Universiteit Antwerpen / UZA

Antwerp University Hospital and University of Antwerp, Belgium

TOGA 26-03-2019

Morphological evaluation of pulmonary nodules

Past, present and future

Annemiek Snoeckx

Tuberculoma*Solitary metastasis*Round pneumonia*Organizing pneumonia*Lung abscess*Aspergillosis*Blastomycosis*Cryptococcosis*Histoplasmosis*Carcinoid Amoebiasis*Echinococcosis*Nocardia*Atypical mycobacteria*Pneumocystis jiroveci*Septic embolus*Hamartoma*Chondroma*Fibroma*Lipoma*Neural tumor*Sclerosis hemangioma*Plasma cell granuloma*Endometriosis*Lung cancer*Teratoma*Arteriovenous malformation*Pulmonary infarct*Pulmonary artery aneurysm*Pulmonary venous varix*Hematoma*Bronchogenic cyst*Lung sequestration*Lymphoma*Bronchial atresia with mucoid impaction*Rheumatoid arthritis*Granulomatosis*Sarcoidosis*Intrapulmonary lymph node*Rounded atelectasis*Amyloidosis*Mucoid impaction*Pulmonary scar*Pseudotumor*Infected bulla

‘Likelihood of malignancy’

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- Growth
- Morphological assessment
- Metabolic assessment

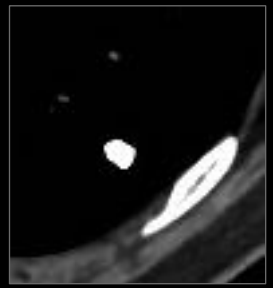
Morphological evaluation of pulmonary nodules

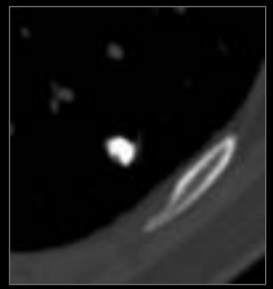
Past * Present * Future

The past

‘Basic’ morphological features

Calcification

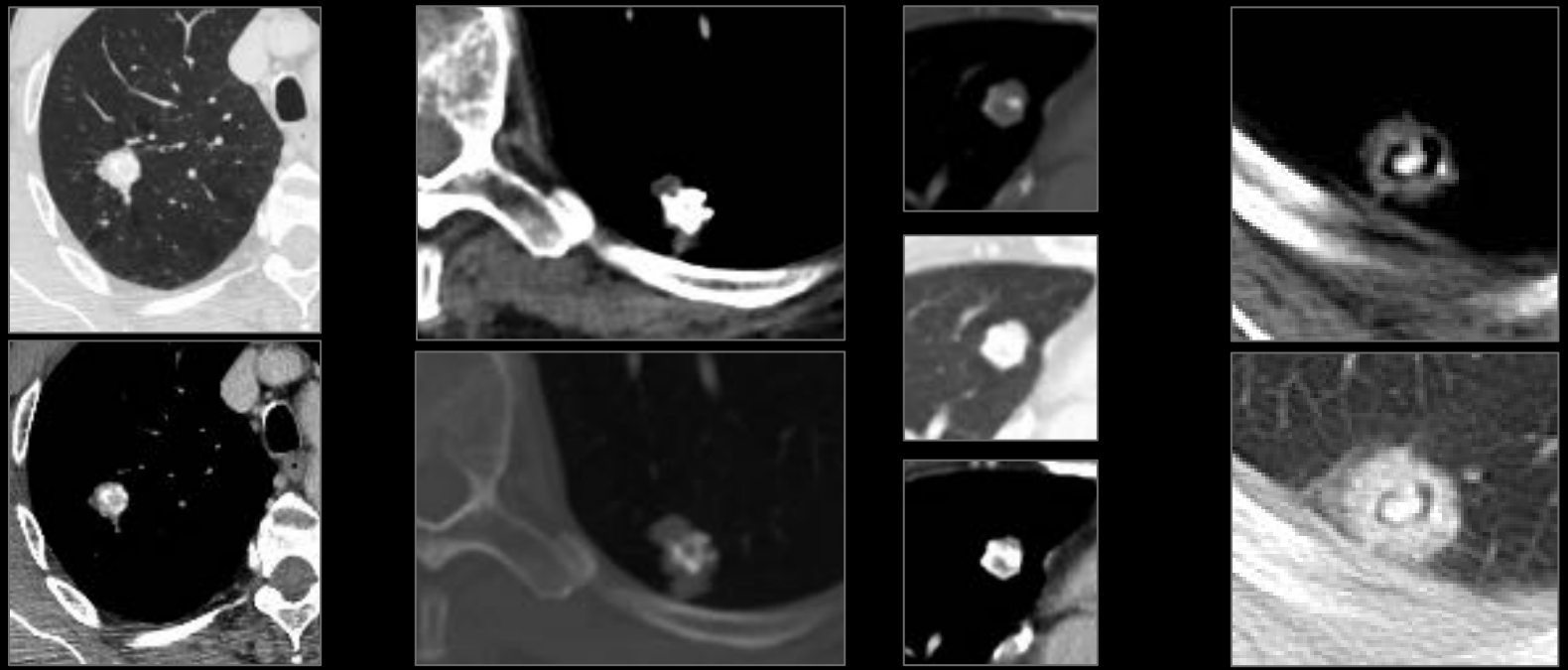




Common BENIGN patterns of calcification

- Attenuation values > 200 HU indicates presence of calcium
- Diffuse – central – laminated
- Popcorn calcifications = characteristic of chondroid calcification in hamartomas

Calcification



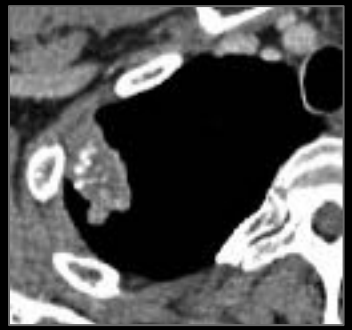
Calcification

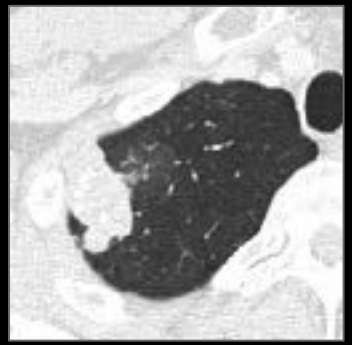
Mucinous adenocarcinoma

MALIGNANT causes

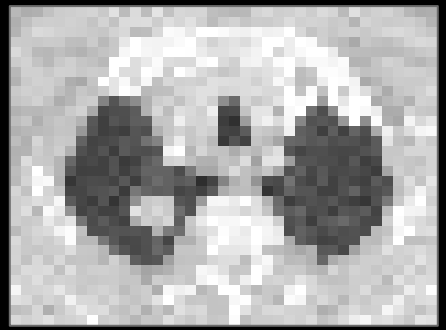
- Metastases:
    - Chondrosarcoma, osteosarcoma, colon, ovary, breast, thyroid, …
- Primary lung cancer: less than 2%
    - Indeterminate patterns: punctate, eccentric, amorphous calcifications

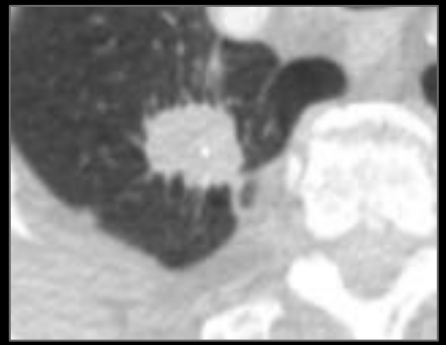
Calcification

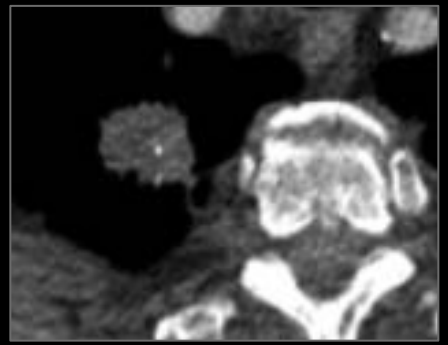




Adenocarcinoma

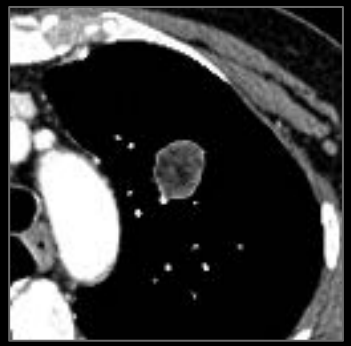




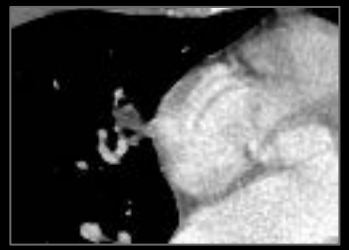


Squamous cell carcinoma

Fat attenuation



Hamartoma



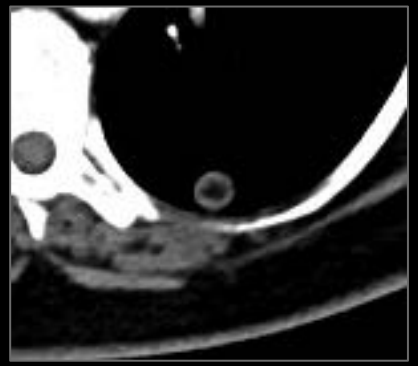
Lipoid pneumonia

- -40 to -120 HU
- Mediastinal window setting
- Most commonly BENIGN → hamartoma

- Also seen in pulmonary metastases from liposarcoma, renal cell carcinoma and in lipoid pneumonia

