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Automatic coronary angiography analysis using convolutional neural networks: segmentation and quantitative features

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THEME: Coronary Interventions

TOPIC(S): Stable CAD, Other Coronary Interventions

AIMS

A software for automatic evaluation of coronary artery angiograms could significantly reduce the time needed to evaluate coronary heart vessels, standardize evaluation of lesion characteristics and make it less operator-dependent. The aim of our study is to create a deep learning based algorithm for the automatic analysis of coronary angiograms.

METHODS AND RESULTS

The criteria for image selection were: a) stable coronary artery disease (SCAD), b) optimal image quality (0.1 mg intracoronary nitroglycerine administered before angiogram; diagnostic catheter should be well visible, filled with dye; coronary tree - well visible, near the centre of the angiogram and shown without foreshortening; at least 3 cardiac cycles filled with dye; an angulation with minimal vessel overlapping), c) no previous history of invasive treatment (stenting or CABG). Two-dimensional images of coronary angiograms of thirty SCAD patients were selected for the present analysis. In the next stage, we manually segmented coronary tree using "3D Slicer" software. The following tasks were then performed: The images and segmentation masks were used to train an U-net based convolutional neural network for contrast-filled vessel segmentation task. We created an algorithm for skeletonization (creating a 1-pixel width map) of the segmentation masks produced by the neural network created in step 1. We created an algorithm for the evaluation of pixel location in the skeletonized map (end pixel/bifurcation pixel/continuous pixel). We created a code, which uses the output produced in steps 1 and 2 to create a segmentation map of the vessels. The algorithm then has the ability to calculate the local radius by calculating the distance of each edge pixel to the edge pixel on a line perpendicular to the centre line. By extracting the scale which is stored in the DICOM metadata the algorithm is then able to calculate the real radius in millimetres.

CONCLUSIONS

The deep learning based algorithm that we have developed is the initial stage of creating software for automatic evaluation of coronary artery angiograms. The current software code is already able to automatically detect and analyse images of coronary angiograms, create segments based on the pixel locations and automatically measure the mean radius. We plan to eventually develop software for use in everyday clinical practice. Further steps planned: a) detection of the course of individual vessels, b) segmentation of functional segments, c) detection of one anatomical area in different projections of the vessel.