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Peri and Postparturient Concentrations of Lipid Lipoprotein Insulin and Glucose in Normal Dairy Cows

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Abstract: In order to provide unique insight into the metabolic disturbances seen after calving cholesterol, triglycerid, high density lipoprotein, low density lipoprotein, very low density lipoprotein, glucose and insulin levels in serum were studied before calving (group I), in early (group II) and late (group III) lactation in 24 normal cows.

Serum lipoproteins were separated into various density classes by repeated ultracentrifugation.

The results indicate that there was a rise in glucose, triglycerid and very low density lipoprotein levels before calving, and in cholesterol and high density lipoprotein levels late lactation, and the dairy cows were inclined fatty liver because of lower very low density lipoprotein and glucose levels in early and late lactation, and were inclined hyperketonemia in early lactation because of lower insulin level than in late lactation.

Key Words: Lipid, lipoproteins glucose, insulin, pre and postpartum, cows

Normal Sütçü Sığırlarda Doğum Öncesi ve Sonrası Lipid Lipoprotein İnsulin ve Glikoz Konsantrasyonları

Özet : Doğum sonrası görülen metabolik hastalıklara ışık tutmak amacıyla normal sığırlarda, buzağılamadan önce (grup I), erken (grup II) ve geç (grup III) laktasyon dönemlerinde serum kolesterol, trigliserid, yüksek dansiteli lipoprotein, düşük dansiteli lipoprotein, çok düşük dansiteli lipoprotein, glikoz ve insülin seviyeleri 24 normal sığırdan araştırıldı.

Serum lipoproteinler, tekrarlanan ultrasentrifüje fraksiyonlarına ayrıştırıldı.

Sonuçlar, buzağılamadan önce serum glikoz, trigliserid ve çok düşük dansiteli lipoprotein, geç laktasyon döneminde de kolesterol ve yüksek dansiteli lipoprotein seviyelerinde artış olduğunu ve sığırların erken ve geç laktasyon döneminde çok düşük dansiteli lipoprotein ve glikoz seviyelerinin daha az olması nedeniyle yağlı karaciğere ve geç laktasyon dönemine göre erken laktasyon döneminde daha düşük insülin seviyesi nedeniyle hiperketonemiye eğilimleri olduğunu gösterdi.

Anahtar Sözcükler: Lipid, lipoproteinler, glikoz, insülin, doğum öncesi ve sonrası, sığır

Introduction

In ruminants almost no plasma lipids arise from ingested fat. Most of them are the result of de novo synthesis. Of course, large amounts of short chain fatty acids are produced in the ruminoreticulum as a result of microbial digestion of carbohydrates. These are absorbed mainly from the forestomach, which can absorb fatty acid-of chain length up to 12. In conventionally fed ruminants only small amount of the carbohydrates as glucose. Most of glucose supply is derived from propionate and also from amino acids by gluconeogenesis in the liver. Fat is stored as triglyceride and from the depots it is transported as free fatty acids bound to albumen. A considerable part of these acids is taken up by the liver. Therefore, they

can be oxidized to CO₂ or to ketone bodies or esterified and combined with phospholipids, cholesterol and apoproteins to form lipoproteins, mainly very low density lipoproteins (VLDL). This lipoprotein fraction transports triglycerids to different organs and tissues. After the loss of triglycerids, low density lipoproteins (LDL) are formed and after further metabolism high density lipoproteins (HDL).

In cattle HDL is the major fraction comprising more than 80% of the lipoproteins (1) and consisting of about 60 % cholesterol (2). As the feed for cattle contains very small amounts of cholesterol and there is high level of this substance in plasma, there must be an important synthesis in the body. Cholesterol can be synthesized in the liver from acetate (3) and it is

probably by this way the cholesterol and the VLDL-fraction is formed. It is not known if a de novo synthesis of HDL occurs in the liver in cattle.

There are large variations in fat metabolism during different stages of lactation and pregnancy and the risk of disturbances are also variable.

The distribution of glucose to different tissues, and thereby also gluconeogenesis is regulated by the two pancreatic hormones, insulin and glucagon. They have opposing and counterbalancing actions: glucagon stimulates and insulin inhibits gluconeogenesis (4). Insulin and glucagon also regulate lipolysis in fat tissues and ketogenesis in the liver (5). Insulin and glucagon are thus very important regulatory factors in the adaptation of the energy metabolism. The requirement of energy at calving that is not supplied by feed consumption is met by increased lipolysis and by gluconeogenesis from glycogen and from tissue protein. To achieve this, there is continuous depression of the basal plasma insulin levels before calving (6). Lomax et al. (7) have shown that insulin production was more than twice as high in nonlactating cows.