Siegelman SS et al. Radiology 1986
Hochhegger B et al. AJR 2012

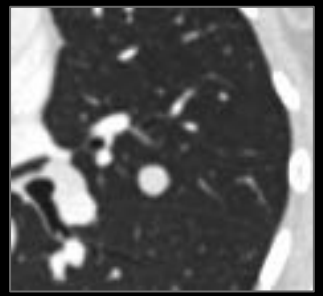
Fat attenuation



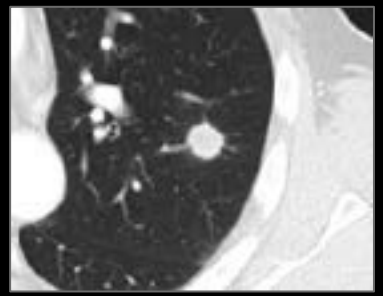
Hamartoma

Smooth margin

- Is more common in benign lesions
- Does not exclude malignancy
- Seen in 20% of primary lung cancers



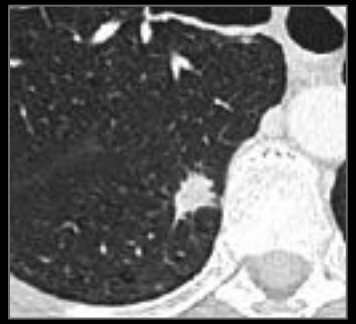
Typcial carcinoid



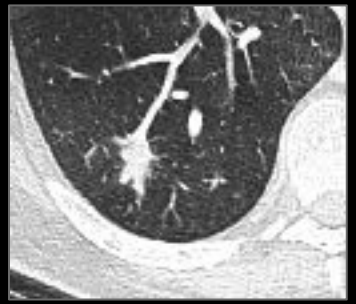
NSCLC

Hamartoma

Spiculation



Adenocarcinoma



Squamous cell CA

- Attributed to growth of malignant cells along the pulmonary interstitium
- 'sunburst' or 'corona radiata'

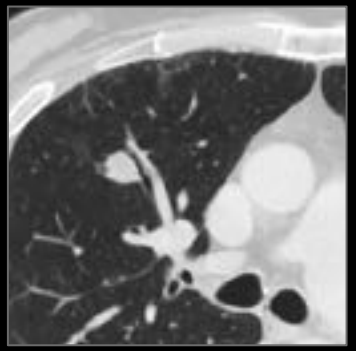
- Highly predictive of malignancy → positive predictive value of 88-94%

- Also seen in benign conditions: infection, inflammation, atelectasis, tuberculoma

Lobulation

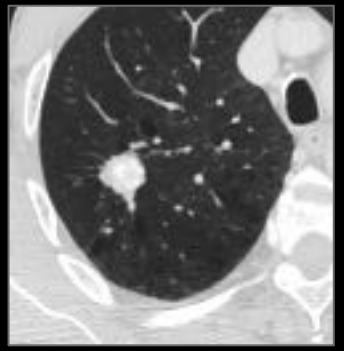
- Is attributed to different growth rates within the nodule
- PPV of 80% for malignancy
- Benign lesions with lobulation: hamartomas

Adenocarcinoma



Squamous cell CA

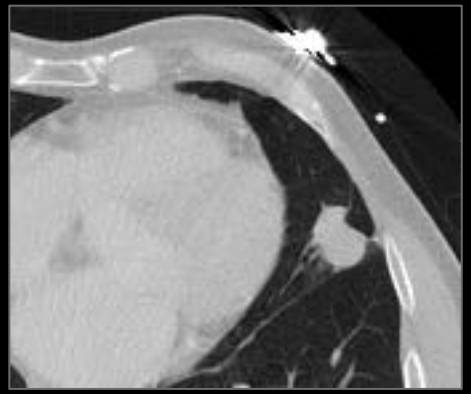
AVM



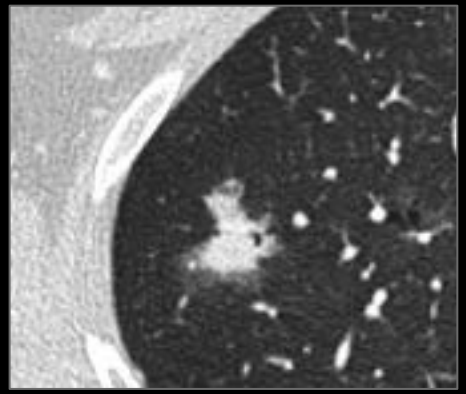
Hamartoma

Lobulation

- ‘Notch sign’
- Abrupt bulging of the lesion contour
- Relatively frequent in malignant nodules

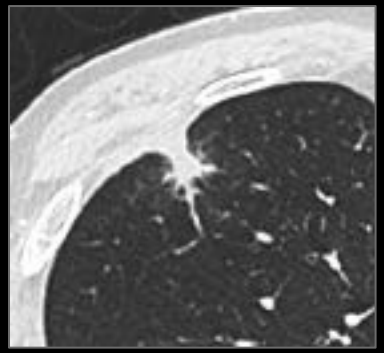


Large Cell Lung Cancer



Adenocarcinoma

Pleural retraction



Squamous cell CA

Adenocarcinoma

- Implies traction from the nodule
- Result from inward retraction and apposition of a thickened visceral pleura

- Typicall occurs in malignancy
- An inflammatory process can also cause contraction in the process of healing

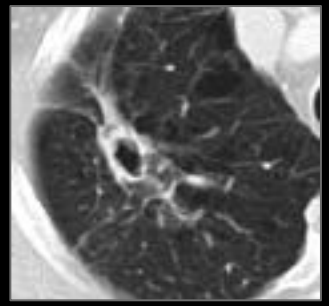
Pleural retraction

Adenocarcinoma

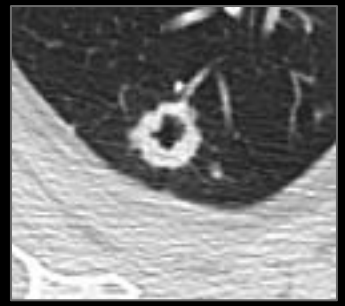
Adenocarcinoma

Cavitation

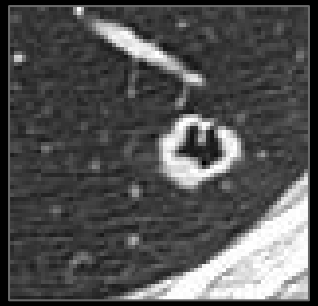
- Impossible to differentiate between benign and malignant
- Wall thickness is imperfect tool
- Malignant: squamous cell carcinoma
- Benign: tuberculosis, histoplasmosis, aspergillus, fungal, Wegener



Candida



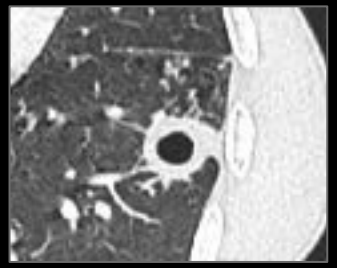
Aspergillus



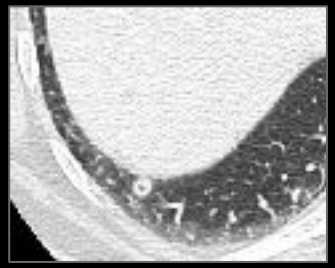
Squamous Ca

Squamous Ca

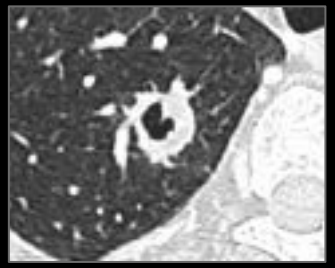
Gafoor et al. Chest 2018



Tuberculosis

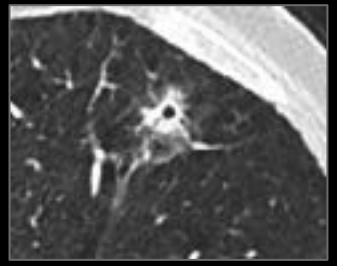


Wegener

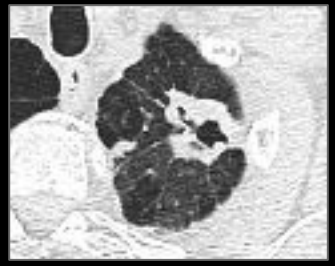


Aspergillus

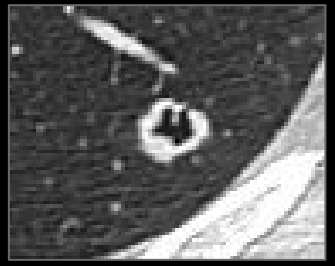
Squamous



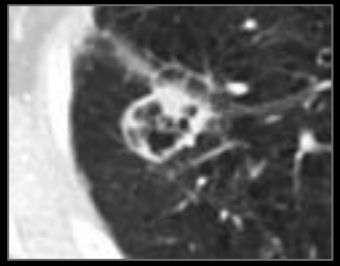
Aspergillus



Tuberculosis



Squamous



Aspergillus

Cavitary pulmonary nodules in a patient without neutropenia or evidence for other disease → histopathology

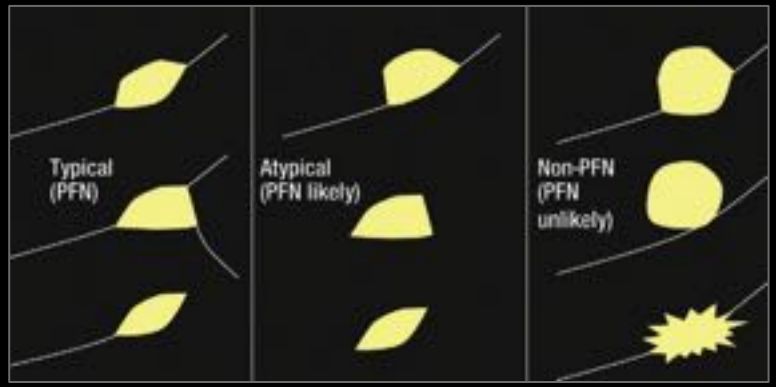
- Spiculation, lobulation, pleural indentation → malignancy
- Fat and popcorn calcifications → benign
- Primary lung cancers can calcify
- Cavitated nodules: histology

