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Trauma-Associated Hyperglycemia after Fall Accident in Three Dogs

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Abstract : Three dogs were referred for emergency care after fall accidents. All cases showed hyperglycemia at initial testing, with no history of diabetes mellitus. After varying periods of time, the blood glucose levels in all cases returned to within the reference range. The present report describes three cases of typical trauma-associated hyperglycemia in dogs.

Key words **:** trauma, hyperglycemia, fall accident, emergency, dog.

Introduction

Hyperglycemia is defined as a blood glucose level exceeding 130 mg/dl, though clinical signs of hyperglycemia usually do not manifest until blood glucose concentration exceeds 180 to 220 mg/dl in dogs (9). The most common cause of hyperglycemia is diabetes mellitus; however, hyperglycemia can also occur due to non-diabetic causes such as administration of dextrose-containing fluids, drug therapy, stress, and excitement (9).

Trauma is commonly associated with hyperglycemia in non-diabetic humans and dogs (6,10). There are multiple factors causing hyperglycemia in trauma patients including release of stress hormones e.g., catecholamines and glucocorticoids, increased hepatic gluconeogenesis and glycogenolysis induced by glucagon, and enhanced insulin resistance (1,5,7). The altered metabolic state observed in the early phase of trauma is referred to as stress-induced hyperglycemia (7). Additionally, the level of hyperglycemia seems to reflect the severity of injury in human and animal patients (3,12), and is related to infection and mortality in traumatized human patients (6,11).

This case series describes three non-diabetic dogs with increased glucose levels after fall accidents and includes a literature review on the clinical significance of this finding.

Case

The first case, a 4-year-old castrated male Shih Tzu dog weighing 6 kg, presented within two hours of a fall accident from the third floor of a building. The dog had a good appetite and activity rate and no relevant medical history including any medication before the accident was reported. In the emergency room, the blood pressure as measured by Doppler was 80 mm of Hg and the pulse was weak. The mucous membranes were pale and dry, indicating mild dehydration. The mental status was evaluated as dull. Complete blood cell counts (CBC) revealed mild decrease in packed cell volume (PCV). Serum chemistry showed elevated lactate, mild hypoproteinemia, hypocalcemia, hyperphosphatemia, and severe hyperglycemia (Table 1). The blood glucose level had decreased to 80 mg/dl at re-examination, 3 hours after the initial test. The glucose level on the next day was 112 mg/dl; the test was not repeated. The urine specific gravity was 1.043 and dipstick test using Combur-Test® strips (Roche; Basel, Switzerland) showed pH = 6 and traces of protein. Based on the results of the radiographic examination, traumatic pneumothorax, pneumoretroperitoneum, and peritonitis with ascites were diagnosed. In addition, fractures of the right ulna and the left 2nd metacarpal bone were detected. Abdominal ultrasonography revealed a moderate amount of anechoic free fluid in the abdomen.

The second case, a 7-year-old female Maltese weighing 1.18 kg, presented within three hours of a fall accident from waist-height. The dog showed nystagmus and head turn and tilt. The results of CBC and serum biochemistry were within reference ranges except for the blood glucose level (Table 1). The urine specific gravity measured by refractometer was 1.028 and dipstick test revealed glycosuria and hematuria. Detailed history taking revealed that the dog had a good activity rate and no medication history but had showed mild neurologic signs before the fall accident. Occipital radiography showed dorsal extension of the foramen magnum and moderate ventriculomegaly was detected on skull sonography. Computed tomography (CT) revealed multifocal calvarial defects which was considered congenital defect rather than trauma-induced injury. Dorsal extension of the foramen magnum and enlarged ventricle detected on CT supported the diagnosis of hydrocephalus. Blood glucose level measured the next day was 83 mg/dl and dipstick test for glycosuria was negative.

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Table 1. Complete blood cell count and serum chemistry profile of 3 cases

Parameter	Case 1	Case 2	Case 3	Reference range
RBC count ($\times 10^6/\mu l$)	5.04	8.05	5.87	5.65-8.87
Hemoglobin (g/dl)	12.2	19.0	16.7	13.1-20.5
PCV (%)	34.9	55.8	41.2	37.3-61.7
MCV (fl)	69.2	69.3	70.2	61.6-73.5
MCHC (g/dl)	35.0	34.1	40.5	32.0-37.9
WBC count ($\times 10^3/\mu l$)	6.2	9.56	6.16	5.05-16.76
Platelet ($\times 10^3/\mu l$)	237	612	162	148-484
Sodium (mmol/L)	147	161	149	144-160
Potassium (mmol/L)	4.2	4.2	3.6	3.5-4.2
Chloride (mmol/L)	109	120	112	109-122
ALT (U/L)	-	78	611	10-125
AST (U/L)	-	-	306	0-50
ALP (U/L)	92	65	874	23-212
GGT (U/L)	3	4	285	0-7
Total bilirubin (mg/dl)	< 0.1	0.1	0.4	0.0-0.9
Glucose (mg/dl)	439	185	181	74-143
Total protein (g/dl)	4.3	6.2	5.3	5.2-8.2
Albumin (g/dl)	2.4	3.3	2.9	2.3-4.0
BUN (mg/dl)	21	22	20.6	7-27
Creatinine (mg/dl)	1.1	0.6	0.7	0.5-1.8
Calcium (mg/dl)	5.4	9.1	6.0	7.9-12.0
Phosphorus (mg/dl)	8.4	3.1	4.9	2.5-6.8
Lactate (mmol/L)	11.96	-	-	0.50-2.50

