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

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Concept and objectives

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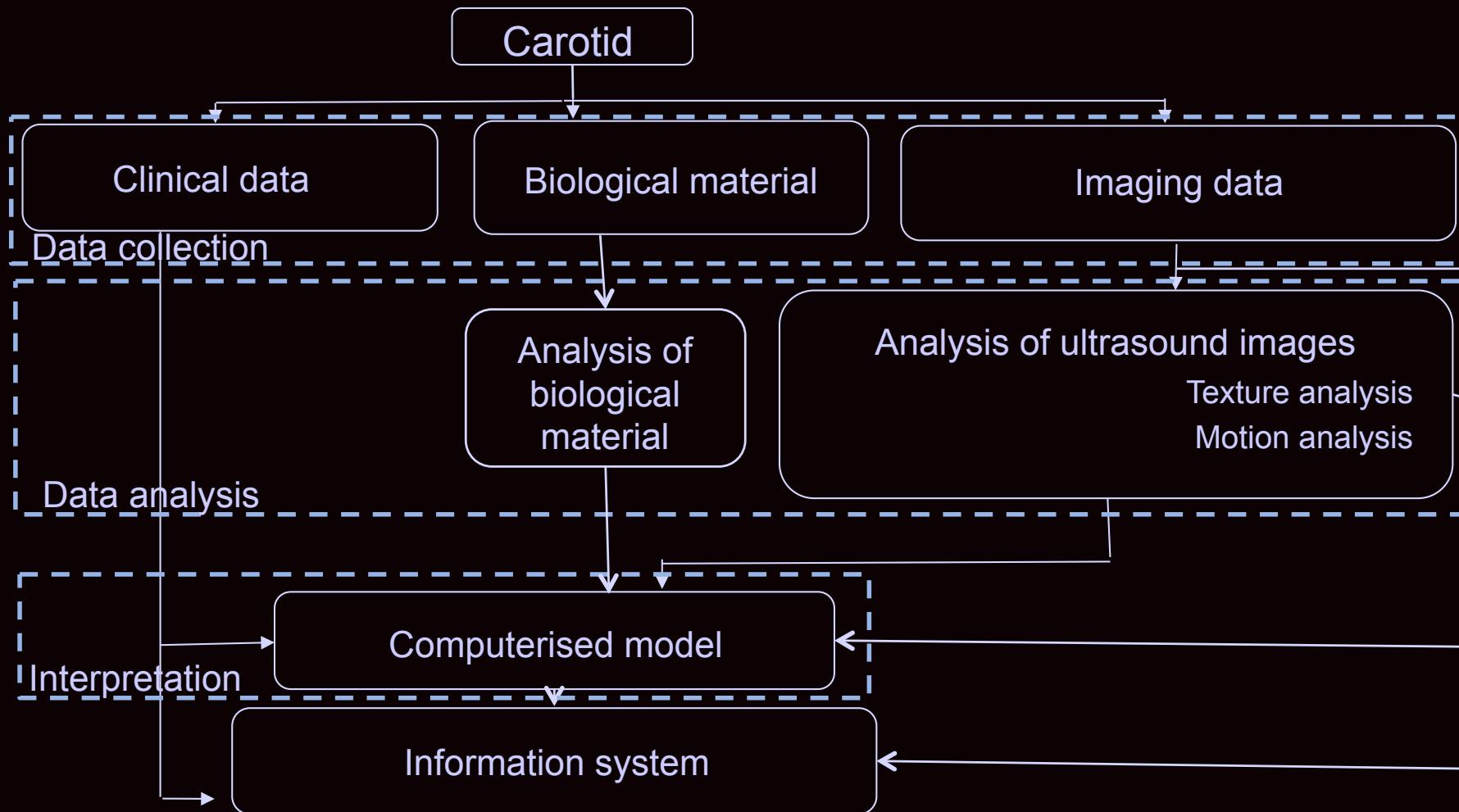 - Multi-disciplinary approach
    - Clinical features
    - Biochemical features
    - Imaging features
    - Mechanical features

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

Project overview

09-SYN-1054 Carotid Atheromatosis

Participants

	Participant
1	Laboratory of Biomedical Engineering, ICCS – NTUA
2	Vascular Surgery/Radiology/Diagnostic Cytology Depts, Medical School, UOA ('Attikon' Hospital)
3	VIDAVO
4	DIGIMED
5	Medical Imaging & Computer Vision Group, Ecole Centrale, Paris

Questions

- Why carotid atherosclerosis?

