The carotid atheromatous plaque: a multi-disciplinary approach towards optimal management of symptomatic and asymptomatic subjects

Spyretta Golemati, PhD

Lecturer in Biomedical Engineering,
Medical School, National Kapodistrian University of Athens
Concept and objectives

- Concept
  - Multi-disciplinary approach
    - Clinical features
    - Biochemical features
    - Imaging features
    - Mechanical features

- Objectives
  - To produce new knowledge
    - Optimal management of patients
    - Academic excellence
Project overview

Carotid

Clinical data

Biological material

Imaging data

Data collection

Analysis of biological material

Analysis of ultrasound images

Texture analysis

Motion analysis

Data analysis

Computerised model

Information system

Interpretation

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<table>
<thead>
<tr>
<th>Participant</th>
<th>Department/Institution</th>
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<tbody>
<tr>
<td>1</td>
<td>Laboratory of Biomedical Engineering, ICCS – NTUA</td>
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<tr>
<td>2</td>
<td>Vascular Surgery/Radiology/Diagnostic Cytology Depts, Medical School, UOA (‘Attikon’ Hospital)</td>
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<td>3</td>
<td>VIDAVO</td>
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<td>4</td>
<td>DIGIMED</td>
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<tr>
<td>5</td>
<td>Medical Imaging &amp; Computer Vision Group, Ecole Centrale, Paris</td>
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Questions

- Why carotid atherosclerosis?
- What could be improved in patient management?
- What tools could be used?
Carotid atherosclerosis

- Carotid artery
Carotid atherosclerosis

- Carotid artery disease

- Atherosclerotic plaque

- Occlusion

- Plaque rupture
Carotid atherosclerosis

- Symptoms
  - Strokes, ischaemic attacks, amaurosis fugax

- Incidence
  - 260/100 000 population in Greece

- Cost
  - € 38 billion in EU
Diagnosis: ultrasound imaging

- External carotid artery
- Internal carotid artery
- Common carotid artery

Carotid duplex

- Ultrasound probe
- Carotid artery

Colour Doppler

B-mode
Therapy

- Medical treatment (e.g. statins)
- Surgical intervention
  - Stenting
  - Endarterectomy
## Therapeutic decision

<table>
<thead>
<tr>
<th></th>
<th>DS &gt; 70%</th>
<th>DS &lt; 70%</th>
<th>DS &gt; 50%</th>
<th>DS &lt; 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptomatic</td>
<td>-</td>
<td>-</td>
<td>surgery</td>
<td>no surgery</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>surgery</td>
<td>no surgery</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

DS: degree of stenosis

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Improve decision making

- Better identification of patients for surgical intervention
  - Some patients are offered unnecessary interventions
  - Some patients are not offered necessary interventions

- Increased patient safety
Examples of carotid image sequences

Young normal
Elderly normal
Atheromatic plaque – Elderly

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Ultrasound image analysis

- Texture analysis
- Motion analysis
- Automatic segmentation
Texture analysis

Asymptomatic

Symptomatic

Systole

Diastole

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Texture analysis

- Histogram-based features
  - Gray-scale median (GSM)
- Statistical features
- Model-based methods
- Multiscale features
  - wavelet transforms
  - ridgelet/curvelet transforms
  - ~ 80% classification
Texture analysis

- Clinical significance
  - Characterise the underlying material distribution
  - Discriminate between stable and unstable cases
Motion analysis

- Characterise mechanical strains
- Radial, longitudinal directions
# Motion analysis

<table>
<thead>
<tr>
<th>Weighted-least-squares optical flow (Lucas &amp; Kanade)</th>
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<tbody>
<tr>
<td>Affine block motion model</td>
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<tr>
<td>Adaptive block matching</td>
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<tr>
<td>Block matching</td>
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<tr>
<td>Optical flow (Horn &amp; Schunck)</td>
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</table>
Motion analysis

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Motion analysis

- Displacement maps

1st cardiac cycle  2nd cardiac cycle  3rd cardiac cycle
Motion analysis

- Displacement maps

![Images of displacement maps for radial and longitudinal directions across three cardiac cycles.](image)
Motion analysis

- Strain maps

radial

longitudinal

cardiac systole  cardiac diastole

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Motion analysis

- Clinical significance
  - Elasticity (mechanical) features
  - Functional information
Automatic segmentation

Hough transform (HT)

HT-initialized snakes

WT-initialized snakes

young
elderly

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Automatic segmentation

- **Clinical significance**
  - Automate the procedures
    - Diameter estimation
    - Wall thickness
    - Degree of stenosis
‘Carotid atheromatosis’

- Ultrasound-image-based features
- Biochemical markers
- Clinical information

Identify novel combined indices of disease
Conclusion

- Improve management of carotid atherosclerosis
  - Re-evaluate the role of ultrasound imaging
  - Consider in combination with other imaging modalities, e.g. CT, MRI