The present

‘Newer’ morphological features

Polygonal or triangular shape

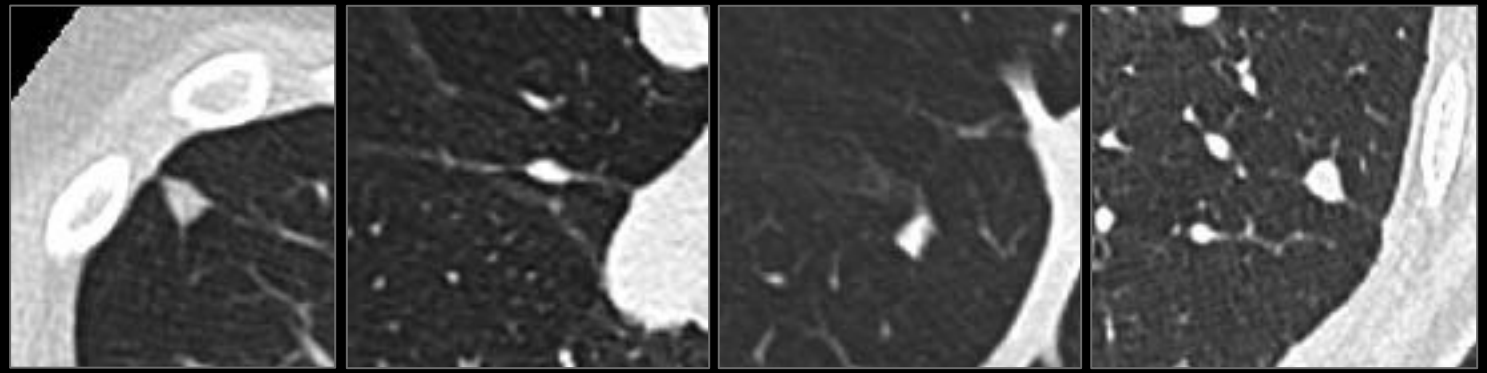
- Perifissural or juxtapleural location
- Perifissural nodules (PFNs)
- Nodules 3-9 mm in diameter
- Represent intrapulmonary lymph nodes
- Can be rapidly growing and have VDT as malignant nodules
- More often in lower part of the lungs



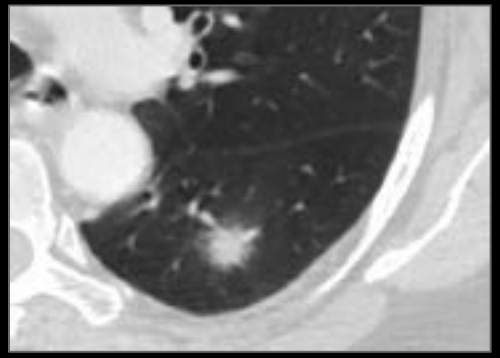
De Hoop et al.
Radiology 2012

Mets O et al. Eur Radiol 2018
Ahn MI et al. Radiology, 2010

Polygonal or triangular shape



Halo sign

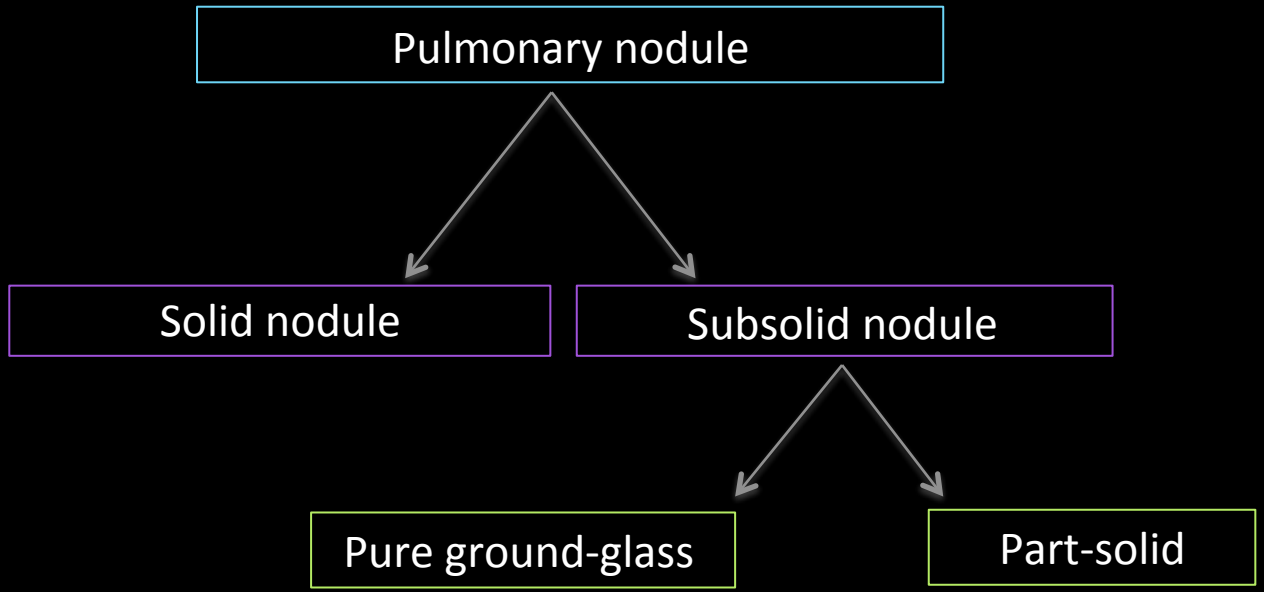


Aspergillus

- Poorly defined rim of ground glass around the nodule
- Ground glass: higher than normal parenchyma − lower than soft tissue
- Hemorraghe − perinodular inflammation - …
- Originally described in Aspergillosis

Ground glass

- Nodules with ground glass attenuation → SUBSOLID NODULES



Ground glass

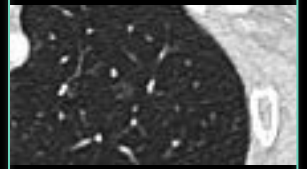
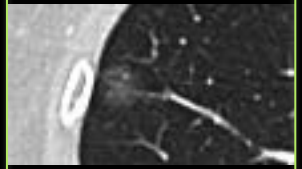
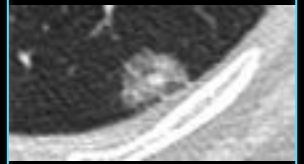
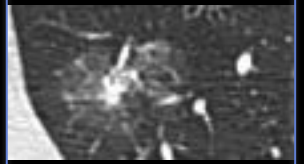
Ground glass → lepidic tumor growth

Persistent after 3 months of follow-up !

