Abdominal aortic aneurysm follow-up after endovascular repair in a canine model with non-invasive vascular elastography

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Introduction: Non-invasive vascular elastography (NIVE) using the Lagrangian Speckle Model Estimator (LSME) may become a complementary follow-up imaging technique for endovascular aneurysm repair (EVAR). NIVE has the capability of providing important information on the thrombus organization within the aneurismal sac and on the detection of endoleaks. A previous study tested the LSME in a type I endoleak canine model. It was possible to characterize the strain of the aneurismal wall and differentiate the venous patch used to create the aneurysm from the native artery. The characterization of the thrombus organization was not possible in the latter study. A limitation was the absence of CT examinations as gold standard for endoleak diagnosis. We aimed to apply and optimize NIVE of abdominal aortic aneurysm (AAA) after (EVAR) with stent-graft (SG) in a canine model to detect endoleaks and characterize thrombus organization.

Methods: SGs were implanted in a first group of 3 dogs with an aneurysm created in iliac arteries and in a second group of 3 dogs in the abdominal aorta. Type I endoleak was created in 6 iliac and 1 aortic aneurysms and type II endoleak in two aortic aneurysms. Duplex ultrasound (Supersonic Imagine) and NIVE elastography examinations (Sonix RP, Ultrasonix) were performed at baseline, 1-week, 1-month, 3-month (first group) and at 6-month (second group) follow-up. Angiography (Koordinat 3D II), CT-scan and histology (Exakt Gmbh) were also performed at sacrifice. Ultrasonic raw RF data were acquired on longitudinal and three axial planes (proximal, mid and distal parts of the aneurysm) to generate with NIVE time-varying strain curves. Elastograms of zones of interest were computed using the LSME. Areas of endoleaks, liquid thrombus (non-organized) and solid thrombus (organized) were identified and segmented by comparing results of CT scan and histology. Strain values in areas with endoleaks, liquid and solid thrombus were compared.

Results: Five iliac and one aortic aneurysms had confirmed type I endoleaks. A type II endoleak was observed in two aortic aneurysms, whereas one iliac aneurysm was sealed. Maximal axial strain values in endoleak, liquid and solid thrombus areas were, respectively, estimated at 0.73 ± 0.14 %, 0.22 ± 0.04 % and 0.11 ± 0.04 %. Strain values were significantly different between endoleaks and liquid or solid thrombus areas ($p = 5.136E-09$) and between solid and liquid thrombus areas ($p = 0.00063$). All endoleak areas were clearly identified on elastography examinations using axial and shear strain parameters.

Discussion: NIVE using the LSME is capable of detecting endoleaks and characterizing the thrombus organization as liquid or solid. Further developments are needed to enable real time elastograms optimized for AAA follow-up after EVAR.

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