Quasi-static ultrasound elastography characterization of thrombus maturation in the aneurysmal sac after embolization of endoleaks with chitosan gels

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Introduction: *Rupture of abdominal aortic aneurysm is considered a major cause of mortality, responsible for more than 15000 deaths per year in the United States. Endovascular aortic aneurysm repair (EVAR) is recommended for high risk patients. However, long term complications are associated with EVAR, mainly due to endoleaks. Embolization has been proposed to prevent or treat endoleaks. However, despite embolization, endoleak recurrences are frequently observed. Our purpose is to investigate if quasi static ultrasound elastography (QSUSE) can characterize the maturation of thrombus and the mechanical properties of embolizing gels after endoleak embolization following aneurysm endovascular repair (EVAR) in a canine model.*

Methods: *Bilateral common iliac artery aneurysms were created on 9 dogs. Then EVAR were performed with creation of a Type I endoleak. 2 types of embolization gels [Chitosan (Chi) or Chitosan-Sodium-Tetradecyl-Sulfate (Chi-STS)] were injected equally in the aneurismal sac to seal the endoleak and promote healing. Aneurysm healing and endoleak evolution were followed by Doppler ultrasound and QSUSE at 1-week, 1-month, 3-months and for 3 dogs at 6-months. At sacrifice, DSA, CT-scan and macroscopic and histological analyses were done to identify residual endoleaks (DSA, CT-scan) and segment different regions of interests (ROI) (thrombus, Chi and Chi-STS gel). At sacrifice, segmentation of fresh thrombus (FT) and organized thrombus (OT) was realized. Elasticity values expressed as strain in percentage were obtained by QSUSE and compared between ROIs and during time evolution.*

Results: *The MaxAxstrain values of thrombus ROIs were recorded at 0.20 ± 0.11 %, 0.12 ± 0.05 % and 0.11 ± 0.05 % at 1-week, 1-month and 6-months respectively. The MaxAxStrain values of chitosan ROIs were estimated at 0.17 ± 0.07%, 0.17 ± 0.12 % and 0.11 ± 0.04 % at 1-week, 1-month and 3-months respectively while chitosan-STS values were lower (0.12 ± 0.07 % at 1-week, 0.09 ± 0.04 % at 1-month and 0.09 ± 0.05 % at 3-months). Higher strain values were observed for fresh thrombus at sacrifice (0.23 ± 0.10 %) as compared to organized thrombus (0.14 ± 0.07 %). All thrombus strain parameters were lower (stiffer) at one month follow-up when compared with baseline (one week) (P values ranging between =0.0005 and 0.02). Lower MaxAxstrain and MaxCumAxstrain values were observed for both Chi and Chi-STS areas at 3-months as compared with 1-week suggesting chitosan degradation. (P values ranging between 0.02 and 0.04).*

Discussion: *We show that QSUSE technique can measure the stiffness of AAA sac content and could be used to classify the organization of the thrombus. In addition, QSUSE could serve also as a tool to monitor embolic gel degradation.*

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Key words: AAA, embolization, elastography, endoleaks, EVAR follow-up