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Comparative analysis of imaging techniques for the diagnosis of liver diseases in falcons in special consideration of amyloidosis

Liver diseases in birds are very common but diagnosed rather lately. Especially amyloidosis is most often diagnosed *post mortem* in birds.

The objective of this study was the comparison of different imaging techniques for the *in vivo* diagnosis of avian liver diseases in special consideration of amyloidosis for different species of falcons.

Sixty-four falcons of one breeding stock were examined. First, each falcon underwent a general physical examination followed by special medical procedures: blood chemistry, haematology, radiography, computed tomography (native as well as with radiopaque material), ultrasonography with first biopsy, endoscopy with second biopsy and histopathology of the biopsies.

The liver biopsy specimens of five falcons (7.8 %) were without any pathological alteration. The histopathological examination of the remaining birds (92.2 %) showed one or multiple diagnosis. The most common histopathological diagnosis was necrosis (59.4 %) followed by hepatitis (50.0 %) and degeneration (43.8 %). For three falcons a high-grade and for two more falcons a middle-grade amyloidosis was diagnosed. The falcons with the high-grade amyloidosis revealed additionally a high-grade necrosis.

In ventro-dorsal x-ray images a ratio of the parameters "maximal liver extension" (Rö-Leber-max) and "sternum length" was calculated. With this ratio (Rö-Leber-max/Sternum-Ratio) a species and body-size independent standard value of relative liver size in falcons was determined.

Falcons exhibiting a Rö-Leber/Sternum-Ratio between 0.286 and 0.532 (onefold standard deviation) can be classified inconspicuous regarding their radiological maximum liver width. The diagnosis of a high-grade amyloidosis led to a statistically significant increase in the "maximum liver width" ($p < 0.05$). In this study, other liver diseases did not affect the "maximum liver width".

The latero-lateral liver extension in the axial image of the computed tomography revealed the most convincing and reliable measure of the liver width. Comparable to

the radiography a ratio of the “latero-lateral liver width” (CT-Leber-axial-II) and the x-ray measured “sternum length” was calculated.

Almost identical to the conventional radiographical results falcons exhibiting a CT-Leber-axial-II/Sternum-Ratio between 0.282 and 0.532 (onefold standard deviation) can be classified inconspicuous regarding their tomographical maximum liver width. In analogy to the conventional radiography a statistically significant increase in the “maximum liver width” ($p < 0.05$) in falcons with a high-grade amyloidosis was detected.

Besides the conventional radiography and computed tomography the estimated liver size assessed by endoscopy is highly related to histopathological diagnosis of amyloidosis ($p = 0.001$). The results from the liver extension measurements by conventional radiography and computed tomography as well as the estimated liver size assessed by endoscopy highly correlated with each other ($p < 0.001$).

The native liver density determined by computed tomography revealed a significant reduction in the birds with high-grade amyloidosis ($p < 0.05$) and birds with high-grade necrosis ($p < 0.05$). Excluding these cases values for estimation of the native liver density were calculated for the right lobe of the liver (52.14 – 75.98 HU) and the left lobe of the liver (54.75 – 80.08 HU). The different histopathological diagnoses had no influence on the liver density acquired by computed tomography with radiopaque material.

The ALT-concentration in the plasma evaluated by blood chemistry analysis highly correlated with the histopathological diagnosed amyloidosis ($r = 0.418$, $p = 0.001$). The ALT-level therefore is a very sensitive but not specific indicator for amyloidosis. In cases of high-grade liver degeneration, elevated bile acids as well as LDH-concentration were detected ($p < 0.05$). Other parameters like AST or GLDH were incapable of being used as diagnostic tools for liver diseases investigated in this study.

The haematological analysis revealed that falcons with amyloidosis exhibited a decreased number of lymphocytes and a lower haematocrit accompanied by an increase in total number of leukocytes and the proportion of heterophiles. Other liver diseases including high-grade necrosis ($p < 0.005$) as well as high-grade degeneration ($p < 0.001$) led to an increase in total number of leukocytes.

Out of a number of parameters, which were significantly influenced by amyloidosis, a score was established that was very sensitive and specific for the identification of

falcons with high-grade amyloidosis in this study. This “amyloidosis-score”, calculated of R \ddot{o} -Leber-max/Sternum-Ratio, inverse haematocrit, ALT-level and total number of leukocytes presented in case of high-grade amyloidosis (Score = 176.1 ± 68.9) an approximately 6.5-fold higher value compared to middle-grade amyloidosis (Score = 27.3 ± 18.8) and about 8.0-fold higher level compared to falcons without amyloidosis (Score = 22.4 ± 14.0). In the daily routine of an average praxis using standard diagnostic tools, this “amyloidosis-score” could supply first evidence for high-grade amyloidosis inducing the inevitable histopathological analysis.