CBC was measured by ProCyte Dx (IDEXX; Westbrook, US) and serum chemistry was measured by Catalyst One (IDEXX; Westbrook, US)
Reference ranges were provided by analysis equipment
RBC, red blood cell; PCV, packed cell volume; MCV, mean corpuscular volume; MCHC, mean corpuscular hemoglobin concentration; WBC, white blood cell; ALT, alanine aminotransferase; AST, aspartate transaminase; ALP, alkaline phosphatase; GGT, gamma-glutamyl transferase; BUN, blood urea nitrogen

The third case, a 4-year-old spayed female poodle weighing 4.7 kg, presented within two hours of a fall accident from the second floor of a building. The dog had no medical history including any medication before the accident. The results of CBC were within normal limits. Serum biochemistry revealed increased alanine aminotransferase (ALT), aspartate aminotransferase (AST), serum alkaline phosphatase (ALP), and γ-glutamyl transpeptidase (GGT) (Table 1). Mild hypocalcemia and hyperglycemia were also noted (Table 1). Radiography showed no remarkable findings. Sylimarin (Sylimarin Tab.; Sinil pharm. Co. Ltd., 10 mg/kg, BID), ursodeoxycholic acid (Ursa Tab.; Daewoong Co. Ltd., 10 mg/kg, BID), biphenyl dimethyl dicarboxylate (Lefotile Tab.; CMG Pharm Co. Ltd., 1 tablet/day, BID), tramadol (Tridol Cap.; Yuhan Co., 2 mg/kg, BID), and cephalexin (Falexin Cap.; Dongwha pharm. Co. Ltd., 22 mg/kg, BID) were prescribed. At the next visit five days later, serum AST and GGT level were within reference range, ALT had decreased to 384 U/L, and ALP to 107 U/L. Blood glucose was at 96 mg/dl.

Discussion

All three cases presented with hyperglycemia after fall accident in their initial tests and showed a return to normal blood glucose levels in a few days. None of the dogs had a history of diabetes mellitus and any medications before the fall accident.

Trauma causes a stress response and alters physiological reaction (4,7). The stress response increases the levels of counter-regulatory hormones like glucagon, growth hormone, catecholamine, and glucocorticoids (7). Alterations observed during a stress response also include increase in circulating or tissue levels of cytokines such as tumor necrosis factor-α and interleukin-1. These responses result in increased gluconeogenesis, glycolysis, and insulin resistance in humans (7); stress induced hyperglycemia has also been described in dogs (8).

In the present report, the glucose level in case 1 was much higher than that observed in the other cases (Table 1). In dogs, trauma is commonly associated with a mild hyperglycemia (10). Blood glucose levels reported in similar previous studies were 155 (10), 310 (13), and 378 mg/dl (12), and the dogs with blood glucose levels of 310 and 378 mg/dl did not survive (12,13). Considering the non-diabetic status of case 1, a blood glucose level of 439 mg/dl, even if transient, is remarkable. Factors causing heightened stress, such as pain from fracture, may be responsible for the higher glucose level in this case. However, no difference in clinical outcome was observed between this case and the other two cases.

In human medicine, many reports have described trauma-associated hyperglycemia and its clinical importance. Laird and colleagues retrospectively reviewed 516 patients admitted to the trauma intensive care unit (ICU), and determined the relationship between early hyperglycemia and clinical outcome in trauma patients (6). The study found early glucose level ≥ 200 mg/dl to be an independent predictor of both infection and mortality (6). Bochicchio and colleagues prospectively evaluated the blood glucose level in 942 ICU patients during the first week in the hospital and its relationship to clinical outcome (2). The patients were divided into three groups based on blood glucose levels, 0-139 mg/dl (low); 140-219 mg/dl (medium); ≥ 220 mg/dl (high). The patients were further divided into six groups based on their glucose patterns - all low, all moderate, all high, improving, worsening, and highly variable. The study showed that high, worsening, and highly variable hyperglycemia were reliable predictors for increased stay in the hospital and in the ICU, greater number of days on the ventilator, and higher rates of infection and mortality.

Compared to human medicine, studies on trauma-associated hyperglycemia are scarce in veterinary medicine. Syring and colleagues showed that there is a correlation between blood glucose concentration and severity of head trauma and

that clinical outcome was independent of the blood glucose level (12). Moreover, Simpson and colleagues showed that mild hyperglycemia was common in blunt trauma in dogs, although the association between blood glucose level and morbidity/mortality could not be determined (10). Further studies to elucidate the impact of hyperglycemia on clinical outcome in veterinary patients with trauma are warranted.

Conclusions

The present report discussed three cases with trauma-associated hyperglycemia including a case with a higher blood glucose level than previously reported. The hyperglycemia resolved within a short span of time and no significant difference in clinical outcomes was observed among the three cases. The present study suggests that veterinary practitioners, especially in emergency clinics, should recognize and pay attention to hyperglycemia associated with fall accidents and other traumatic events.

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