- What could be improved in patient management?
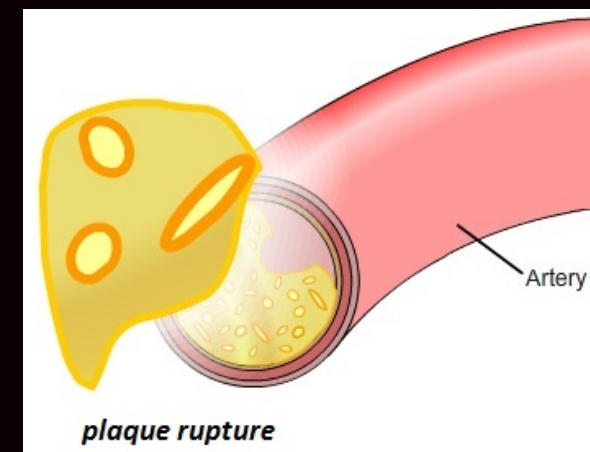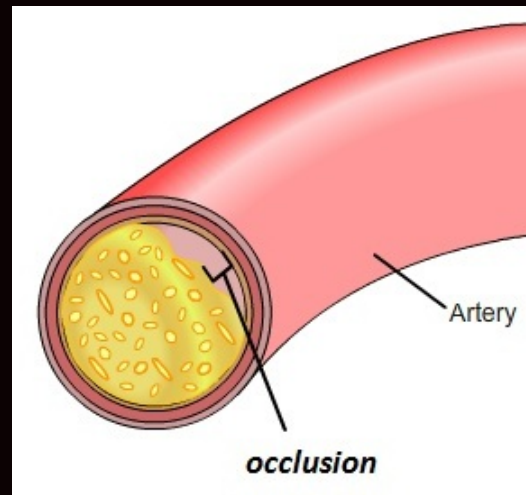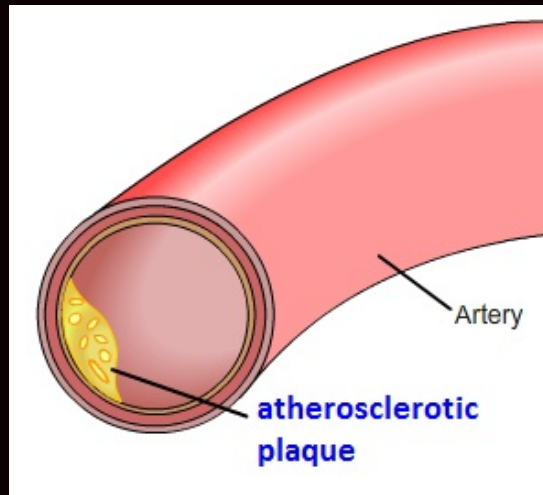
- What tools could be used?

Carotid atherosclerosis
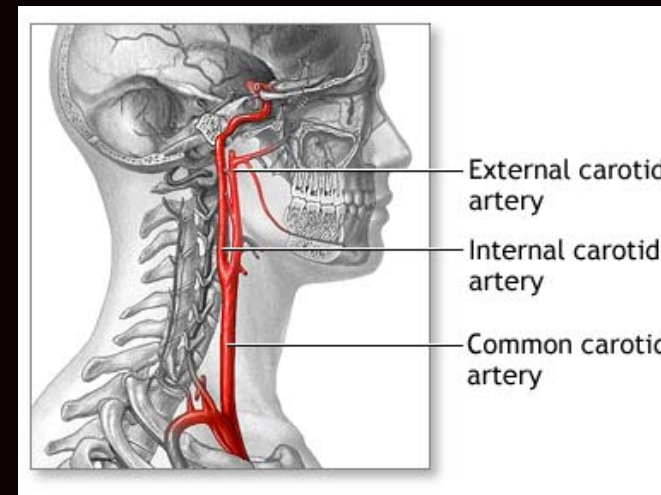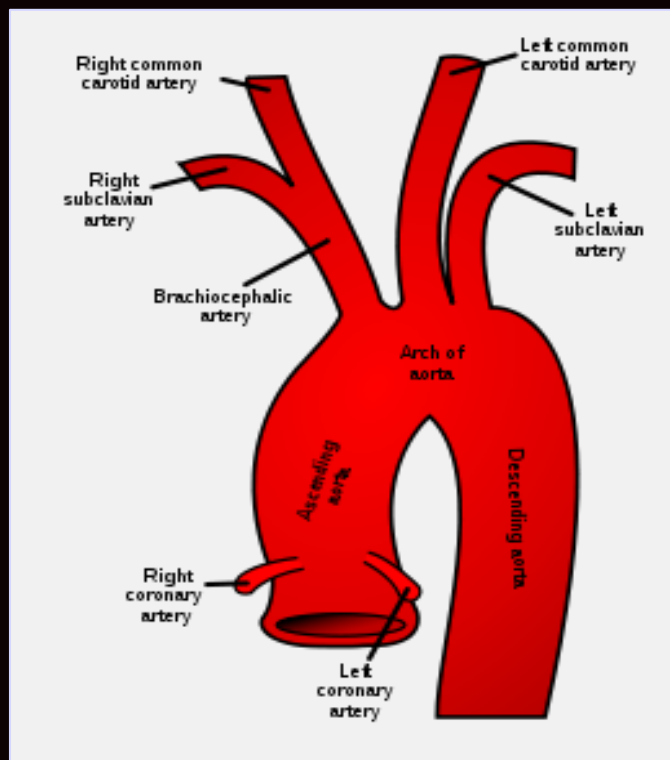
- ## Carotid artery

