study describing the successful induction of BHKS in dairy cows by use of ISO. In that study, BHKS was induced in 2 lactating Holstein dairy cows by depriving them of feed for 4 days and administering 20 mg of ISO on days 2, 4, and 6. However, it should be noted that dosages recommended for ISO were exceeded in 2 of those studies. The manufacturer recommends that 10 to 20 mg of ISO be administered IM to cattle, and this dose may be repeated in 12 to 24 hours. Because inappropriate dosages have been used and other factors including anorexia, ketosis, metabolic alkalosis, and hypophosphatemia may have predisposed cows to BHKS, the risk of severe hypokalemia developing after routine ISO administration remains unclear.
Effects of administering DEX or ISO to lactating cows have only been compared prospectively in a study published in 1970. Cows that received a single injection of DEX or ISO at a dose of 0.03 mg/kg had significantly higher whole-blood glucose concentrations and significantly lower milk production, compared with the control group. In that study, none of the cows had clinical signs of weakness or became recumbent. However, serum potassium concentrations were not measured; therefore, hypokalemia could have gone undetected. To the authors' knowledge, a prospective study examining and comparing glucocorticoid and mineralocorticoid properties of DEX or ISO has not been performed in cattle.

The purpose of the cohort study reported here was to determine whether administration of ISO to healthy cows increases the frequency of severe hypokalemia and whether DEX has detectable mineralocorticoid properties. This latter question was examined because Peek et al. reported that 4 cows that received DEX developed BHKS, and this drug is commonly used as an alternative to ISO. One or 2 doses of corticosteroid were administered to determine whether multiple dosing affected the number of cows that developed severe hypokalemia after treatment.

Materials and Methods

Cows—Thirty-three multiparous Holstein dairy cows at 20 to 25 days of lactation were evaluated. Cows from a herd of approximately 110 cattle at the Eastern Tennessee Research and Education Center Dairy Unit were studied.

Experimental design—Cows were randomly allocated to groups as they entered the study at 20 to 25 days of lactation (day 0 of the study), and each cow was evaluated for 8 days. The study lasted for 240 days and was performed from September 2003 to June 2004. Cows were required to be free of observed medical problems for a minimum of 7 days before the beginning of the study, as determined by behavior and milk production. Milking procedures, housing, and diet were not controlled in the study, and cows remained within the herd except when physical examinations were performed and samples were collected. Cows were randomly allocated to 5 groups and received 2 IM injections 48 hours apart. Cows received 2 injections (10 mL each) of saline (0.9% NaCl) solution (SAL group; n = 6), an injection of DEX (20 mg) followed by an injection of saline solution (DEX1 group; n = 6), an injection of ISO (20 mg) followed by an injection of saline solution (ISO1 group; 6), 2 injections of DEX (20 mg; DEX2 group; 7), or 2 injections of ISO (20 mg; ISO2 group; 7). Injections were administered between 9 and 11 AM on days 0 and 2 after collection of samples. Milk production was measured, physical examinations were performed, and blood and urine samples were collected daily for 8 days. Cows were milked at approximately 7:30 AM and 7 PM and spent the remaining time in a free-stall barn where they were fed a total mixed ration, except during winter months (November through February) when they were turned out on pasture at night. Farm personnel were contacted 30 minutes prior to arrival of investigators, and cows were moved to a separate barn and restrained in stanchions. Procedures were performed within 1 hour of cows being restrained, and then cows were returned to the herd. The study protocol was approved by the University of Tennessee Institutional Animal Care and Use Committee.

Physical examinations—Physical examinations were performed and samples were collected between 9 AM and 3 PM. Single measurements of rectal temperature, heart rate, respiratory rate, and number of rumen contractions per 2-minute time interval were collected each day. Cows were also observed by farm personnel at milking times to assess for weakness and changes in behavior; however, these observations were not scored or recorded.

Sample collection—Blood was collected from a jugular vein with an 18-gauge needle into tubes containing EDTA, sodium heparin, or no anticoagulant. Tubes containing anticoagulant were gently agitated and placed in ice, whereas tubes without anticoagulant were left at approximately 20°C to permit clotting of blood. Plasma or serum was obtained within 60 minutes of collection by low-speed centrifugation at 1,000 × g for 10 minutes and stored at –70°C until further analysis. Urination was induced by perineal stimulation, and midstream urine was collected into empty glass tubes and transferred to 4-mL polypropylene tubes for storage at –20°C.

Analysis of plasma lipid concentrations—Concentrations of nonesterified fatty acids, phospholipids, total cholesterol, and triglyceride were measured in plasma (EDTA) by use of enzymatic colorimetric reagents on a microtitrator plate reader. The intra-assay coefficient of variation was < 5% for duplicate analyses of samples.

