

Treatment of copper deficiency in Texel-crossbred sheep by the feeding of a concentrate formulated for dairy cows

Koperdeficiëntie bij schapen (kruising texelaar) behandeld met het voeren van koeienbrok

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ABSTRACT

Six Texel-crossbred sheep, from a flock with a history of a dull appearance and mild diarrhea, were presented to the faculty of veterinary medicine (University of Utrecht). The clinical signs were found to be related to Copper (Cu) deficiency as indicated by low hepatic Cu values. It was decided to treat the animals by feeding them concentrates specifically formulated for dairy cows because such concentrates have a rather high Cu content compared to concentrates designed for sheep. Sheep Cu status was monitored by measuring liver Cu concentrations. Current results indicate the potential of feeding cow concentrate as a practical method to treat Cu deficiency in Texel-crossbred sheep. In contrast to hepatic Cu concentrations, serum Ceruloplasmin concentration (Cp) values did not respond to the treatment thereby indicating that serum Cp is inferior to evaluate Cu status in sheep compared to liver Cu measurements.

SAMENVATTING

Zes schapen (kruising texelaar) met klachten van milde diarree en een doffe vacht werden aangeboden aan de Faculteit Diergeneeskunde van de Universiteit Utrecht. De klinische verschijnselen werden gerelateerd aan koper (Cu) deficiëntie op basis van lage Cu-waarden van de lever. Er werd besloten om de schapen te voeren met koeienbrok om het Cu-tekort op te heffen. In vergelijking met schapenbrokken bevatten deze brokken relatief veel Cu. De Cu-status werd gemonitord door Cu-concentraties van de lever te bepalen. Uit de resultaten blijkt dat het voeren van koeienbrok een praktische methode kan zijn om koperdeficiëntie te behandelen bij schapen (kruising texelaar). In tegenstelling tot de lever Cu waarden, veranderde de serum-ceruloplasmineconcentratie (Cp) niet, wat erop duidt dat serum Cp een minder betrouwbare indicator is van de koperstatus dan lever Cu.

BACKGROUND

One of the many sheep breeds in the Netherlands is the Texel breed. The Texel breed is well known for its meat production and also for its high susceptibility to Cu intoxication (Van den Berg et al., 1983; Underwood and Suttle, 1999). Therefore, Dutch commercial concentrates formulated for sheep are typically not supplemented with Cu but do contain supplemental sulfate (SO₄) and molybdenum (Mo), thereby target-

ing to depress Cu absorption (Underwood and Suttle, 1999). Ingestion of sulfate and molybdenum results in the formation of so-called thiomolybdates, which have a high affinity for Cu, thereby rendering Cu unavailable for absorption (Suttle, 1991; Underwood and Suttle, 1999; Gould and Kendall, 2011). Clearly, this practice is instrumental in preventing Cu intoxication in Texel sheep, but it may also result in Cu deficiency in other breeds given the large differences in Cu requirements between breeds (Van den Berg et al.,

1983; Underwood and Suttle, 1999). Moreover, the risk of Cu deficiency is increased by a low Cu content in roughage. Thus, feeding the same particular ration for all sheep may induce either Cu deficiency or Cu intoxication depending on the genetic background of the breed and the roughage provided.

CASE PRESENTATION

In 2015, a sheep owner farming on western peat soils in the Netherlands, reported a high prevalence of dead lambs shortly after parturition to his veterinarian. The lambs were delivered by the youngest ewes of the flock. The whole flock of sheep had been participating in a monitoring program on gastro-intestinal parasites since the observation in 2014 that the sheep suffered from a dull appearance in combination with mild diarrhea. However, given that diarrhea was only observed in the ewes and not in the lambs, it was concluded that the death of the lambs was most likely unrelated to gastro-intestinal parasites.

As grasses from peat soils are known to be generally low in Cu (Ouweltjes et al., 2002), it was speculated that the combined clinical signs could be related to Cu deficiency. For screening purposes, initially, several sheep were randomly sampled and only serum Cu concentrations were determined. Serum Cu concentrations were found to be $< 10 \mu\text{mol/l}$ (reference: 12-20 $\mu\text{mol/l}$), indicating that the animals suffered from Cu deficiency (Dutch Central Bureau for Livestock Feeding, 2005). It was therefore recommended to implement dietary measures to restore the Cu status of the animals, but the owner waived this advice. The same happened at six and nine months after the first sampling, when the Cu status was re-evaluated and serum Cu concentrations were still below the reference values. Given the poor condition of the animals, the owner finally agreed to transport six young ewes to the Faculty of Veterinary Medicine of the Utrecht University with the aim to confirm Cu deficiency by measuring liver Cu concentrations. The liver Cu concentrations were found to range from 11 to 50 mg/kg DM (reference: 100-400 mg/kg DM), thereby confirming that all sheep were Cu deficient (Dutch Central Bureau for Livestock Feeding, 2005). It was then decided to treat the animals by feeding them concentrates specifically formulated for dairy cows. Such concentrates are not supplemented with SO_4 and Mo and are typically supplemented with Cu to reach minimum values of 20 mg/kg (Dutch Central Bureau for Livestock Feeding, 2005). The authors anticipated that the higher Cu content of the cattle concentrate together with the higher efficiency of Cu absorption after the ingestion would be a practical tool to treat Cu deficiency in the six ewes. For the evaluation of the effects of this treatment to restore the Cu status, liver biopsies and blood samples were taken. The first sampling was performed after feeding the animals a ration