The objective of the present study was to analyse basal blood levels of lipid, lipoproteins, insulin and glucose in cows around calving and in lactation and to provide unique insight into the metabolic disturbances seen after calving.

Material and Methods

Twenty four healthy and mature Swiss Brown Cows in late pregnancy (group I, n=8), early (group II, n=8) and late (group III, n=8) lactation from Konya Central Animal Research Institute's dairy herd were used. Group I of cows were in dry period, group II of cows in the first month and group III of cows in the fourth month after calving. The milk yields in previous lactations had been at least 4000 kg.

Blood samples were taken from the jugular vein before the morning feeding and at 3 h after this.

VLDLs were isolated at plasma density $d < 1.006$ g/ml by centrifugation at 100.000 g for 18 hours. Other lipoprotein fractions were isolated by sequentially raising the plasma density to $d = 1.063$ g/ml LDL, and 1.21 g/ml HDL by adding crystalline potassium bromide and centrifugation at 100.000 g for 20 and 40 hours, respectively (8).

Serum for insulin determinations was obtained after centrifugation within 2 hours and kept at -20 °C

until analysis by radioimmunoassay (Insulin RIA 100, Pharmacia Diagnostics AB, Uppsala, Sweden).

Glucose, cholesterol and triglycerids were determined by commercial enzymatic kits (Boehringer Mannheim Diagnostica).

The Fisher's F test and Duncan's multiple Range test were used to analyse data (9).

Results

The glucose, triglycerid and VLDL levels were significantly higher in periparturient cows than in early and late lactation. The cholesterol and HDL levels were also significantly higher in cows in late lactation than of the other two groups. The insulin and LDL concentrations in periparturient cows were significantly lower than in late lactation (Figure 1,2,3).

Discussion

Plasma lipoproteins are complex molecules that are heterogeneous in composition, size and biological activity. According to Raysiguer et al. (10) the most significant result obtained two weeks postpartum in cows with severe fatty liver was the dramatic decrease in plasma HDL and VLDL. During these same period the animals in the moderately steatotic group were no different from the controls as regards the LDL. In contrast, by the fourth week, the moderately steatotic animals had an LDL fraction that was significantly lower than control animals. In normal cows, lipid infiltration of the liver postpartum, different workers have shown that lipid infiltration reached a maximum one to two weeks postpartum, and regressed rapidly. In the present study, VLDL levels of cows in postpartum early and late lactation were also significantly lower than in periparturient, and HDL level of cows in late lactation was significantly higher than in periparturient and in early lactation. The results from the studied indicates that the dairy cows are inclined fatty liver after calving. Because, Holtenius and Hjort (1) show that accumulation of fat in the liver cells and development of fatty liver is caused by reduced synthesis of VLDL. The reduced synthesis is most probably associated with feeding factors. High energy-low protein prepartum feeding is shown to be such a factor. There was significant alteration in LDL levels between periparturient cows and in late lactation.

In the normal cows there is a rise in FFA-level and a reduction in cholesterol and phospholipids from 6

