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Study on the assessment of hepatic congestion and fibrosis in dogs with
cardiac disease using Shear Wave Elastography
(犬の心疾患における剪断波エラストグラフィを用いた肝うっ血および肝線維化
の評価に関する研究)

< abstract >

Heart failure is characterized by systemic venous congestion and reduced cardiac output. In right-sided heart failure (RHF), elevated central venous pressure leads to passive hepatic congestion, while reduced cardiac output impairs hepatic perfusion and promotes hypoxic liver injury. When sustained, these hemodynamic abnormalities may contribute to hepatic fibrosis and worsen prognosis. Despite the clinical importance of hepatic involvement in heart disease, non-invasive methods to assess hepatic congestion and fibrosis remain limited in veterinary medicine.

Two-dimensional shear wave elastography (2D-SWE) is a non-invasive ultrasound technique that enables the measurement of two quantitative parameters: shear wave speed (SWS) and dispersion slope (DS). SWS reflects both tissue elasticity and viscosity (viscoelasticity), whereas DS reflects viscosity alone. In the liver, tissue elasticity primarily increases in association with fibrosis, whereas tissue viscosity increases in response to inflammation and congestion. This study investigated the clinical utility of 2D-SWE for assessing hepatic congestion and fibrosis in dogs with cardiac disease through two complementary studies.

In Chapter 1, hepatic SWS, DS, and the caudal vena cava short-to-long diameter ratio (CVC SD/LD) were measured before and after blood transfusion in anaemic dogs as a clinical model of acute volume loading. CVC SD/LD, assessed by ultrasonography, was used as a non-invasive indicator of systemic venous congestion. Seventeen dogs (20 transfusions) were enrolled. Both SWS and DS increased significantly following transfusion, in parallel with a marked rise in CVC SD/LD, indicating the development of hepatic congestion. SWS showed a moderate positive correlation with CVC SD/LD, whereas DS demonstrated a strong correlation, suggesting that viscosity-based assessment

may be more sensitive to congestion-related hemodynamic changes.

In Chapter 2, hepatic 2D-SWE was performed in 100 client-owned dogs with structural heart disease. Dogs were classified according to the presence or absence of ascites, a representative clinical sign of RHF. Dogs with RHF ($n = 27$) exhibited significantly higher hepatic SWS, DS, CVC SD/LD, and right atrial area index (RAA index), an echocardiographic marker of right atrial enlargement, compared with dogs without RHF ($n = 73$). In contrast, left ventricular outflow tract velocity–time integral (LVOT-VTI), an echocardiographic index of cardiac output, was significantly lower in dogs with RHF. DS achieved the highest diagnostic accuracy for detecting RHF ($AUC = 0.977$). Multiple regression analysis revealed that DS was strongly associated with CVC SD/LD and RAA index, both reflecting venous congestion and right-sided pressure overload, whereas SWS was influenced by both congestion-related indices and reduced LVOT-VTI, suggesting that SWS may also reflect hepatic changes related to reduced cardiac output, such as chronic hypoxic injury or fibrosis.

Overall, these findings demonstrate that 2D-SWE is a valuable non-invasive modality for evaluating hepatic involvement in dogs with heart disease. DS appears to be a sensitive and relatively specific marker of hepatic congestion, useful for assessing congestion severity. In contrast, SWS may provide complementary information regarding hepatic changes associated with both venous congestion and reduced cardiac output. Combined interpretation of SWS and DS may therefore enhance clinical assessment of hepatic pathophysiology and support longitudinal monitoring in dogs with cardiac disease.