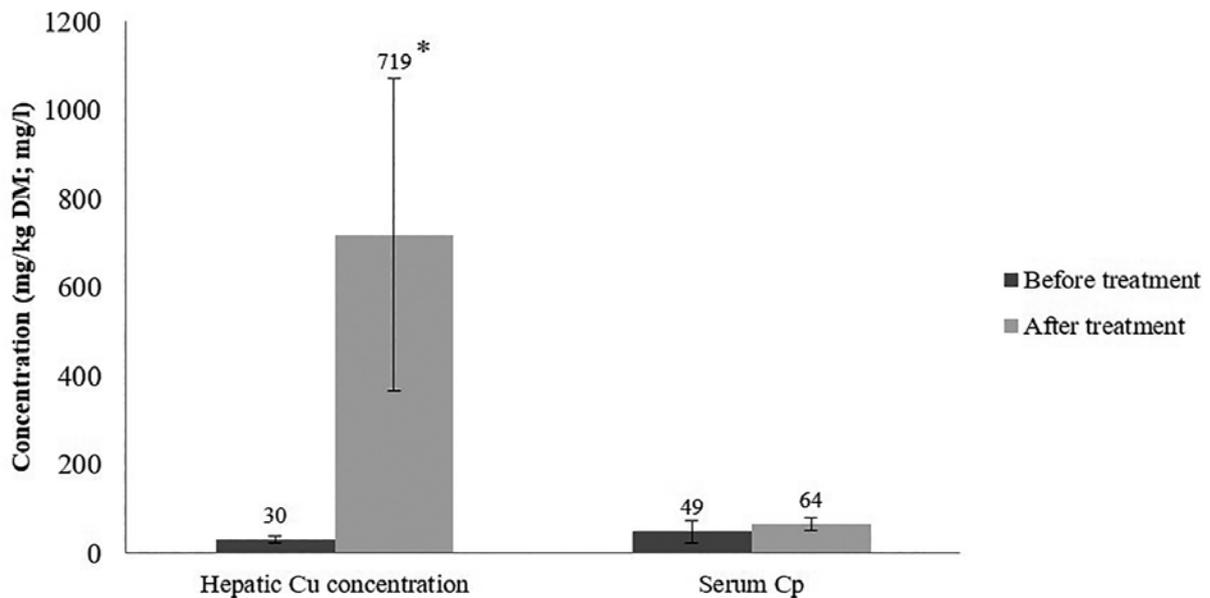
consisting of 50% sheep concentrate and 50% grass silage (DM basis) for three weeks. This diet contained a Cu content of $\sim 10 \text{ mg/kg DM}$. Thereafter, the sheep concentrate was replaced by a dairy cow concentrate, thereby keeping the concentrate to silage ratio constant. This resulted in an estimated dietary Cu content of $\sim 17,5 \text{ mg/kg DM}$. The level of feed intake was set to meet the energy requirement of the sheep according to the Dutch Central Bureau for Livestock Feeding i.e. $207 \text{ kJ NE/kg}^{0,75}$. After three months, the sampling was repeated to evaluate the effect of the dietary treatment. At both sampling moments, liver biopsies were collected to measure the liver Cu concentration and jugular blood samples to measure ceruloplasmin (Cp), as serum Cp has been suggested as a potential indicator of the Cu status (Blakley and Hamilton, 1985). The diagnostic value of blood samples is of interest because blood sampling is easier, less invasive and less laborious than taking liver biopsies. While no clinical abnormalities, such as swayback were seen, the subjective overall clinical impression of the sheep improved over time. A clear increase in liver Cu concentrations of 689 mg/kg DM was observed after the cow concentrate was fed (Figure 1). Feeding cow concentrates also resulted in a numerical increase in serum Cp, but the concentrations were not statistically significantly different from the initial values.

DISCUSSION

Cu is a well-known essential trace element and component of many enzymes, such as Cp, tyrosinase and superoxide dismutase. Chronic redundant Cu contents in the ration of sheep typically results in a hemolytic crisis and death, while Cu deficiency is associated with growth retardation, diarrhea, low birth weight and weight gain, as well as swayback (enzootic ataxia) (Underwood and Suttle, 1999).