Carotid atherosclerosis

■ Carotid artery disease

atherosclerotic plaque

Artery

occlusion

Artery

plaque rupture
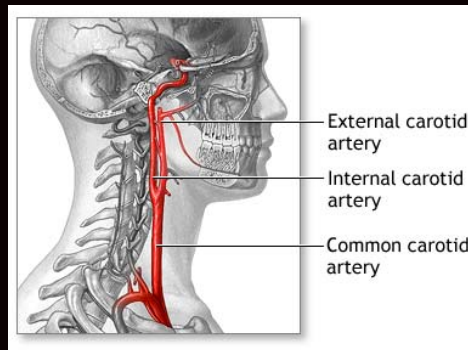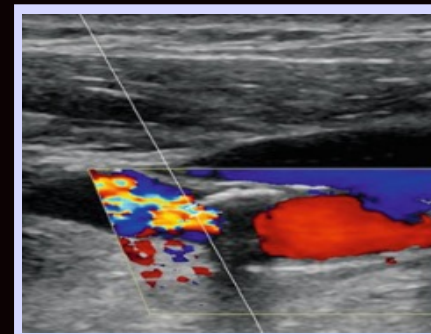
Artery

Carotid atherosclerosis

- ## Symptoms
  - Strokes, ischaemic attacks, amaurosis fugax

- ## Incidence
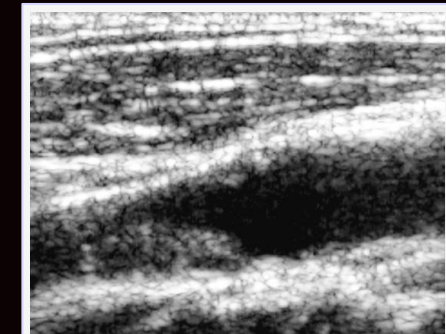 - 260/100 000 population in Greece

- ## Cost
  - € 38 billion in EU

Diagnosis: ultrasound imaging

External carotid artery

Internal carotid artery

Common carotid artery

Carotid duplex

Ultrasound probe

Carotid artery
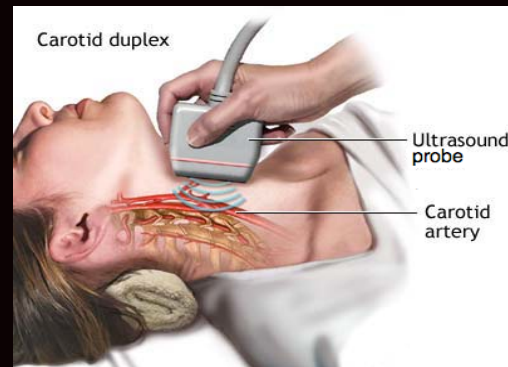
Colour Doppler

B-mode

Therapy

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

Therapeutic decision

|	DS > 70%	DS < 70%	DS > 50%	DS < 50%
Symptomatic	-	-	surgery	no surgery
Asymptomatic	surgery	no surgery	-	-

DS: degree of stenosis

Improve decision making

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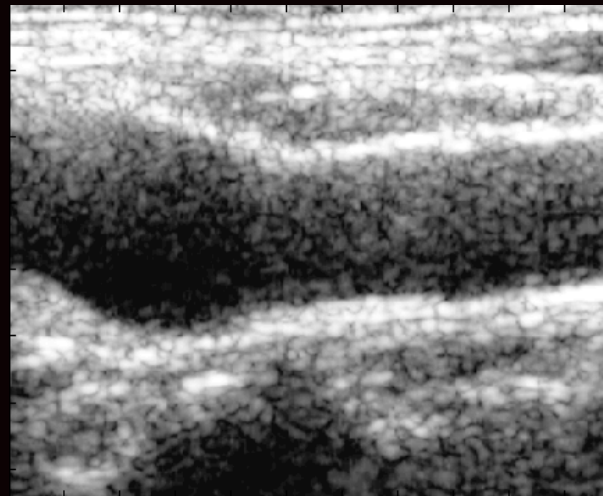 - Some patients are not offered necessary interventions