Plasma biochemical analysis—Concentrations of BUN, calcium, chloride, creatinine, glucose, potassium, magnesium, sodium, phosphorus, TRIL, TCO2, and total protein and activities of AST and GGT were measured in duplicate in heparinized plasma by use of the respective enzymatic colorimetric reagents in an automated discrete analyzer.

Measurement of serum beta BHBA concentrations—Serum was shipped frozen to another laboratory, and BHBA concentrations were measured in duplicate by use of enzymatic colorimetric reagents in an automated discrete analyzer. Hyperketonemia was defined by a serum BHBA concentration > 15 mg/dL, which is a cutoff value used to define subclinical ketosis.

Urinalysis—Concentrations of glucose, acetoacetate, and protein; pH; and specific gravity were measured in urine by a dipstick immediately after collection, and samples were stored at –20°C. Urine acetocetate concentrations were determined to be 0, 5, 15, 40, 80, or 160 mg/dL on the basis of the color of the reagent after 40 seconds. Concentrations of chloride, creatinine, potassium, sodium, and phosphorus were subsequently measured in duplicate in urine collected from cows in the ISO2 group by use of the respective ion-specific potentiometry (chloride, sodium, potassium) or enzymatic colorimetric (creatinine) reagents in an automated discrete analyzer. Urine samples were diluted 10-fold with deionized water to maintain linearity if chloride, potassium, sodium, and phosphorus concentrations were > 250, 80, and 250 mg/dL, respectively. Urinary FE values for chloride, phosphorus, and sodium and FEK were calculated by use of an established formula. Only samples from cows in the ISO2 group were analyzed because of financial constraints.

Statistical analysis—Treatment, time, and treatment × time effects were examined by repeated-measures ANOVA. When significance was established, the Bonferroni test for multiple comparisons was used to compare differences of least squares means for days 1 to 7 with day 0 (before injection) values within the same group. Differences in milk production were also examined among cows that received 1 or more injections of DEX or ISO and cows in the SAL group. Effects of time on urinary FE of electrolyte values were examined in cows in the ISO2 group by repeated-measures ANOVA. Correlations among variables were assessed by examining Pearson correlation coefficients. Development of severe hypokalemia (plasma...
potassium concentration < 2.3 mEq/L) was compared among groups by use of the Fisher exact test. Values of P < 0.05 were considered significant.

**Results**

Groups did not differ significantly with respect to physical examination measurements; however, 1 cow in the ISO2 group developed atrial fibrillation on day 4 that was confirmed via ECG. Heart rates of 80, 100, 60, 60, 100, 100, and 72 beats/min were detected on days 0 through 7 in this cow. This cow was retained in the study because its behavior, respiratory rate, and rumen contractions were considered normal and the cow appeared to be healthy. Fluids containing potassium were administered orally and IV at the end of the study; however, atrial fibrillation persisted and was evident 6 months later.

Significant treatment × time effects were detected, and mean values differed from mean values on day 0 (baseline) for plasma potassium (P < 0.001), TCO2 (P < 0.001), glucose (P < 0.001), phosphorus (P < 0.001), and TBIL (P = 0.012) concentrations (Figures 1–4). Significant treatment × time effects were also detected for chloride (P = 0.035), magnesium (P = 0.002), calcium (P = 0.036), total protein (P < 0.001), AST (P = 0.046), and GGT (P = 0.032); however, means did not differ from day 0 values, and responses to various treatments did not follow any identifiable patterns (Figure 5).

Mean plasma potassium concentrations were significantly lower than the baseline mean value on day 2 in ISO1-group cows and on days 1 to 5 in ISO2-group cows, and the largest difference from baseline (~46%) was detected on day 3 (Figure 1). Mean plasma potassium concentrations ranged from 1.8 to 5.2 mEq/L in all cows, and severe hypokalemia developed only in cows that received ISO. Severe hypokalemia was detected on 1 or more occasions in 1 of 6 cows in the ISO1 group and 5 of 7 (P = 0.021 vs SAL group) cows in the ISO2 group but was not detected in cows from other groups.

Mean plasma TCO2 concentration was significantly higher than the baseline mean value on days 2 through 5 in ISO2-group cows (Figure 2). Plasma TCO2 and potassium concentrations were negatively correlated (n = 56; r = –0.81; P < 0.001) in the ISO2 group. These variables were also negatively correlated (n = 264; r = –0.48; P < 0.001) across all groups.