Sheep with Cu deficiency are commonly treated with Cu injections or supplemented with Cu in mineral supplements developed for cattle or special salt blocks, drinking water or by fertilizing pastures with Cu sulphate. To the authors' knowledge, this is the first case report in which feeding cow concentrates is shown to be a practical method to treat Cu deficiency in Texel-crossbred sheep. However, caution is warranted to generalize the described strategy, because after three months of feeding the cow concentration, in the present report, the mean hepatic liver Cu concentration was around 1.8 times higher than recommended for healthy animals (Dutch Central Bureau for Livestock Feeding, 2005), which implies that there is a risk of inducing Cu intoxication. Despite the high liver Cu values, no clinical symptoms of Cu intoxication, such as depression, lethargy, hemoglobinuria and jaundice, were observed.

As the liver Cu concentrations were clearly above the reference values, it was concluded that the current



* $p < 0.01$ (students paired t-test) compared to hepatic Cu concentration before treatment.

Figure 1. Hepatic Cu concentration and serum Cp before and three months after treatment.

treatment period was actually too long. Unfortunately, intermediate liver Cu values were not available, and it is therefore difficult to provide a time span, which is both effective and safe. Furthermore, susceptibility to Cu toxicity differs substantially between breeds of sheep, which means that it is probably not possible to provide a general effective and safe treatment strategy for all breeds.

The results of the present study indicate the inaccuracy of serum Cp as an indicator of the Cu status in sheep. Indeed, Cp remained relatively constant, despite the increase in liver Cu concentration. To the authors' knowledge, no reference values for serum Cp are available in sheep; however, 45-100 mg/l is considered to be normal in plasma (Radostits and Gay et al., 2007). Given that in serum less Cu is associated with Cp (55%) than in plasma (66%), the reference values for serum are estimated to be around 38-83 mg/l (Radostits and Gay et al., 2007). Based on this estimation, Cp appeared to be approximately normal in all of the sheep of the present case report, even before treatment. It may be suggested that even in the Cu deficient sheep, hepatic Cu stores are sufficient to maintain a certain Cp activity (Underwood and Suttle, 1999).

Although it is not clear why the sheep in this study developed Cu deficiency, it seems likely that the animals did not absorb enough Cu to meet their requirements. Unfortunately, it was not possible to collect and analyze soil and roughage samples in order to investigate whether this was due to a low feed intake, a low roughage Cu content or a high content of SO_4/Mo in the roughage.

Furthermore, in the past, pig feed was supplemented with Cu, resulting in Cu-rich pig manure that was

spread on the pasture. Since the restriction in Cu supplementation in pig feed, the Cu content of pig manure has decreased, hence increasing the occurrence of Cu deficiency.

CONCLUSION

Feeding cow concentrate can be used as a practical tool to treat Cu deficiency in Texel-crossbred sheep. Given the results, it seems that feeding this concentrate for three weeks is too long, but it remains difficult to generalize this experience for other breeds. Furthermore, serum Cp concentration was found to be inferior to the liver Cu measurement for the evaluation of the Cu status in sheep. Taking liver samples is difficult in practice. Therefore, future research is warranted to find good markers for the detection of Cu deficiency.

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Oproep

Enquête bij Vlaamse dierenartsen omtrent hartritmestoornissen bij de hond

Aan de Faculteit Diergeneeskunde verrichten we momenteel onderzoek naar de diagnose en behandeling van hartritmestoornissen bij de hond.

Hartritmestoornissen komen regelmatig voor bij de hond en zijn een belangrijke oorzaak van hartfalen en plots overlijden. Vaak veroorzaken deze aandoeningen in de initiële fase slechts vage, niet specifieke klachten (bijvoorbeeld inspanningsintolerantie, braken, diarree, soms syncope, tekenen van stress of angst, ...). Hierdoor wordt het probleem door de eigenaar of dierenarts vaak pas herkend in een laat stadium, samenvallend met het ontwikkelen van hartfalen. Verder is ook de behandeling van hartritmestoornissen niet eenvoudig, zijn er beperkte medicamenteuze opties en is er gelimiteerde toegang tot interventionele (en curatieve) behandelingsmethoden in de praktijk.

Via deze enquête trachten we te achterhalen hoe frequent dierenartsen in de praktijk geconfronteerd worden met hartritmestoornissen bij de hond en hoe ze op dit moment de diagnose en behandeling aanpakken. Deze informatie helpt ons in de zoektocht naar een betere diagnostische en therapeutische aanpak van deze patiënten. Net daarom is uw deelname zo belangrijk.

De enquête neemt ongeveer 10 minuten van uw tijd in beslag. De verwerking ervan gebeurt binnen het kader van mijn doctoraatsonderzoek aan de faculteit diergeneeskunde, Universiteit Gent.

Wenst u deel te nemen aan de enquête, dan kan dat vanaf 12 januari via de onderstaande link:
<https://hartritmestoornissen.wixsite.com/cardioteamkhd>

Voor verdere vragen omtrent deze enquête kan u steeds mailen naar arnaut.hellemans@ugent.be

Alvast erg bedankt voor uw deelname.

Arnaut Hellemans