Initial Exam

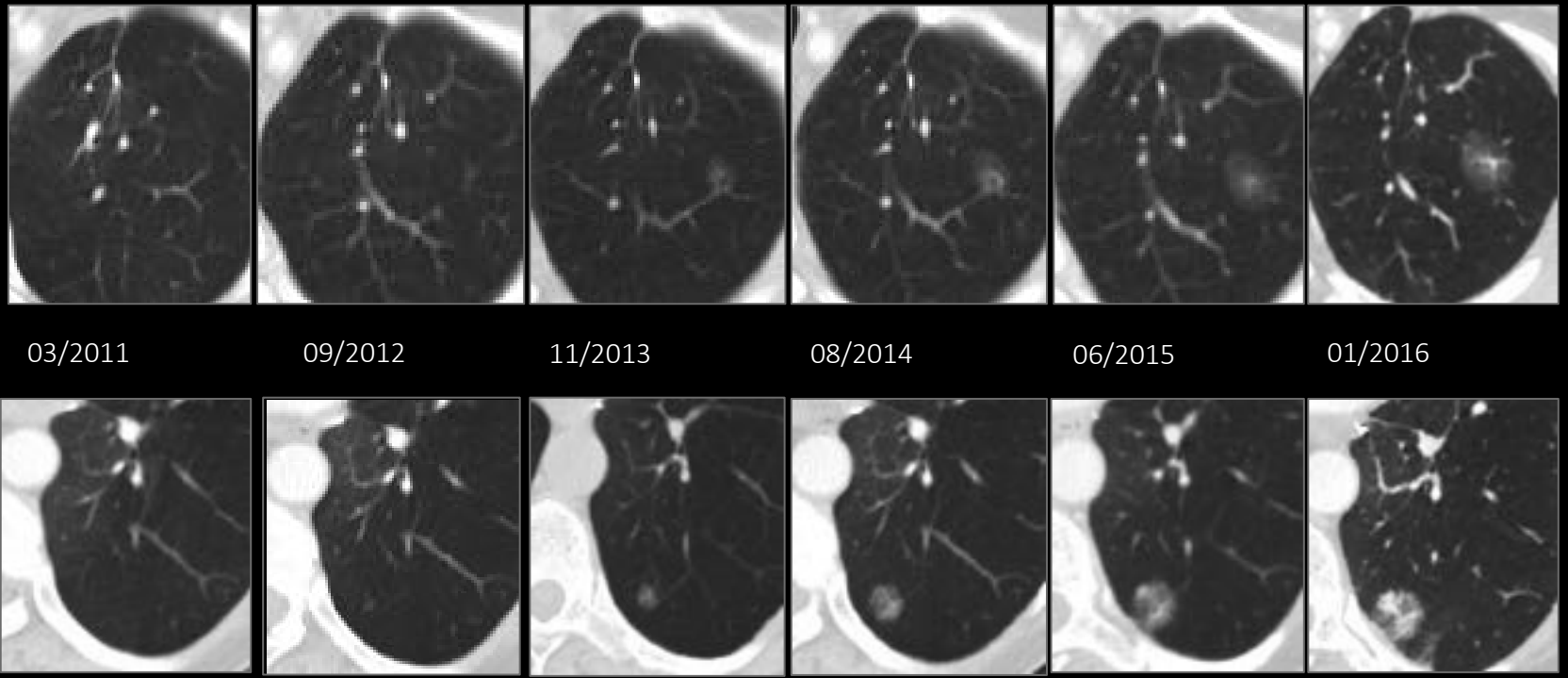
3 months later

Subsolid nodules

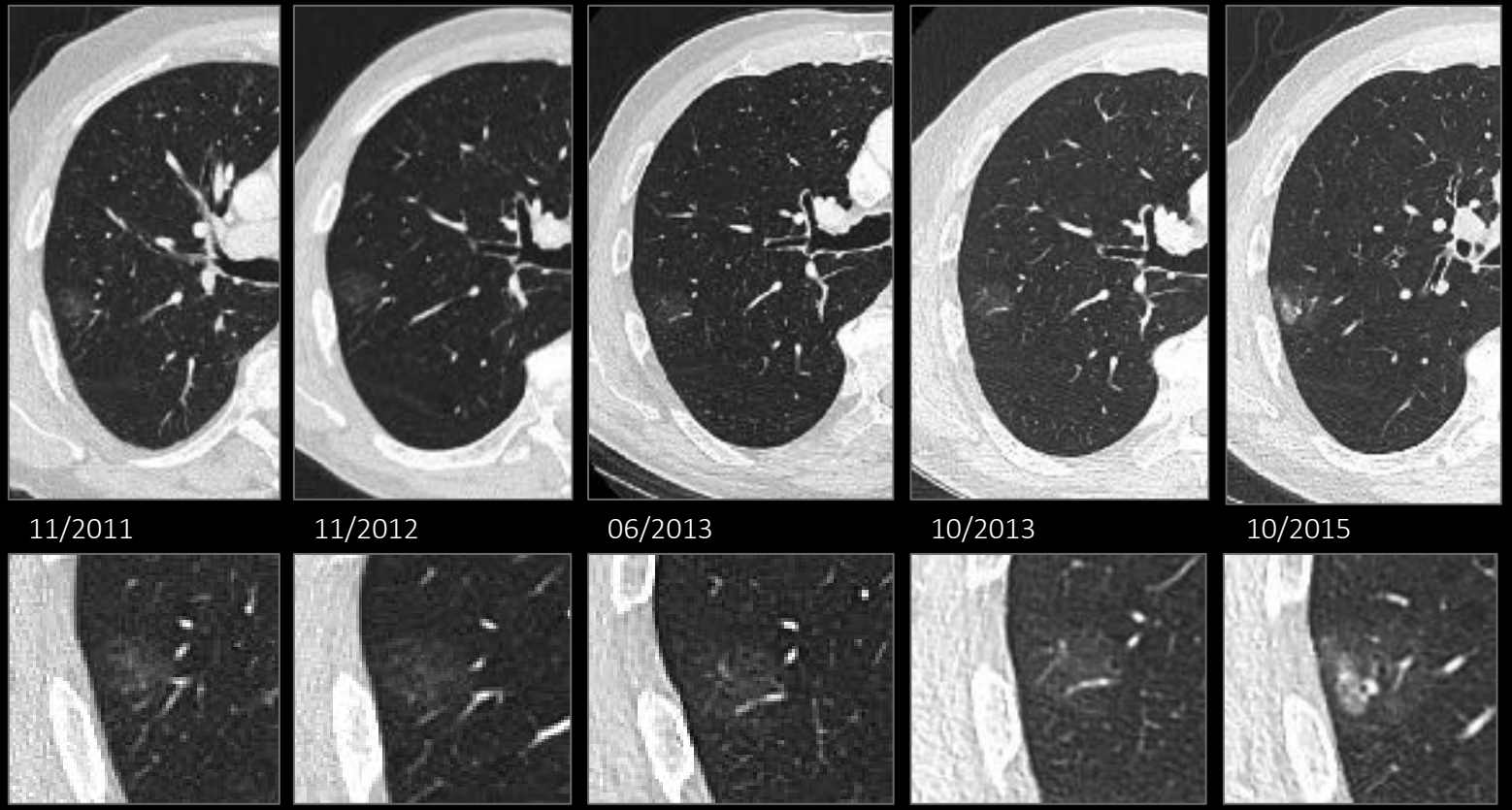
Atypical Adenomatous Hyperplasia	Adenocarinoma in situ	Minimally Invasive AdenoCA	Lepidic Predominant AdenoCA
			
≤ 5 mm Pure GGO	≤ 3 cm Pure GGO	≤ 3 cm GGO Solid component ≤ 5 mm	≤ 3 cm GGO Solid component > 5 mm
AAH	AIS	MIA	LPA

Spectrum of tumors with lepidic growth

Travis WD et al. JTO 2015



63-year-old woman
Previous history LUL adenoCA



71-year-old man
2011 adenoCA LUL – FU pure ground glass nodule RUL

3 Golden Rules for FU of Subsolid Nodules

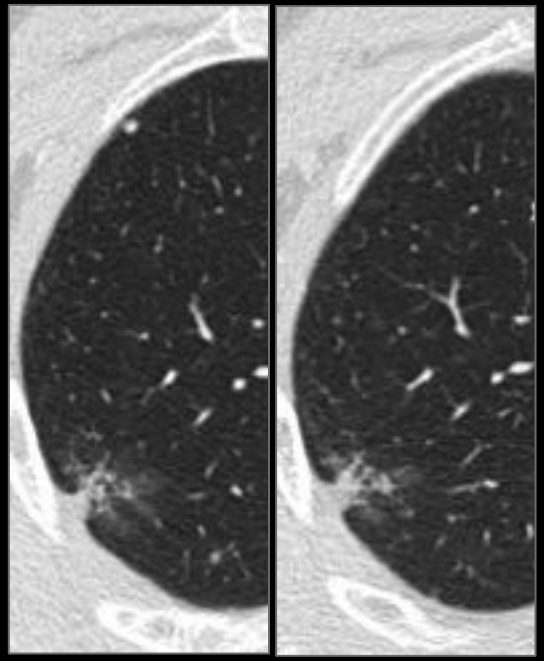
1. Consistency in CT technique − contiguous 1 mm thick sections

2. Morphology − detection of solid component

3. Always compare with the earliest available study!

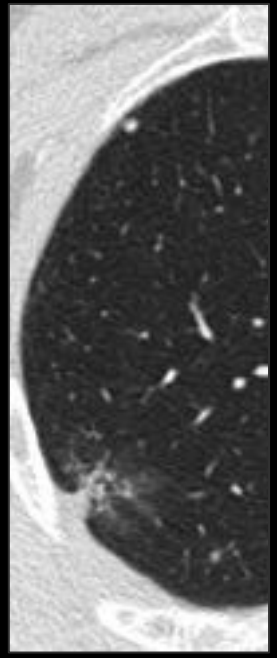
77-year-old man
Previous history 2006 invasive adenocarcinoma
FU lesion right lung

02/2006 01/2007



77-year-old man
Previous history 2006 invasive adenocarcinoma
FU lesion right lung

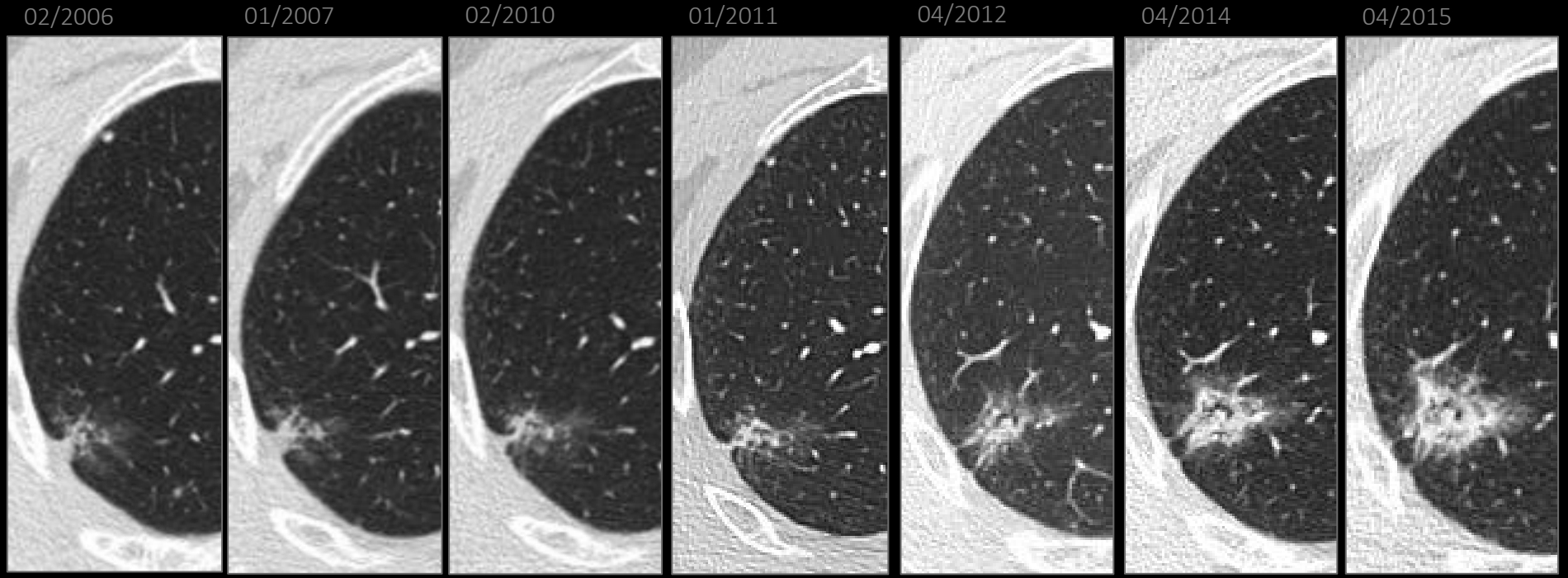
02/2006



04/2015

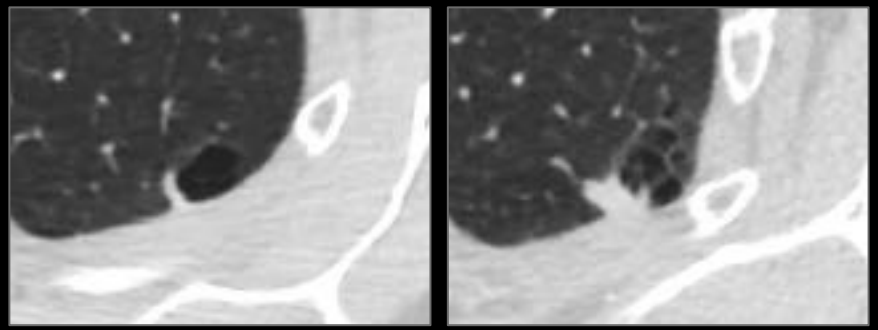
77-year-old man
Previous history 2006 invasive adenocarcinoma
FU lesion right lung

