Carotid plaque vulnerability assessed by combined shear wave elastography and ultrafast doppler compared to histology: the UF-plaque study

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Purpose: New biomarkers are needed to assess the vulnerability of carotid plaque to guide carotid surgery decision. Ultrafast Ultrasound Imaging (UUI) provides an estimation of plaque stiffness by Shear Wave Elastography (SWE) and the quantification of wall shear stress (WSS) by ultrafast Doppler. We aimed at evaluating the plaque stiffness and WSS applied on the plaque as potential biomarkers of plaque vulnerability.

Methods: Patients were referred for carotid endarterectomy because of symptomatic or asymptomatic carotid stenosis. Their plaques were evaluated by UUI within 48 hours before surgery. For each plaque, WSS and SWE were obtained on a longitudinal view at the stenosis. After endarterectomy, gross analysis and histology were performed on each removed plaque.

Results: 46 plaques with SWE data and 29 with WSS data were analysed. Histological analysis revealed 29 vulnerable and 17 stable plaques. Analysis of the Gray Scale Median by B mode, mean and standard deviation of stiffness by SWE were not helpful in identifying vulnerable plaques. Figure 1 presents the SWE acquisition on one plaque (A) and the distribution of plaque's stiffness average over all plaques showing the 4 ranges of stiffness (B). SWE analysis revealed that the percentage of stiffness range of [3–5] m/s was significantly increased in vulnerable plaques (p=0.048) (Figure 2A). WSS alone showed no significant difference between stable and vulnerable plaques regardless of which segment of the plaque was analysed. A multiparametric score using maximal WSS at the peak of the plaque associated with SWE texture analysis parameters was created by a stepwise analysis, leading to a score with a sensitivity of 80% and a specificity of 78%. The ROC curve of this score found an AUC of 0.85 (Figure 2B).

Conclusions: Multiparameter scoring including plaque stiffness and flow analysis using ultrafast ultrasound imaging allows an effective identification of histologically vulnerable carotid plaques.

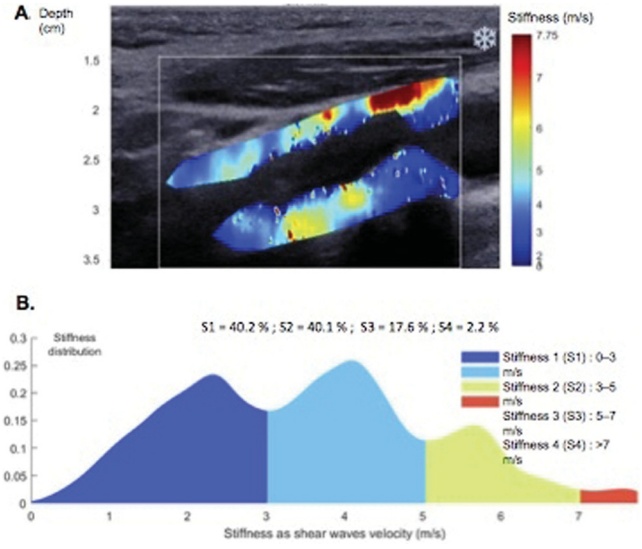

Figure 1

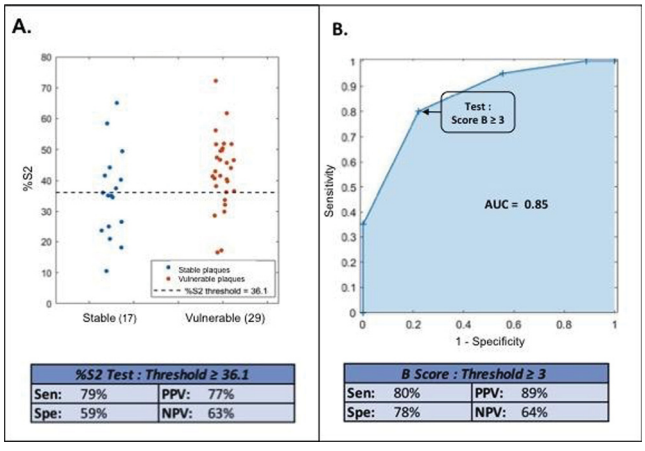

Figure 2