- Increased patient safety
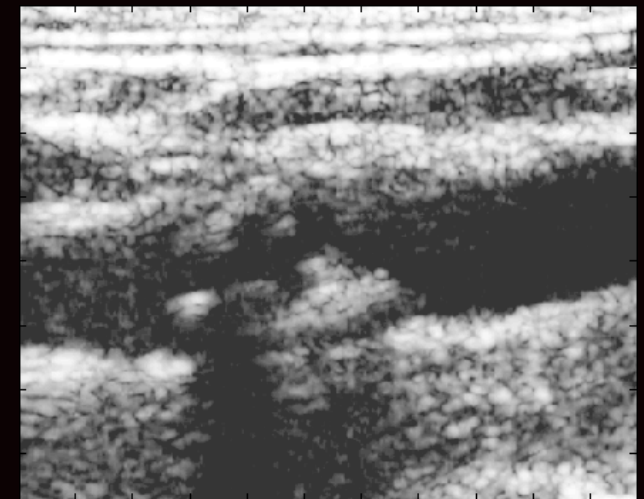
Examples of carotid image sequences
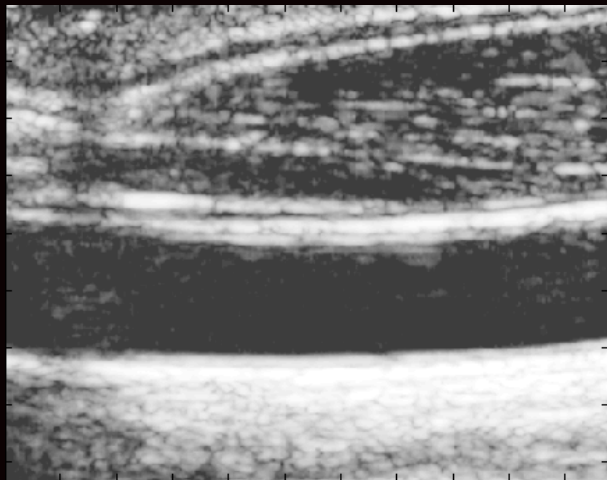
Young normal   Elderly normal   Atheromatic plaque –
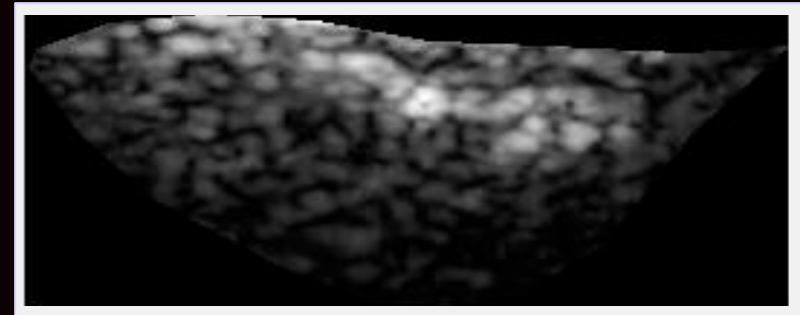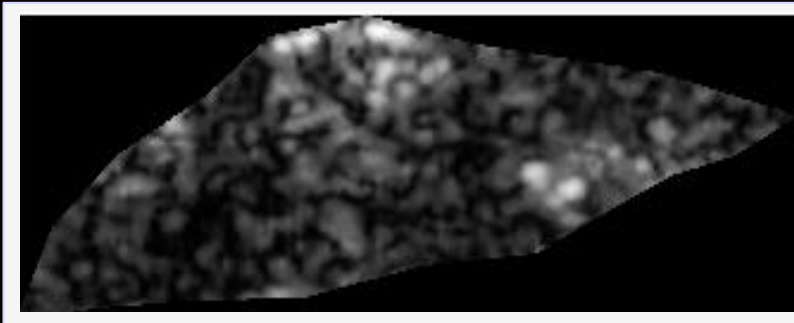
Elderly

Ultrasound image analysis

- Texture analysis

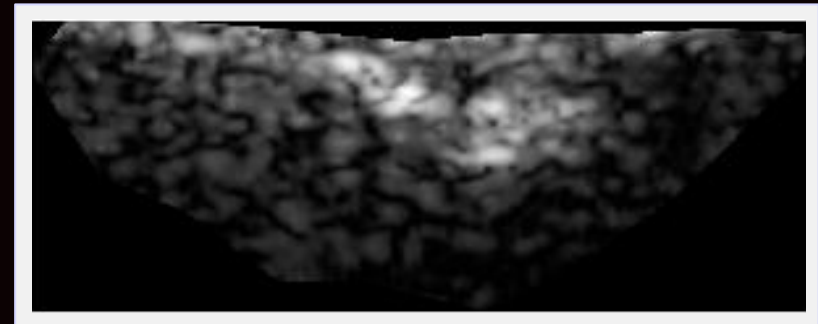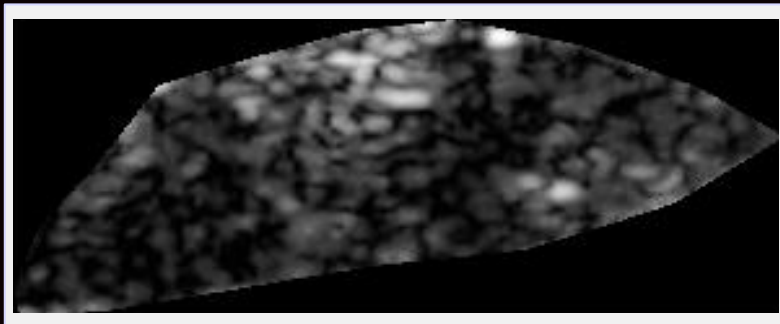- Motion analysis