Moderately differentiated adenocarcinoma, acinar subtype



Cystic airspace

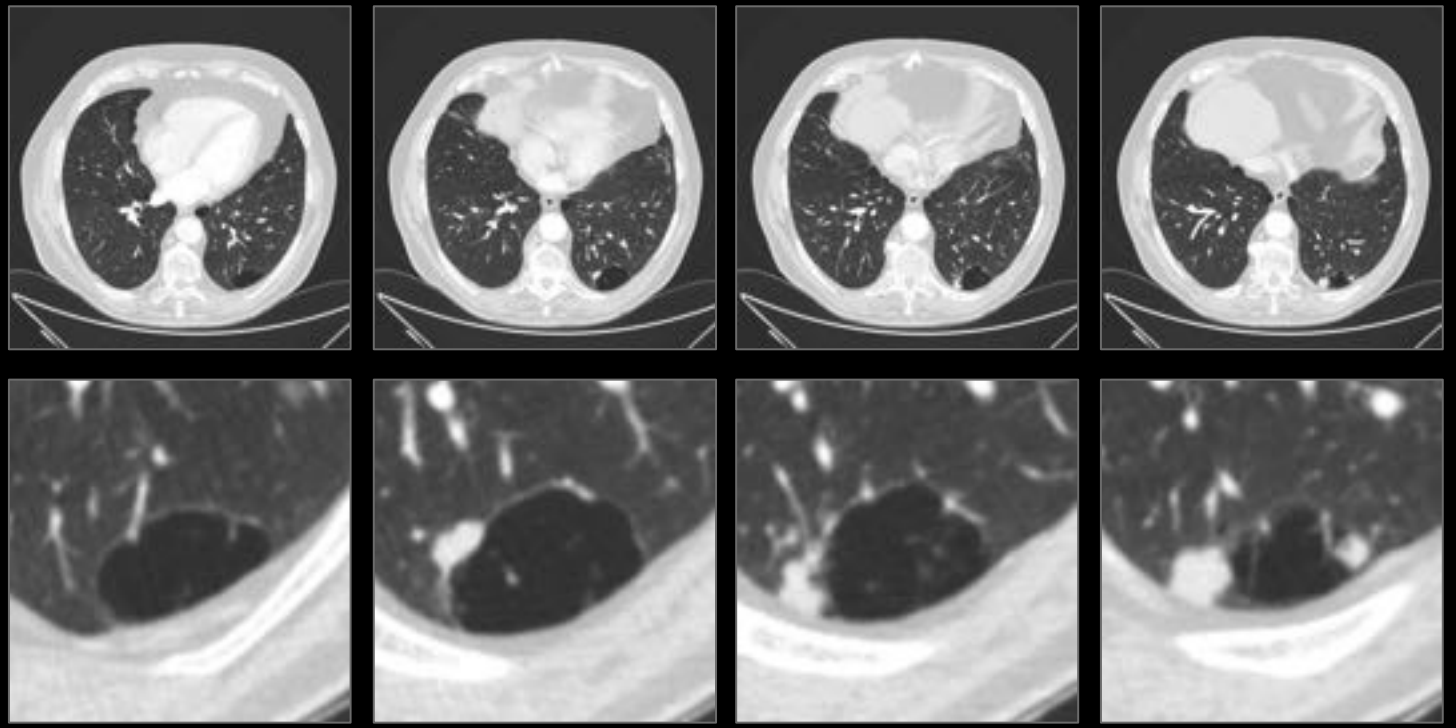
- Rare – more frequently encountered
- Lung cancer associated with cystic airspaces
- Nodule abutting the wall of a cystic airspace – focal wall thickening
- Cystic airspace: change in morphology, size, obliteration
- Adenocarcinoma and squamous cell carcinoma
- Check-valve mechanism involving the small airways → outflow obstruction



Adenocarcinoma

Farooqi et al. AJR 2012
Fintelmann FJ et al. J Thorac Imaging 2017
Mascalchi M et al. JCAT 2015

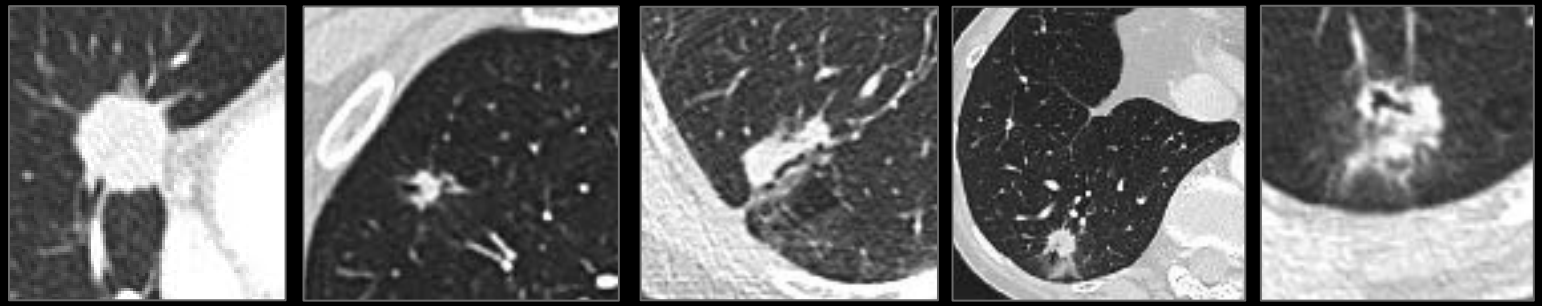
Cystic airspace



Adenocarcinoma

Air bronchogram

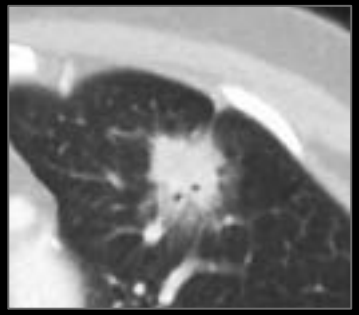
- Pattern of air-filled bronchi on a background of airless lung
- Different types
- Used to be associated with infectious causes of consolidation
- More frequent in malignant than benign nodules
- Tumours with lepidic growth - adenocarcinoma



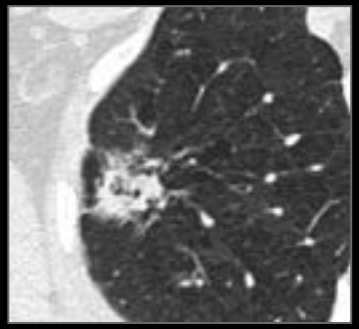
Adenocarcinoma

Dai J et al. Lung Cancer 2016

Bubble like lucencies



Adenocarcinoma

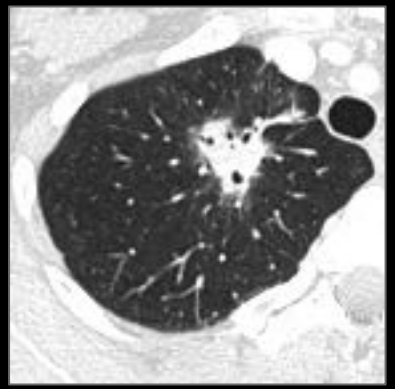


Adenocarcinoma

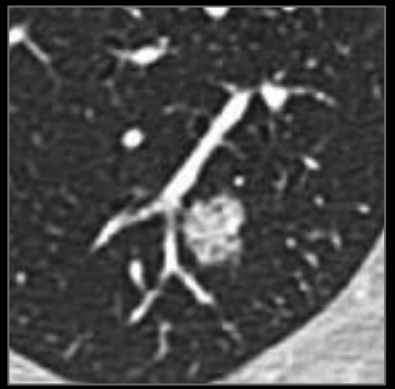
- ‘Pseudocavitation’
- Sign different from the airbronchogram = branch-like
- Areas of low attenuation
- Small patent air containing bronchi
- Highly suggestive of malignancy
- In subsolid nodules: suggests invasive adenoCA rather than preinvasive lesions