Mean plasma glucose concentrations significantly increased after administration of ISO or DEX, and plasma phosphorus concentrations were significantly lower than baseline in cows in the DEX1 and ISO2 groups on day 1 (Figures 3 and 4, respectively). A significant treatment × time effect was detected for plasma magnesium concentrations; however, mean values did not differ significantly from baseline on any specific day (Figure 5). Mean TBIL concentration significantly increased on day 4 from 0.14 ± 0.05 mg/dL (day 0) to 0.29 ± 0.11 mg/dL in the ISO2 group.

Measured urine dipstick values did not differ significantly with time among groups. Urinary FE values were measured only in cows in the ISO2 group, and FEK increased significantly (P = 0.048)
with time in those cows (Figure 6). Plasma potassium concentrations were negatively correlated (n = 51; $r = -0.48; P < 0.001$) with urinary FE K in ISO2-group cows. Urinary FE of sodium and chloride did not change significantly with time in ISO2-group cows.

Hyperketonemia (serum BHBA concentration > 15 mg/dL) was detected on day 0 in 3 cows from the DEX1 group, 1 cow from the DEX2 group, and 1 cow from the ISO2 group. This condition resolved within 24 hours in 4 cows from the DEX1 and DEX2 groups, but persistent hyperketonemia (from days 0 to 7) was detected in the cow from the ISO2 group, and atrial fibrillation developed in this cow. Increased serum BHBA concentrations were also detected in 1 cow from the SAL group on day 5, 1 cow from the DEX1 group on day 5, and 2 cows from the ISO2 group on days 4 and 7. One cow from the DEX2 group was hyperketonemic on days 6 and 7. Plasma concentrations of potassium and BHBA were not significantly correlated (n = 264; $r = 0.06; P = 0.365$), and only 1 of the 6 cows that developed severe hypokalemia was con-
Concentrations measured by dipstick were positively correlated (n = 239; r = 0.70; P < 0.001) with serum BHBA concentrations. A significant (P = 0.004) treatment x time effect was detected for milk production, but means did not differ from day 0 values in any of the 5 groups (Figure 7). However, milk production was significantly lower on days 1 and 3 (–12% and –14%, respectively) when results from corticosteroid-treated cows were pooled and compared with cows in the SAL group.

**Discussion**

To the authors’ knowledge, effects of administering DEX and ISO to early lactation dairy cows were examined for the first time by use of a prospective cohort study design. Results indicated that only ISO had mineralocorticoid effects and the risk of developing severe hypokalemia significantly increased when 2 doses of ISO were administered instead of saline solution or DEX. Milk production was suppressed by corticosteroids on days 1 and 3.

With the exception of 1 cow that developed atrial fibrillation on day 4, urine acetacetate concentrations measured by dipstick were positively correlated (n = 239; r = 0.70; P < 0.001) with serum BHBA concentrations. A significant (P = 0.004) treatment x time effect was detected for milk production, but means did not differ from day 0 values in any of the 5 groups (Figure 7). However, milk production was significantly lower on days 1 and 3 (–12% and –14%, respectively) when results from corticosteroid-treated cows were pooled and compared with cows in the SAL group.

**Plasma potassium concentrations** significantly decreased after treatment, and severe hypokalemia was induced in cows that received ISO. Isoflupredone acetate administration has been associated with hypokalemia in dairy cattle and horses. In our study, severe hypokalemia developed in cows that received two 20-mg doses of ISO 48 hours apart, which is longer than the 12- to 24-hour interval recommended by the manufacturer. The risk of developing severe hypokalemia may therefore be even higher if manufacturer’s recommendations are followed. In contrast, DEX did not have mineralocorticoid activity with respect to plasma potassium concentrations and this drug is not likely to contribute to development of BHKS. Potassium concentrations also remained unaffected when horses were injected with DEX (0.04 mg/kg, IV) once daily for 6 days. In the study reported here, administration of ISO resulted in lower plasma potassium concentrations and increased urinary FEK, both of which are mineralocorticoid effects.

Published references ranges for urinary FEK vary widely. Fleming et al reported that urinary FEK values range from 19.2% to 138% in cows 1 to 197 days after parturition, whereas Itoh reported mean values of 55.2%, 47.4%, 32.4%, and 21.7% in nonlactating Holstein-Friesian cows examined during the summer, autumn, winter, and spring, respectively. Lactating cows may excrete more potassium than nonlactating cows because of an increase in dietary intake associated with the consumption of concentrates. In our study, mean urinary FEK values were higher than the upper limit of the range reported by Fleming et al on days 2, 3, and 4 in cows receiving 2 doses of ISO, indicating that this corticosteroid had mineralocorticoid effects within 48 hours of administration, and this response persisted for approximately the same length of time after the second injection. Urinary FEK values may have been underestimated in our study because of the method of analysis used to measure urine potassium concentrations. Ion-specific potentiometry was used, and this method is appropriate for measurement of electrolyte concentrations in urine. However, it has been found that potassium concentrations are consistently underestimated when urine samples from sheep, horses, cows, and cats are analyzed, and this interference is attributed to the presence of anionic or zwitterionic chemicals. Urine samples were diluted with deionized water when the limits of linearity were reached to minimize this problem; however, urinary FEK values may have still been underestimated.