- Automatic segmentation

Texture analysis

Asymptomatic

Symptomatic

Systole

Diastole

Texture analysis

- **Histogram-based features**
    - Gray-scale median (GSM)
- **Statistical features**
- **Model-based methods**
- **Multiscale features**
    - wavelet transforms
    - rigdelet/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**
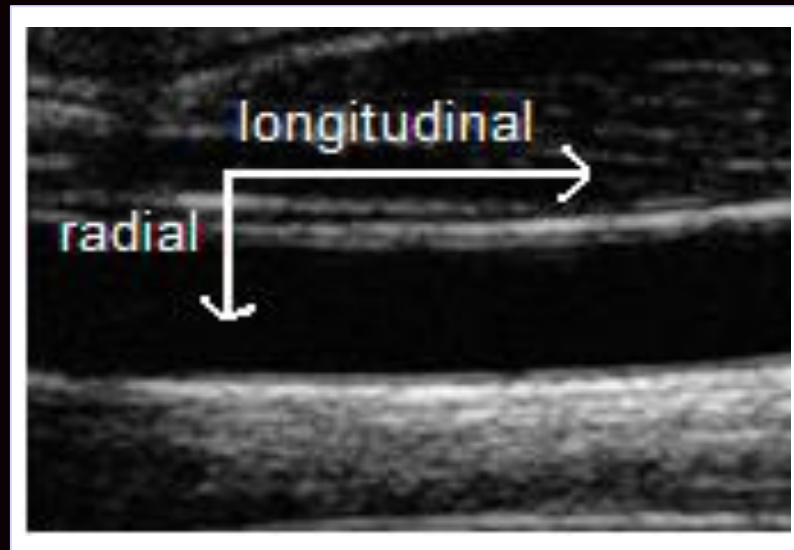
Motion analysis