Nakazono T et al. Eur Radiol 2005
Kim TJ et al. Lung Cancer 2007

Bubble like lucencies



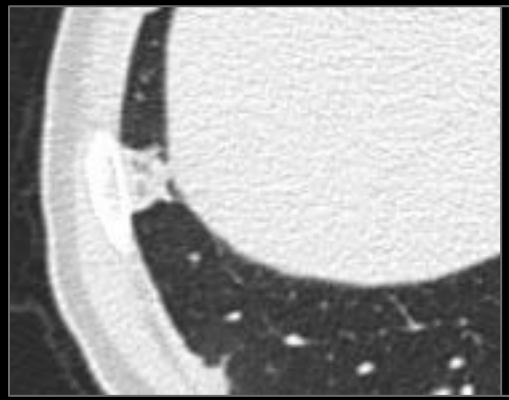
Adenocarcinoma

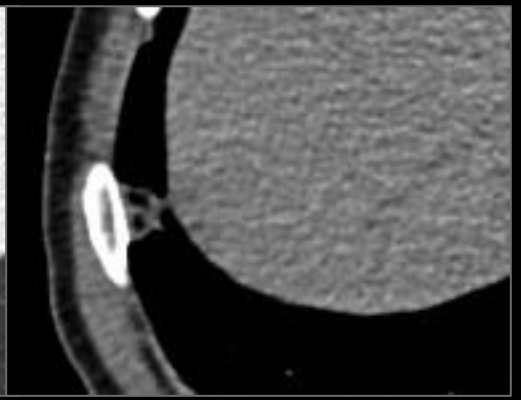


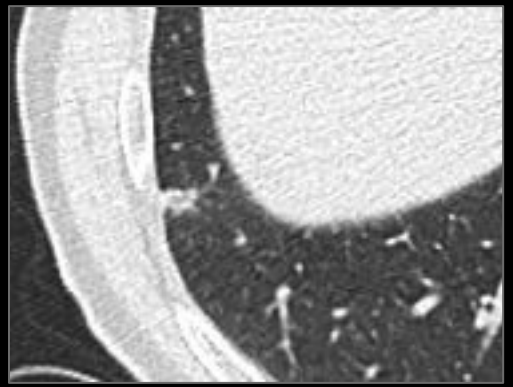
Adenocarcinoma

LCNEC

Mimicker







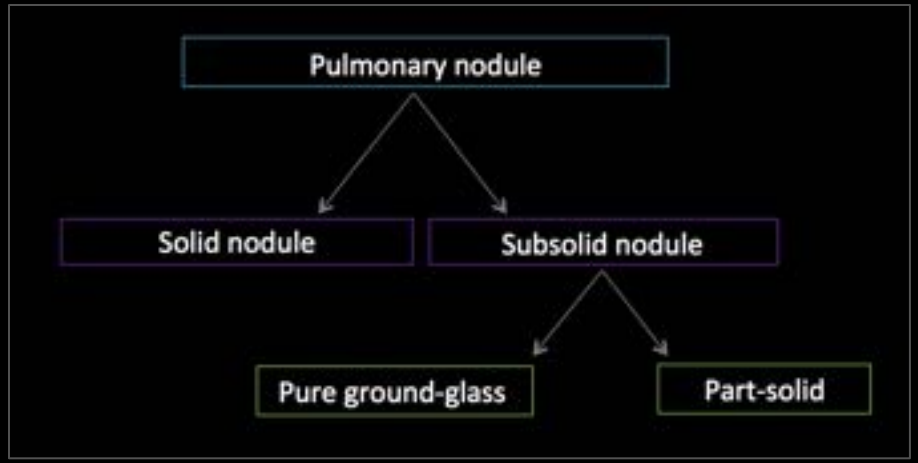
6 weeks later

- Recognition of typical PFN's is important
- Complex features → malignancy
- Air bronchogram is not a sign of benignity
- Cystic airspace: look at the wall
- Comparison with old images

The future

Room for improvement

Classification



Important for

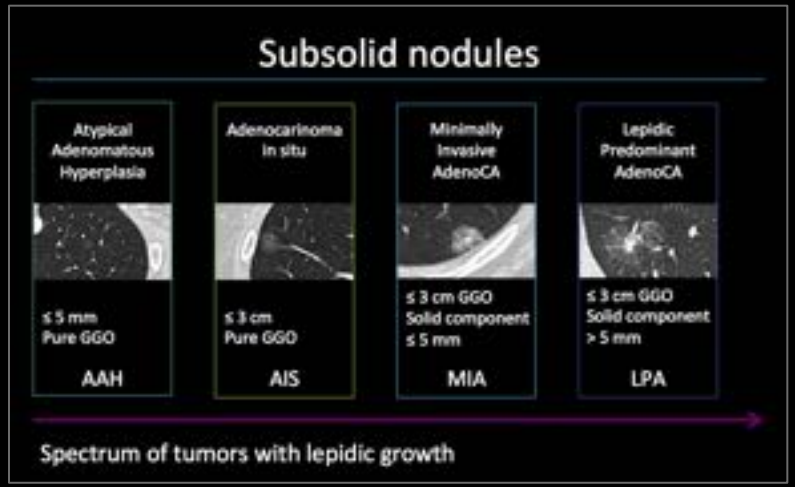
- Nodule management
- Likelihood of malignancy
- Prognosis

But…

- Moderate inter- and intra-observer agreement
- Size and presence of a solid component

Van Riel S. Et al. Radiology 2015
Penn A et al. Acta Radiol 2015
Ridge CA et al. Radiology 2015
Nair A et al. ERJ 2018

Rad-path correlation in subsolid nodules

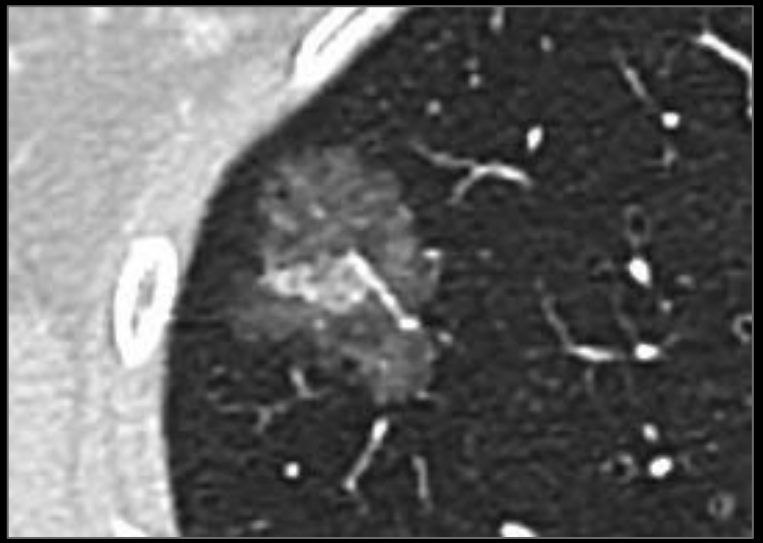


Assessment of invasiveness = key for management

Solid component defines invasiveness

Risk of overdiagnosis
Risk of underdiagnosis

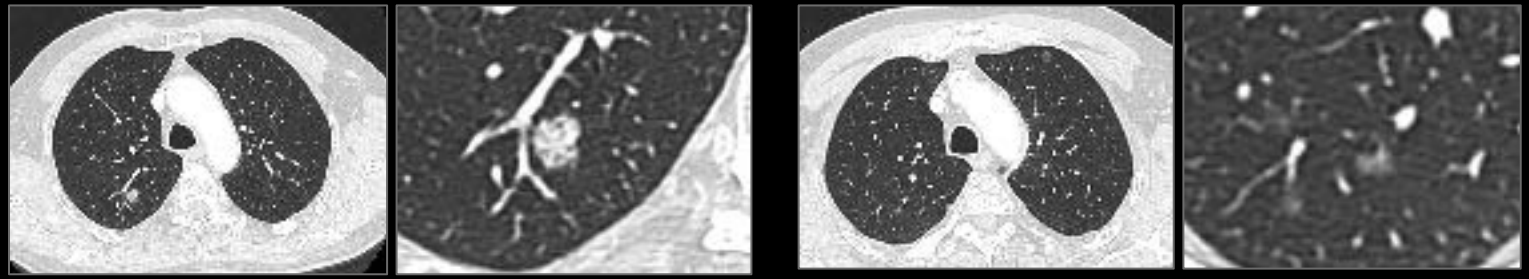
Rad-path correlation in subsolid nodules



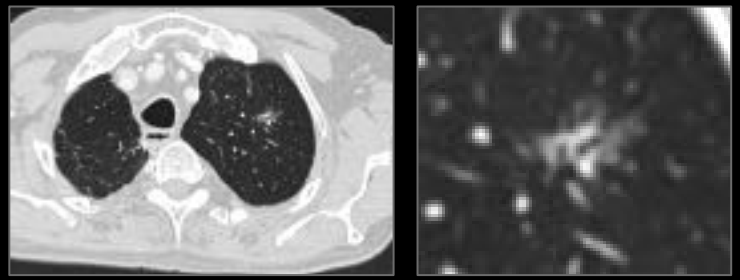
82-y-old woman – looks like an invasive adenocarcinoma
Pathology: MIA – invasive focus of 3 mm

Rad-path correlation in subsolid nodules

70-year-old man
2010 lepidic predominant adenocarcinoma and AAH



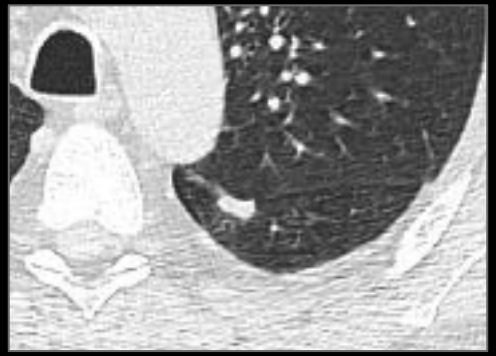
2014 New lesion - Looks like an invasive adenocarcinoma
Pathology: AIS