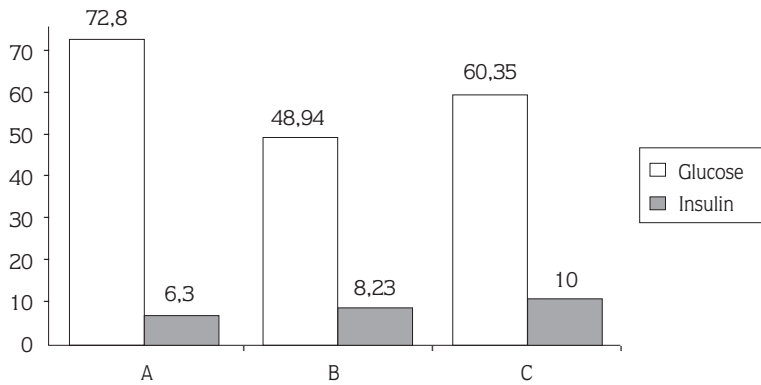


Figure 1. Serum insulin and glucose levels in all group of cows

A: before calving B: early lactation C: late lactation

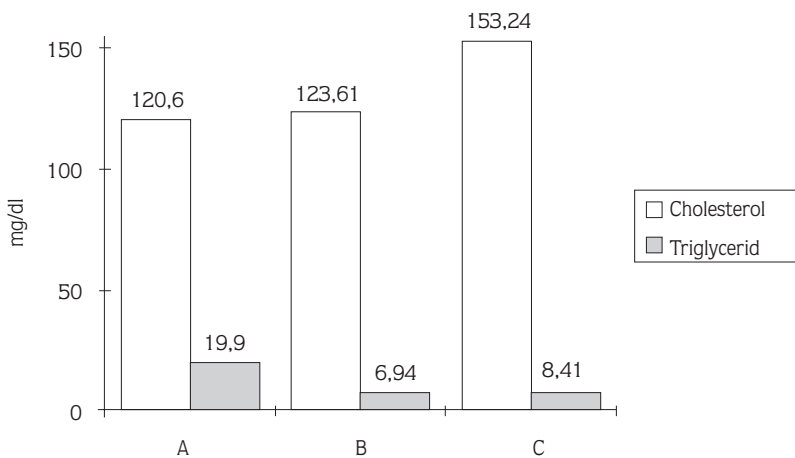


Figure 2. Serum cholesterol and triglycerid levels in all group of cows

A: before calving B: early lactation C: late lactation

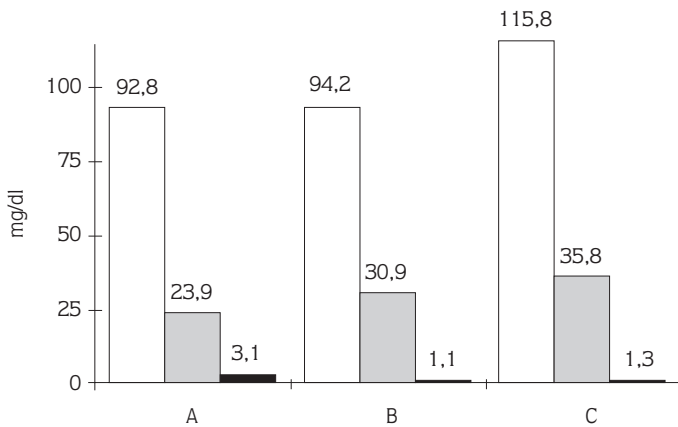


Figure 3. Serum HDL, LDL and VLDL levels in all group of cows

A: before calving B: early lactation C: late lactation

week before to the day after calving. During the following 6 weeks the level increased continuously. However, the cows with fatty livers had lower amounts of cholesterol. In the present study, cholesterol level in late lactating cows was also higher than before calving

and in early lactating cows, and there was a rise triglycerid level in periparturient cows.

A degree of hipoglycemia was apparent in periparturient cows which was more marked before than after calving (11). In contrast, in the present study,

serum glucose concentration was significantly higher in periparturient cows than in early and late lactation.

According to Holtenius et al.(12), before calving the feeding regimen had a very strong influence on the basal insulin level. High amount of concentrate increased basal insulin levels until one week before calving and caused an interruption in the physiological decreasing course. After calving the insulin levels were low in all groups of cows. Hyperketonemic cows had lower insulin than normal cows. However, there was continuous depression of the basal plasma insulin level before calving (6). In the present study, the insulin level was also higher significantly in late lactating cows than in periparturient accordance with this and Staufenbiel et al.(13).

Almost all newly calved high producing dairy cows are in negative energy balance as energy requirement

exceeds the feed consumption capacity. However, this energy deficit in early lactation is compensated by mobilisation of stored energy. By the mobilisation of fat, some degree of hyperketonemia without clinical signs can occur and is considered as physiological. Baird (14) has reported that clinical ketosis occurs at a minimum blood acetoacetate concentration of about 0.5 mmol/L. Fat mobilisation is stimulated by low insulin activity.

In conclusion, the dairy cows in the study were inclined fatty liver after calving because of lower VLDL and glucose levels in early and late lactations and were inclined hyperketonemia in early lactation because of lower insulin level than in late lactation. The determined parameters, thus can provide unique insight into the metabolic disturbances seen after calving.

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