Radiomics applied to carotid CT angiograms can identify significant differences between culprit and non-culprit lesions in patients with stroke and transient ischaemic attack

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Background: Carotid artery atherosclerosis is an important cause of ischaemic stroke. In oncology, textural analysis ("radiomics") of computed tomography (CT) images can predict the metastatic potential and prognosis of several types of malignant tumours. We investigated whether this quantitative approach could be applied in carotid artery disease.

Purpose: (1) To evaluate the feasibility of computed tomography angiography (CTA) texture analysis in differentiating symptomatic from asymptomatic patients. (2) To investigate whether CTA carotid texture analysis can identify culprit lesions in patients with stroke and transient ischaemic attack (TIA).

Methods: Carotid CTAs of consented research subjects were included in the study. Symptomatic patients had confirmed carotid artery-related ischaemic stroke or TIA in the 7 days before CTA imaging. Asymptomatic (ASX) patients had no prior stroke/TIA. Both TexRAD, a research texture analysis software, and PyRadiomics, a Python package for radiomics studies, were used to extract 99 first-order and higher-order texture features from regions-of-interest (ROI) drawn around the outer wall of the carotid artery. Single-slice analysis compared the carotid bifurcations of symptomatic and asymptomatic patients, and of culprit (CC) and non-culprit (NC) arteries in symptomatic patients. Multi-slice analysis was conducted using a 3D volume defined by ROIs drawn on 14 consecutive CT slices of 3mm thickness, covering 3cm of carotid artery. The Mann-Whitney U test was used for inter-subject comparisons (ASX vs CC; ASX vs NC) and the Wilcoxon signed-rank test was used for intra-subject comparisons (CC vs NC). A p value <0.0005 was deemed statistically significant after Bonferroni correction for multiple comparisons. Non-normally distributed variables are reported as median (interquartile range).

Results: The dataset comprised 82 carotid arteries from 41 symptomatic patients (41 culprit; 41 non-culprit) and 50 carotid arteries from 25 asymptomatic patients. Single-slice analysis revealed greater homogeneity in asymptomatic carotids versus symptomatic culprit carotids (Uniformity: ASX 0.11 (0.05); CC 0.08 (0.05), $p<0.0005$) and non-culprit carotids (NC 0.08 (0.18), $p<0.0005$). In multi-slice analysis, culprit and non-culprit carotid arteries displayed greater heterogeneity than asymptomatic carotids (GLSZM zone entropy: CC 6.57 (0.59); NC 6.76 (0.65); ASX 6.21 (0.32), $p<0.0005$). Multi-slice analysis of symptomatic culprit versus non-culprit carotids revealed greater heterogeneity in culprit carotids than non-culprit carotids (GLRLM run entropy CC 6.57 (0.59); NC 5.05 (0.70), $p<0.0001$).

Conclusion: Textural analysis of carotid CTAs reveal significant differences between symptomatic and asymptomatic patients and between culprit and non-culprit carotid arteries within symptomatic patients. This approach could be used to identify patients at high risk of further stroke for aggressive medical therapy and surveillance.

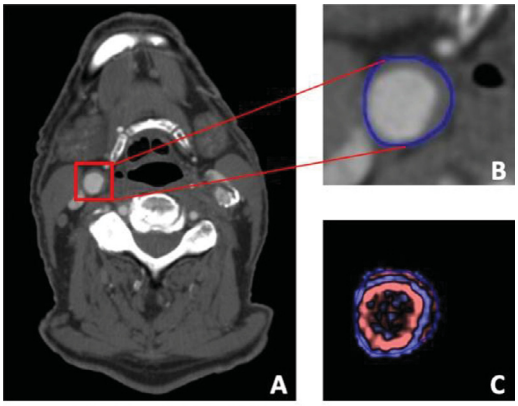

Figure 1. Texture Analysis Method
A) Carotid computed tomography angiogram
B) Manual ROI segmentation
C) Texture feature extraction