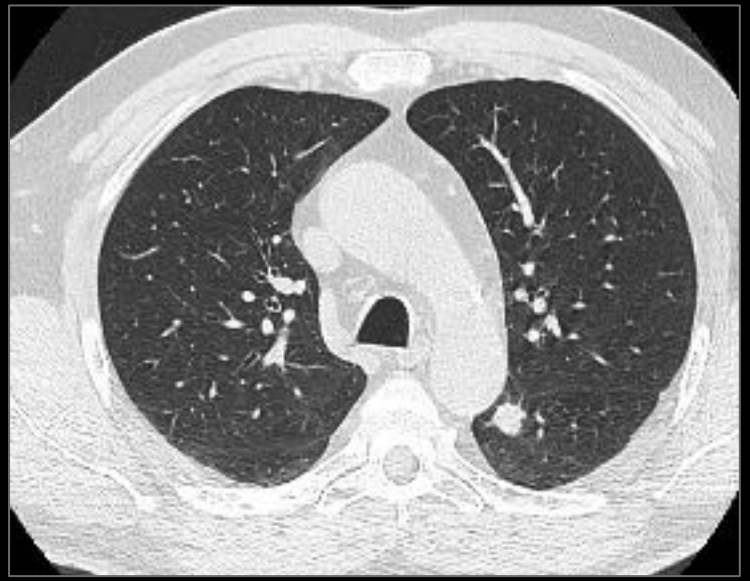


Rad-path correlation in subsolid nodules

63-year-old man
Solid nodule – no ground-glass component
PET-negative

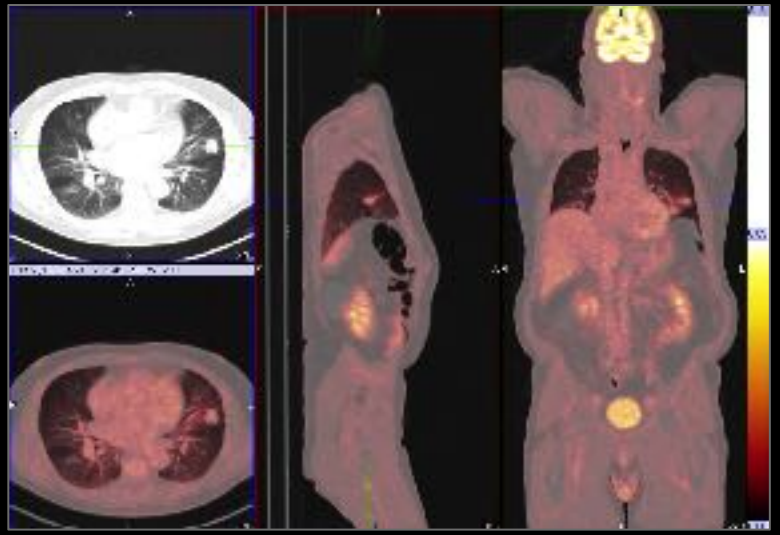
Lepidic Predominant AdenoCA





Rad-path correlation in subsolid nodules

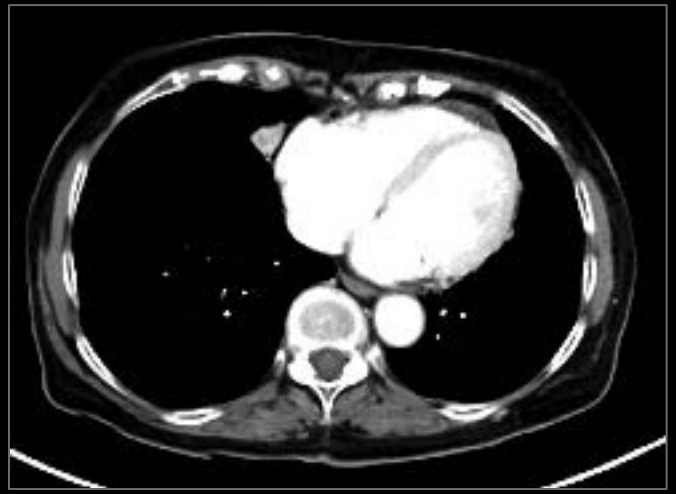
69-year-old man
No uptake on PET

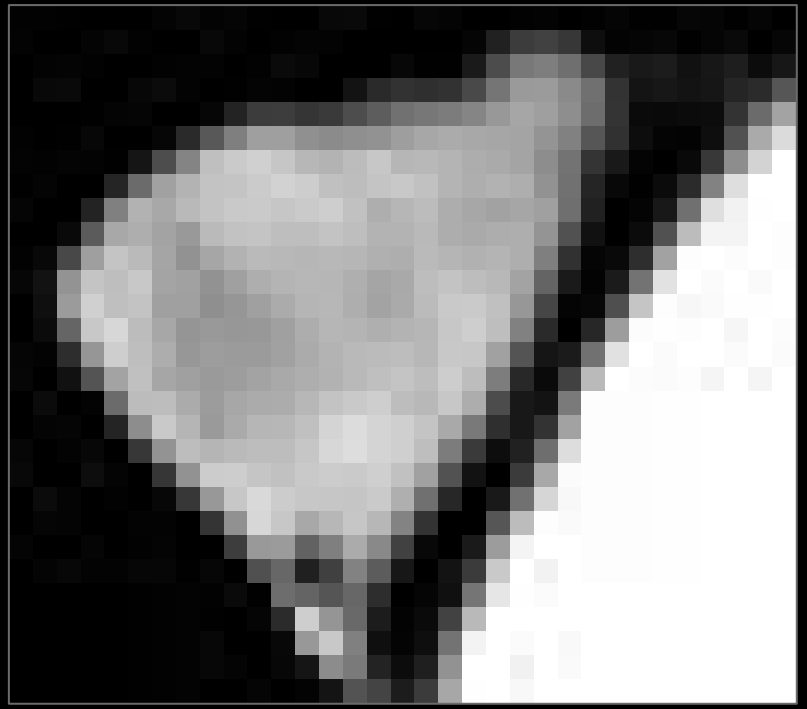


Lepidic predominant adenocarcinoma

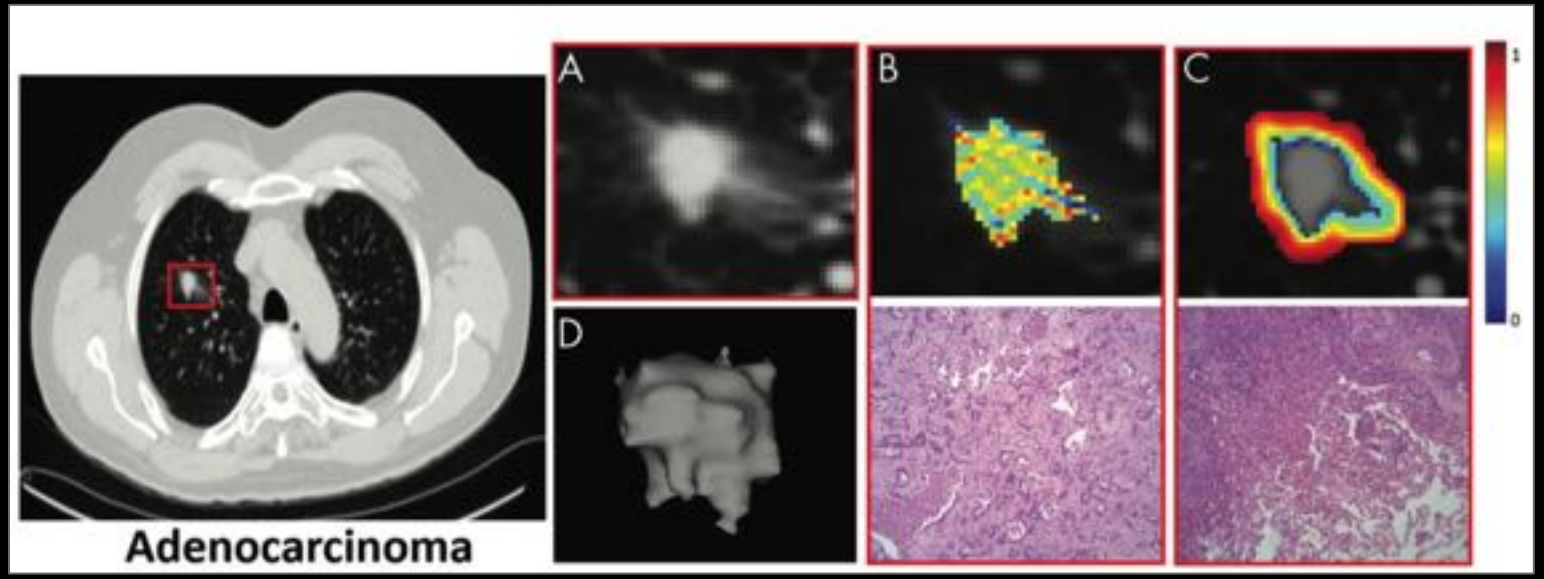
More than meets the eye…

‘Images are more than pictures, they are data’