Potassium is primarily absorbed within the small intestine and colon of cows and primarily excreted via the distal tubules of the kidney. Potassium is also lost through milk (approx 13%), sweat, saliva, and secretions from colonocytes. Aldosterone increases potassium excretion in the late segment of the distal renal tubules and collecting ducts of the kidney and may also enhance secretion of potassium by colonocytes. Results of 1 study indicate that no associations were detected among whole blood and urine potassium and plasma aldosterone concentrations in lactating cows, and it was concluded that potassium homeostasis is
not under direct hormonal control. However, this conclusion is not supported by results of our study because urinary FEK and plasma potassium concentrations were negatively correlated ($r = -0.48; P < 0.001$) in cows. In humans, mineralocorticoid receptors are located within principal cells of the late segment of the distal renal tubules and collecting ducts, and both apical sodium channels and basolateral Na-K-ATPase pumps are stimulated by these hormones. This increases reabsorption of sodium from tubular fluid and enhances potassium secretion. High urinary FEK values detected in cows treated with ISO indicated that this corticosteroid had aldosterone-like effects on renal excretion of potassium. Aldosterone also increases the uptake of potassium into muscle and brain tissues; therefore, it cannot be assumed that hypokalemia directly reflects depletion of total body potassium stores. Serum concentrations are a poor indicator of whole-body potassium status because only 2% of potassium is found within the extracellular fluid. Muscle and erythrocyte potassium concentrations can be measured to assess whole-body potassium status; however, neither measurement was performed in our study. Subtle alterations in potassium homeostasis may have been detected after DEX administration if those measurements had been obtained or if urinary FEK had been measured in every cow. Unfortunately, these analyses were not performed because of financial constraints. However, DEX administration did not affect plasma potassium concentrations; therefore, it is unlikely that this drug negatively affects potassium homeostasis in lactating cows.

Metabolic alkalosis developed in cows that received ISO, and this finding was also attributed to the mineralocorticoid activity of this drug. Mineralocorticoids enhance hydrogen ion secretion and increase bicarbonate reabsorption by the intercalated cells of the cortical collecting tubules. Mineralocorticoid-induced hypokalemia also contributes to metabolic alkalosis because hydrogen ions enter cells in response to whole-body potassium depletion to maintain adequate concentrations of positively charged ions within the intracellular space. Results of 3 retrospective studies indicate that metabolic alkalosis was detected in 7 of 10 cows, 10 of 14 cows, and 9 of 17 cows with hypokalemia and other clinical signs of BHKS. In the prospective study reported here, plasma TCO2 and potassium concentrations were strongly correlated ($r = -0.81$) in healthy cows that received 2 doses of ISO and plasma TCO2 concentrations peaked after potassium concentrations reached their nadir, providing evidence that metabolic alkalosis develops as a consequence of hypokalemia in healthy cows.

Plasma glucose concentrations increased significantly after administration of DEX or ISO and peaked 24 hours after each injection. Glucocorticoids increase serum glucose concentrations by stimulating gluconeogenesis and decreasing glucose utilization by peripheral tissues. Braun et al found that whole-blood glucose concentrations increased and peaked 24 hours after DEX or ISO was administered, and this hyperglycemic effect has also been associated with DEX administration in other studies. In 1 study, serum glucose concentrations remained significantly increased for as long as 9 days in cows receiving a combination of dexamethasone phosphate and dexamethasone phenylpropionate.

Hypophosphatemia was detected on day 1 in cows in the DEX1 and ISO2 groups at the same time that plasma glucose concentrations peaked. In horses, hypophosphatemia has been associated with refeeding syndrome, which develops when the amount of carbohydrate fed is increased too rapidly after prolonged starvation. Serum glucose concentrations increase and insulin is secreted in response, which causes glucose and electrolytes, including phosphorus and potassium, to move into cells. Hypophosphatemia is also exacerbated by increased consumption of intracellular phosphorus resulting from insulin-stimulated amino acid synthesis. Serum insulin concentrations were not measured in our study; however, hyperglycemia was detected in cows that received corticosteroids. Hypophosphatemia has also been detected in cows with BHKS; however, reports do not indicate whether this condition was associated with specific treatments. Marginal phosphorus deficiency is a cause of acute recumbency in dairy cattle; therefore, hypophosphatemia may contribute to BHKS.