accuracy →

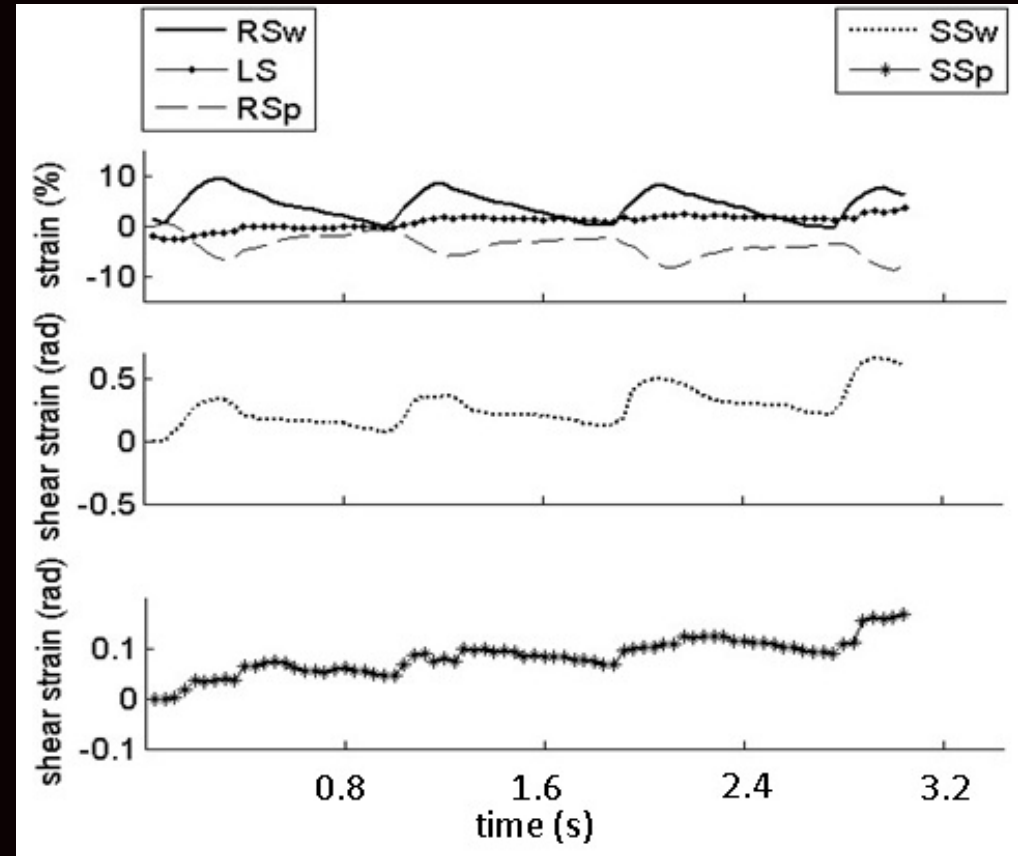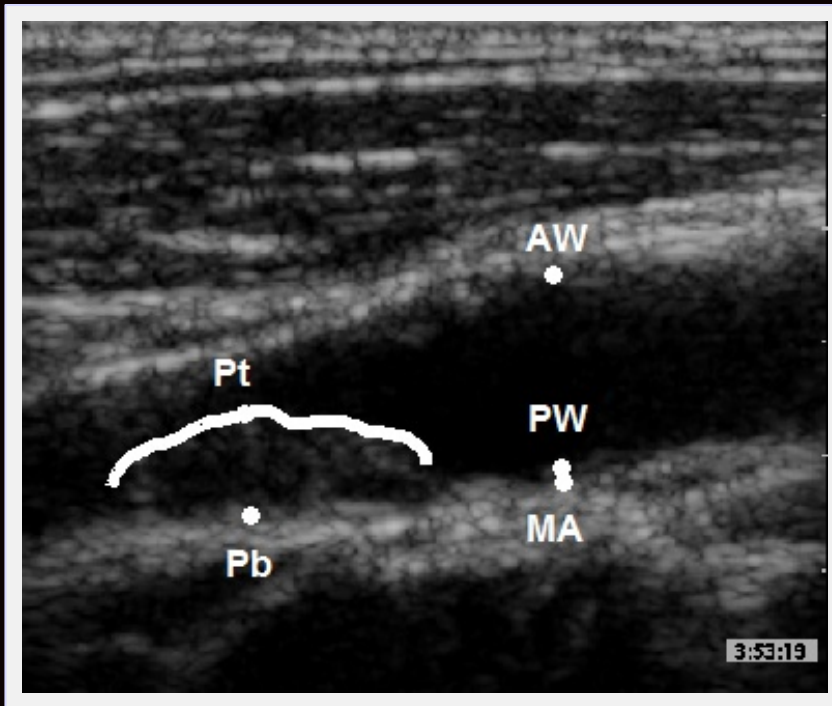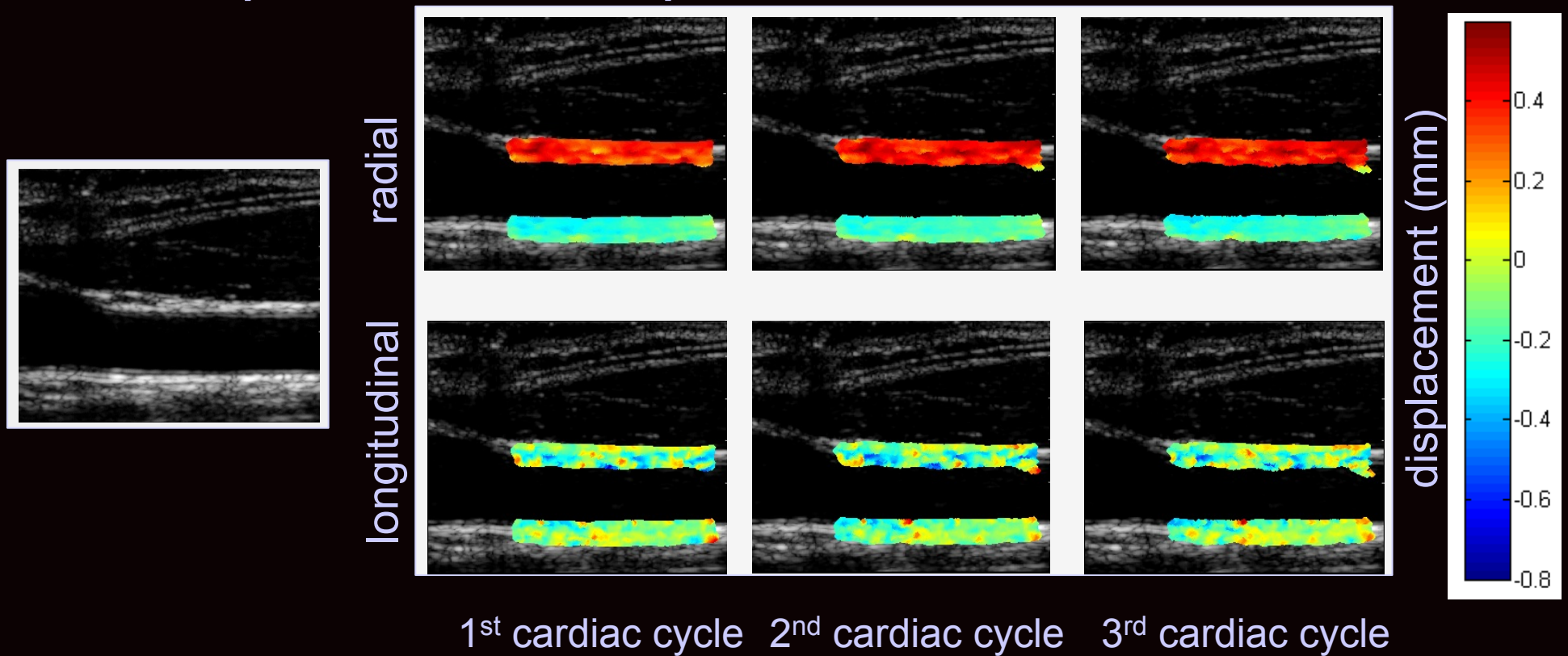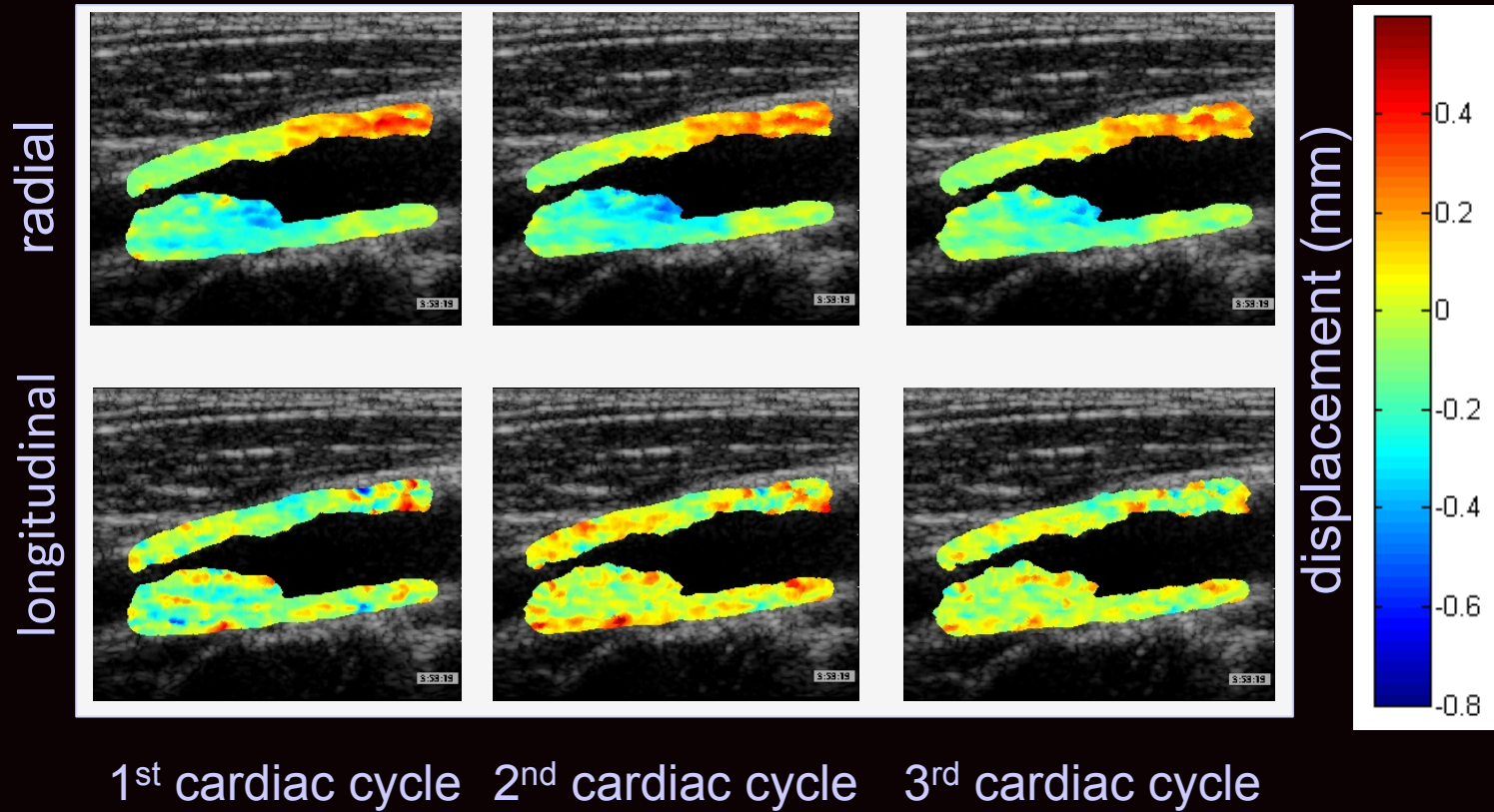| |
|---|
| **Weighted-least-squares optical flow (Lucas&Kanade)** |
| Affine block motion model |
| Adaptive block matching |
| Block matching |
| Optical flow (Horn&Schunck) |

