Automatic Detection of Significant and Subtle Lesions from Coronary CT Angiography

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I. Introduction

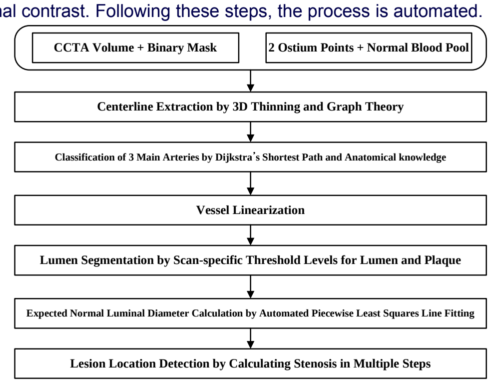
- Coronary Artery Disease (CAD) is the leading cause of death worldwide for both men and women.
- CCTA has shown high accuracy for detection of coronary artery stenosis & atherosclerotic plaque.
- Current clinical assessment of CCTA is based on visual analysis: time consuming and observer-variable.
- A few studies on automatic lesion detection (≥50%).
- **There has been no reported attempt to automatically detect less-stenosed (25~49% stenosis) lesions, which have been shown to contribute to cardiovascular events.**

II. Goals

- **To develop and validate an automated algorithm for detecting nonobstructive (25-49% stenosis) and obstructive (≥25% stenosis) arterial lesions from coronary CTA.**

III. Methods

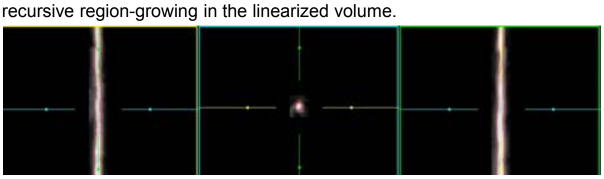
- The algorithm needs two points as input, at the ostium of the RCA and the LM coronary artery, and secondly, the placing of a standard circular region of interest in the aorta at the level of the LM ostium, to obtain scan-specific attenuation range for luminal contrast. Following these steps, the process is automated.



- Centerline extraction and classification of 3 main arteries (LAD, LCX and RCA) by 3D Thinning + Dijkra's shortest path + anatomical knowledge.

Centerline extraction & 3 main artery classification with small branches.

- The vessels are subsequently converted to a linearized 2D representation, which are stacked up cross-sectional planes perpendicular to the centerline.
- Computed the attenuation range for lumen and plaque automatically from the image histogram of the normal blood pool. Then, Lumen is segmented by local recursive region-growing in the linearized volume.

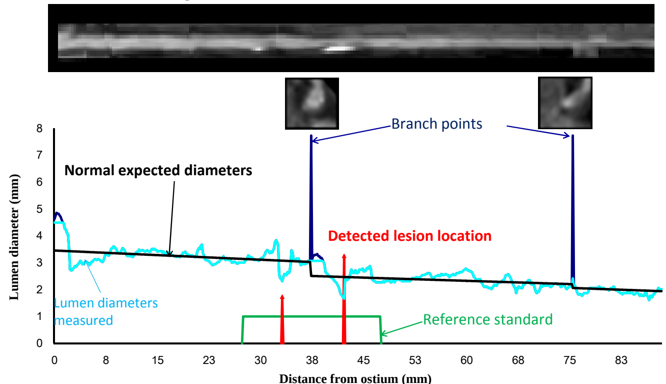


Vessel linearization and lumen segmentation (red).

- Presence and location of lesions are identified using lumen diameters from 2D cross-section obtained from lumen segmentation.
- Expected or "normal" luminal diameter is derived from the scan by automated piecewise least squares line fitting over coronary lumen diameters between small branch points, allowing the presence of "normal tapering".

$$S_t = \left[1 - \frac{l_s}{l_p - \frac{s_p}{s_d}\left(l_p - l_d\right)} \right] x100$$

S_t (%): stenosis.
s_p & s_d: linear distance between the proximal reference, and the distal reference, and s respectively.
l_s, l_p, l_d: luminal diameters at s, proximal and distal reference.



Lesion presence and location detection.

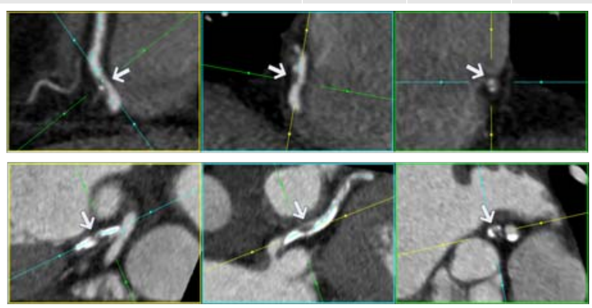
IV. Results

- 42 patients data (57% male, a mean age of 60±12.
- 252 coronary artery segments (proximal/mid).
- An expert observer identified 21 patients with 45 lesions (≥25% stenosis). 21normal patients had no luminal stenosis or plaque.

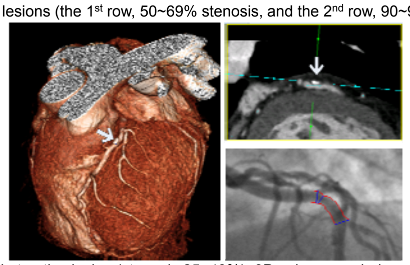
	Lesions by Experts (≥25% stenosis)	Sensitivity	Specificity	Accuracy
LAD	24	92%	75%	80%
LCX	10	100%	76%	79%
RCA	11	100%	82%	75%
Total	45	96%	78%	80%

Breakdown of detected false positives lesions.

	LAD	LCX	RCA
Stenosis <25% by expert	9	6	8
Normal segments with narrowing (no stenosis or plaque [normal variant])	3	2	3
Undetected small vessel branch	2	3	8
Unclear Image contrast + blurring	0	2	0



Detected lesions (the 1st row, 50~69% stenosis, and the 2nd row, 90~99% stenosis).



Detected nonobstructive lesion (stenosis 25~49%). 3D volume rendering, CCTA, and according ICA.

V. Conclusions

- We developed a novel automated algorithm for detection and localization of significant (≥50%) and non-significant (25~49%) arterial lesions from CCTA, which performed with high sensitivity compared to an expert reader.

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