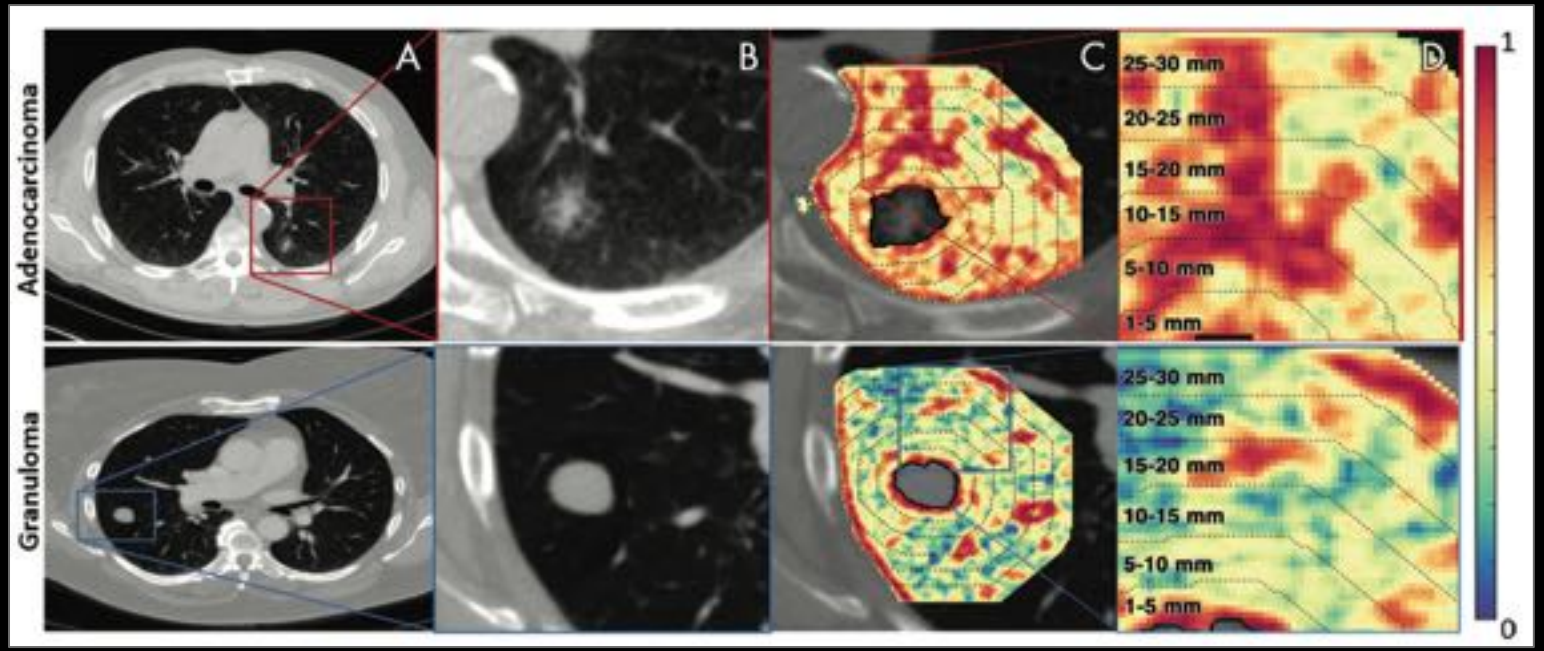


Radiomics



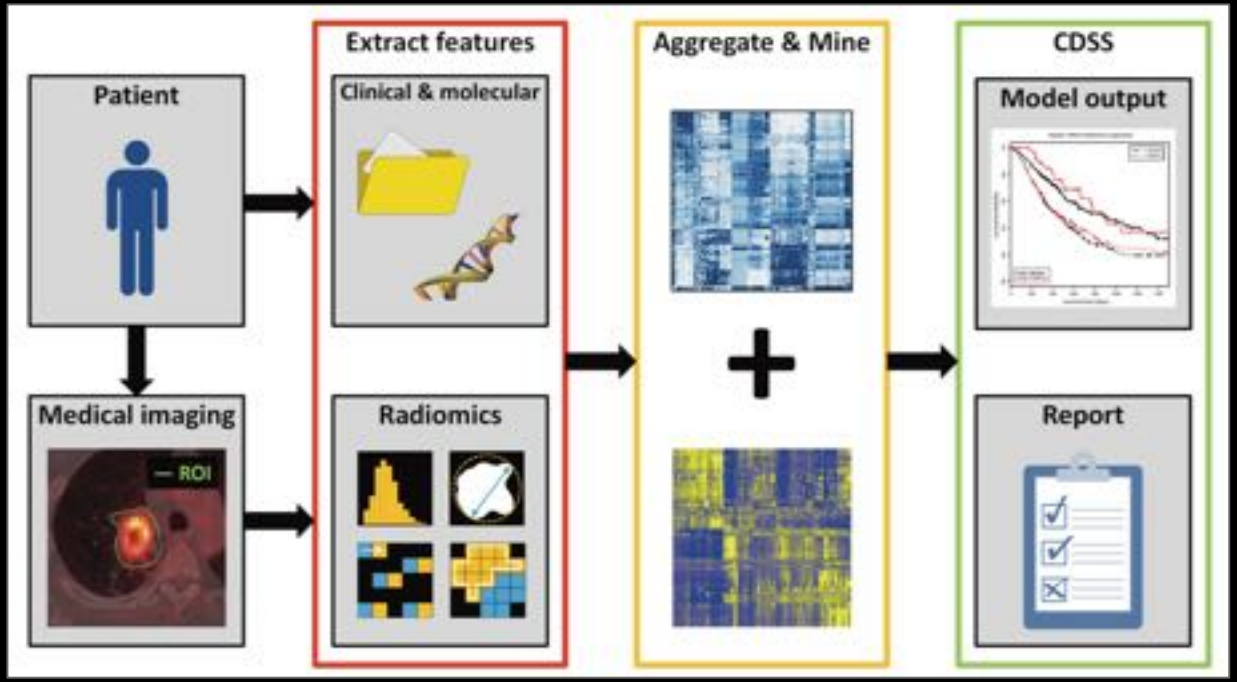
Beig et al. Radiology 2019

Radiomics



Beig et al. Radiology 2019

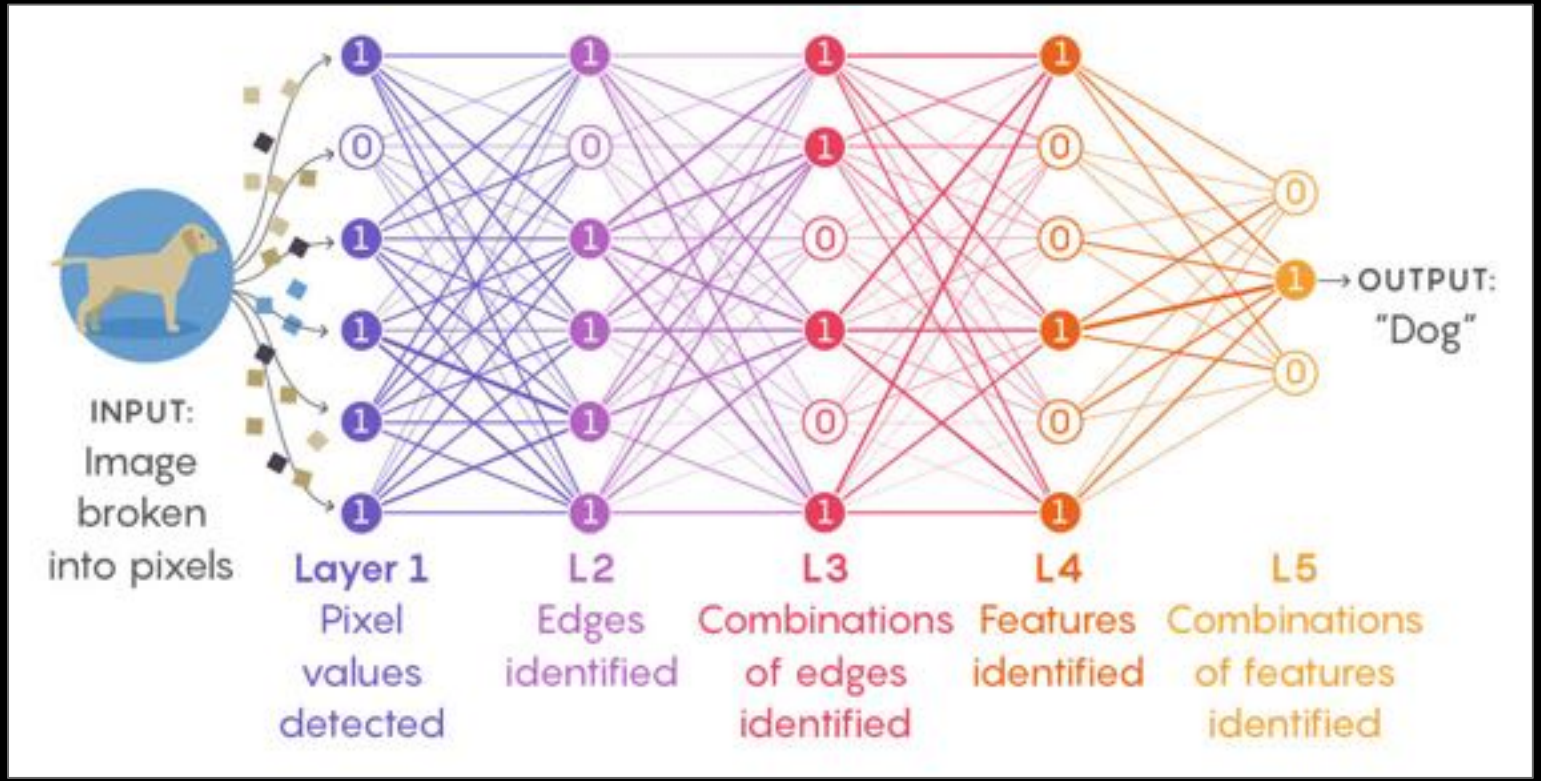
Radiomics



Scrivener et al. Transl Cancer Res 2016

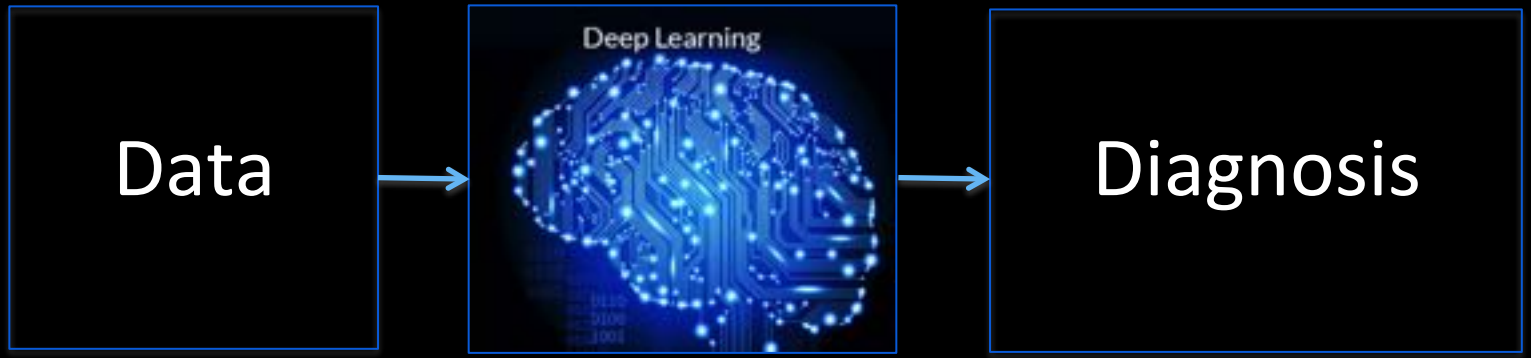
AI

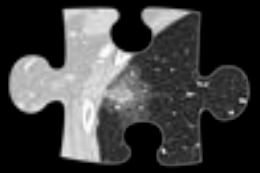
AI & Deep learning



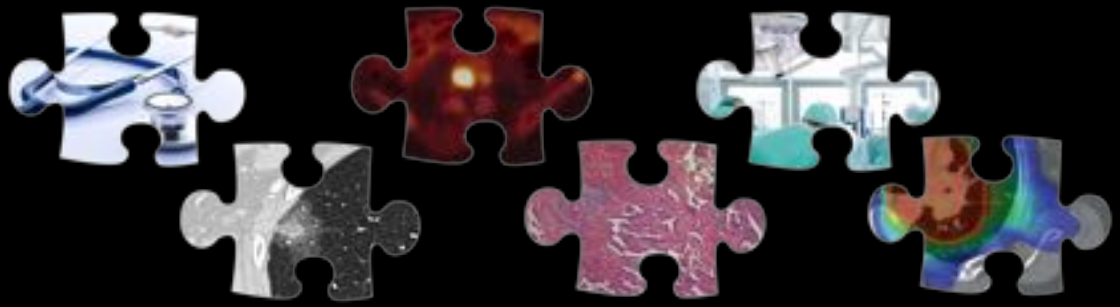
Source image: www.quantamagazine.org

Solutions





Morphological assessment of pulmonary nodules remains important



Multidisciplinary approach