Motion analysis

Motion analysis

- ## Displacement maps

Motion analysis

- ## Displacement maps

radial

longitudinal

displacement (mm)

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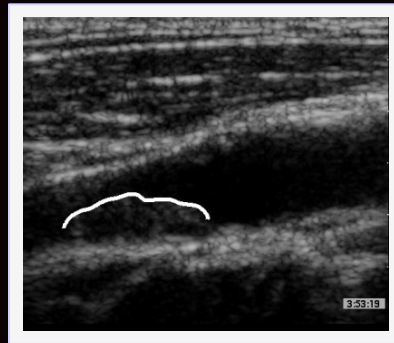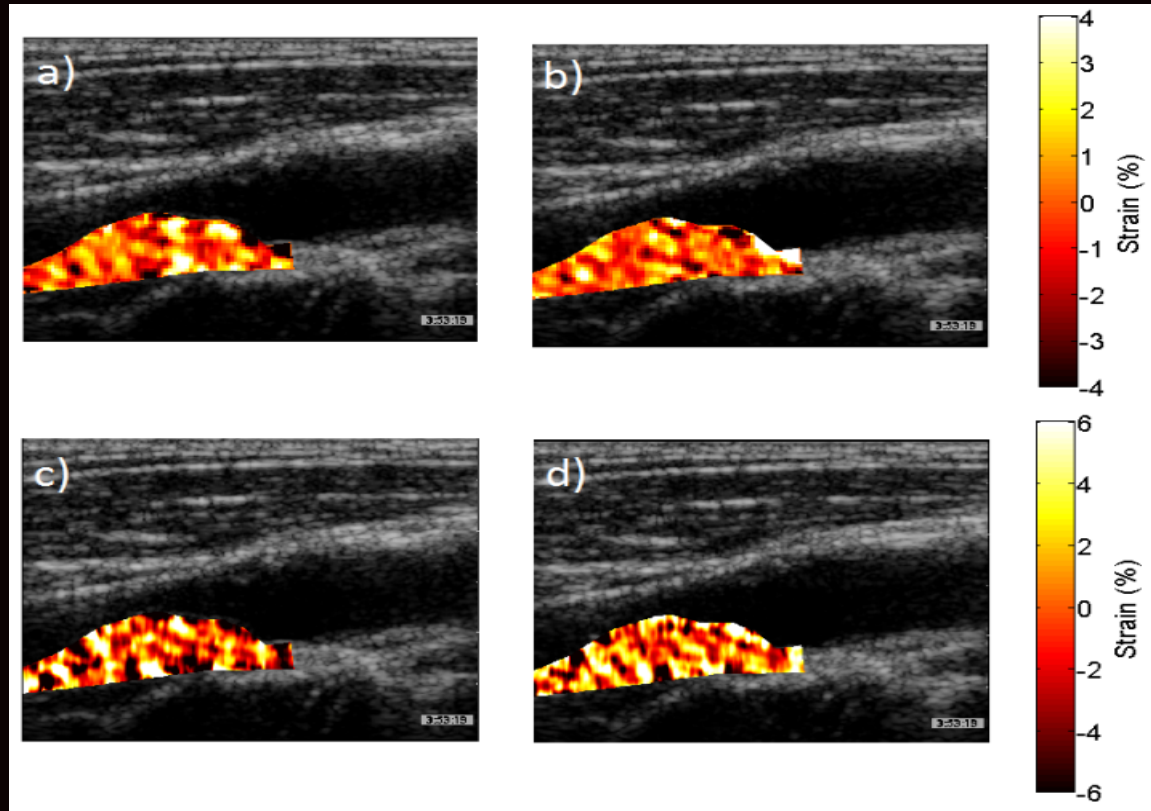
Motion analysis

- ## Strain maps
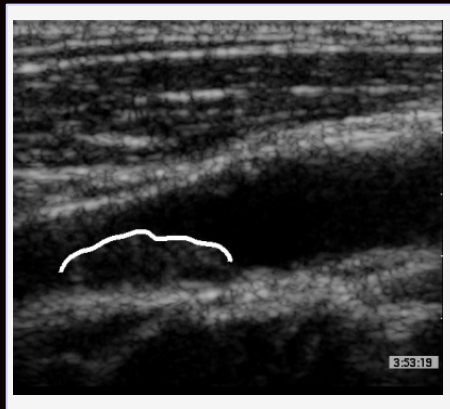
radial

longitudinal

cardiac systole   cardiac diastole
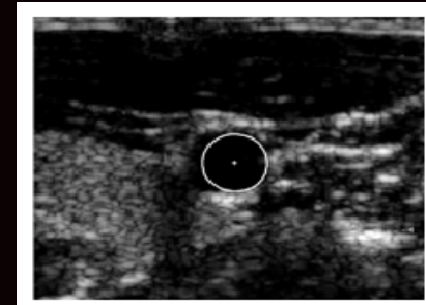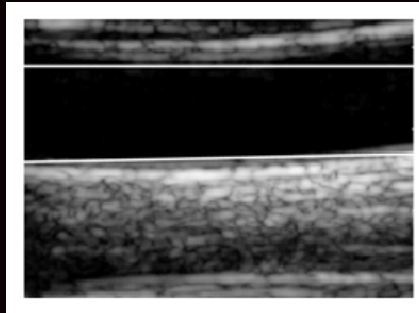
Motion analysis

- ## Clinical significance
  - Elasticity (mechanical) features
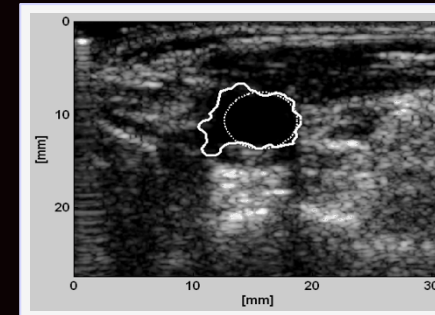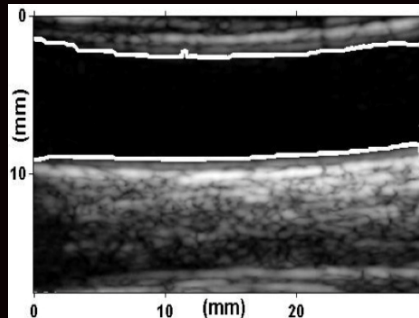 - Functional information

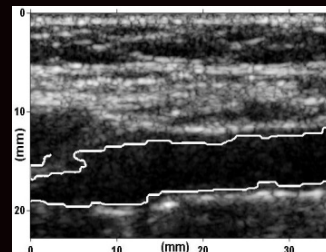# Automatic segmentation

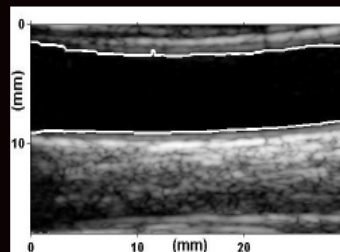Longitudinal section

Transverse section

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