Computer Aided Detection and Diagnosis: Cardiac Imaging Applications

U. Joseph Schoepf, MD, FAHA, FSCBT-MR, FSCCT
Professor of Radiology, Medicine, and Pediatrics
Director of Cardiovascular Imaging
Consultant for / research support from

Bayer
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Medrad
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CAD for Coronary CTA: The Need

- Computer aided diagnosis and detection systems developed and described for
  - Lung nodules
  - Pulmonary embolism
  - Colon polyps
  - etc.

- Cardiovascular disease has the highest mortality and greatest socio-economic importance
  - Only 3 articles in pubmed on clinical CAD applications for coronary artery disease
Coronary CTA Challenges

- **Interpretation**
  Complex, requires special expertise, time consuming

- **Physicians**
  New to field, neither used nor willing to spend much time on workstations

- **Acute Chest Pain in ED**
  24/7 coverage?

- **Peripheral environment**
  Few readers with limited experience, significant interpretation delay
Computer Aided Detection at cCTA
Workflow

Image Acquisition

Computer Aided Detection

Reading Physician

Workflow
Automatic identification and segmentation of large anatomical structures
Processing Steps

Automatic identification of left and right coronary tree ostia. Tracking and segmentation of the coronary tree and extraction of vessel centerlines.
The image describes the processing steps for automatic labeling of coronary arteries in the extracted tree. It highlights automated stenosis detection and provides labeled trees with different branches indicated as RCA, LM, LAD, LCX, and Others.
### Export to Workstation

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**LAD:**
There is a Mixed Plaque lesion in the proximal section producing 50-75% stenosis.

**LCX:**
There is no significant obstructive disease.
Clinical Evaluation

- 59 patients underwent cCTA and quantitative coronary angiography.
- All cCTA data analyzed with CAD without human interaction for detection of coronary artery stenosis >50%.
- Results compared with QCA.
- CAD had 74%/100% sensitivity, 83%/65% specificity, 46%/58% PPV, 94%/100% NPV on per-vessel/per-patient analysis.
- 33 false positive detection marks (average 0.56/patient).

Automated computer-aided stenosis detection at coronary CT angiography: initial experience

E. Arnoldi et al., Eur Radiol 2009
Clinical Evaluation

E. Arnoldi et al., Eur Radiol 2009

100% Negative Predictive Value
Effect on Reader Performance

- 50 patients studied with cCTA and catheter angiography
- Interpretation by five observers (inexperienced to expert)
- Reevaluation after three months with CAD guidance
- Inexperienced readers improved from 65% sensitivity to 82% per-vessel and from 86% to 100% per-patient
- Experienced readers improved slightly from 92% to 96% per vessel but no change per-patient
- False negative rate reduced from an average 2 to 0 for inexperienced readers but did not change for experts

J. Abro et al.,
AHA 2009
Effect on Reader Performance

ROC Curve (Area) at patient level:
- Inexperienced reader 1 (0.81)
- Inexperienced reader 2 (0.80)
- Intermediate experienced reader (0.91)
- Expert reader 1 (0.98)
- Expert reader 2 (0.90)
Effect on Reader Performance

NPV - Per Patient

- Inexperienced 1: 90 without CAD, 100 with CAD
- Inexperienced 2: 96 without CAD, 100 with CAD
- Intermediate: 97 without CAD, 97 with CAD
- Expert 1: 100 without CAD, 100 with CAD
- Expert 2: 97 without CAD, 97 with CAD
Effect on Reader Performance

Specificity - Per Patient

- Inexperienced 1: 84 without CAD, 84 with CAD
- Inexperienced 2: 78 without CAD, 63 with CAD
- Intermediate: 91 without CAD, 91 with CAD
- Expert 1: 97 without CAD, 97 with CAD
- Expert 2: 97 without CAD, 97 with CAD

Legend: 
- without CAD
- with CAD
64-slice cCTA in 61 year old woman with BMI > 40kg/m² and atypical chest pain. CAD detected significant stenosis caused by non-calcified plaque in proximal RCA confirmed by invasive catheter angiography. Lesion was missed by three / five readers, due to high image noise.
Prognostic Value

• 247 TRO CT studies in patients with acute chest pain processed with CAD
• 209 patients without emergent pathology (ACS, PE, AAS)
• CAD marks deployed in 131 patients (63%)
• No CAD marks deployed in 78 patients (37%)
• Mean follow-up period of 12.8±7.0 months.
• 28 patients with CAD marks had MACE during follow-up.
• No patient without CAD marks had MACE

E.R. Sansoni et al.,
RSNA 2010, submitted
Clinical Scenarios

- “Wet read” when no experienced reader available
  - ER – chest pain triaging
  - Peripheral hospitals

- Prioritization for high volume practices
  - Focus on patients who need immediate care
  - Alleviate bottlenecks and workflow issues

- Second reader
  - Increase sensitivity
  - Boost confidence
  - Reduce interpretation time
Limitations

- No PACS / workstation integration
  Raises the bar for utilization

- Influence on interpretation time unclear
  Likely beneficial because few false positives

- Specificity good, but could be better
  May sway inexperienced observers to overcall stenosis and increase number of unnecessary caths

- Works best in low / intermediate likelihood pts
  In line with recommended use of cCTA