A significant treatment x time effect was detected for plasma total magnesium concentrations; however, mean concentrations did not differ significantly from baseline values on specific days. This finding was not expected because an increase in plasma magnesium concentration was anticipated in cows that developed hypokalemia. An inverse association was expected because both of these ions are primarily intracellular cations and electroneutrality must be maintained. This inverse association plays a role in the development of hypomagnesemia in cattle because the electrogenic uptake of magnesium by the rumen epithelium is impaired by potassium when potassium-rich diets are consumed. However, it should be noted that total magnesium concentrations represent only 0.86% to 2.3% of total body magnesium stores; therefore, changes in whole-body magnesium status may have gone undetected in the study reported here.

Mean plasma TBIL concentrations were significantly higher than the baseline mean value on day 4 in cows in the ISO2 group; however, this finding was primarily a result of 1 cow that was markedly hyperbilirubinemic. This was the same cow that developed atrial fibrillation, and plasma TBIL concentrations ranged from 0.27 to 0.93 mg/dL over 8 days in this cow. Plasma AST and GGT activities were not increased, but this cow may have had hepatic dysfunction associated with ketosis.

Ketosis is a common cause of anorexia in early lactation dairy cows and may therefore be an indirect cause of hypokalemia. In our study, hyperketonemia was detected in 10 cows but resolved within 24 hours in 8 cows. Anorexia and ketosis are both risk factors for BHKS. It has been suggested that anorexia triggers hypokalemia because renal potassium excretion is high in lactating dairy cows that consume potassium-rich diets, and 24 to 48 hours are required for the kidneys to adjust to a reduction in dietary potassium intake.
Unfortunately, feed intake was not measured in our study because cows were housed with the main herd, and this represents a weakness in our study design. Subclinical ketosis or anorexia may therefore have contributed to hypokalemia in our study. However, it is unlikely that these conditions confounded results because plasma potassium and BHBA concentrations were not significantly correlated and severe hypokalemia developed concurrently with hyperketonemia in only 1 cow in the IS02 group. Interestingly, this cow developed atrial fibrillation on day 4.

Atrial fibrillation has been associated with BHKS. Atrial fibrillation was detected in 4 of 10 cows with BHKS in 1 study and 6 of 14 cows with BHKS in another study. Hypokalemia has also been associated with atrial premature complexes in cows, and increased vagal tone and hypokalemia are thought to contribute to the development of this arrhythmia. In the study reported here, atrial fibrillation was detected in only 1 cow and was accompanied by hypokalemia, metabolic alkalosis, hypochloremia, hyperketonemia, and hyperbilirubinemia. It was assumed that atrial fibrillation developed in this cow as a result of corticosteroid administration, but underlying cardiac disease could not be ruled out because a complete cardiac evaluation was not performed.

Milk production decreased 24 hours after administration of corticosteroids (days 1 and 3) in cows that were producing 44.7 kg of milk/d on average according to the records for day 0 of the study. Reductions in milk yield have also been detected 24 hours after administration of corticosteroids to healthy cows in other studies, and this finding is attributable to a reduction in glucose uptake by the mammary gland. Hartmann and Kronfeld reported a 35% reduction in milk production in cows that received 2 IM injections of DEX 12 hours apart, and the net mammary gland uptake of glucose decreased by 38% in those cows. It is likely that glucocorticoids antagonize the actions of insulin within the mammary gland and decrease the amount of glucose available for lactose synthesis. However, treatment with a single IM injection of dexamethasone isonicotinate (2 mg/100 kg) did not alter mean milk production in dairy cows with spontaneous ketosis. When ketosis is present, corticosteroids may correct excessive consumption of glucose by the mammary gland but not affect milk yield because excessive amounts of fatty acids are available for conversion into milk fat.

In the study reported here, severe hypokalemia developed as a result of ISO administration in healthy early lactation dairy cows, and the frequency of severe hypokalemia was significantly higher when 2 doses of ISO were administered instead of saline solution or DEX. Both DEX and ISO had glucocorticoid effects on plasma glucose concentrations, but plasma potassium concentrations were not significantly altered by DEX. Injection of ISO twice was associated with an increase in urinary FEK, which confirmed that this drug had mineralocorticoid effects on the kidney. Metabolic alkalosis was detected in cows treated with ISO and was attributed to the drug’s mineralocorticoid activity. The risks of developing severe hypokalemia should be considered before multiple doses of ISO are administered to early lactation cows.

References


