



My background

- Middle sized hospital:
 - 57'000 x-ray
 - 27'500 CT

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Disclosures

- Head cardiac and thoracic imaging Kantonsspital Baden (KSB), CH
- Technology partnership KSB - Siemens
- Founder YourPersonalTutor.ch
- Speaker for Siemens

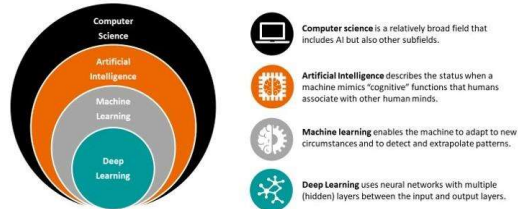
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Was ist AI in der Radiologie?



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Was ist AI allgemein?



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Was ist AI? – neural networks

the first thing to think about:

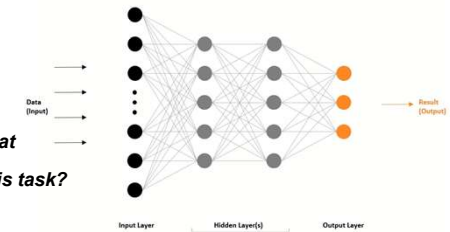
What task should the algorithm solve and what network structure will be most efficient for this task?

Neural networks are **inspired by the brain**.

As within the brain, they consist of **multiple layers**.

The **input layer** receives the data (such as a CT volume), while **hidden layers** extract characteristic data features, which are relevant for the specific diagnostic task and vary between various medical fields of application.

In a next step, the detection and expression of the features is being learned by the network to assess them and assign respective interpretation. To **train** this **neural network**, a large amount of data is needed to learn, for example, how to differentiate a lung nodule from a healthy lung. For the accuracy of the algorithm, it is important to have a good quality of the data to feed the algorithm, so for supervised learning for example, annotated data is needed.



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Introduction

Key AI trends in radiology:

- **informed decision making**
- **integrated diagnostics**
- **digital twins**

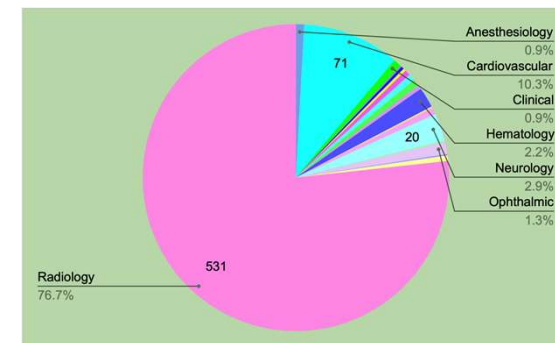
Radiology plays a major role in the digital transformation of healthcare.

AI holds a vast amount of potential to transform aspects of the healthcare industry, and is not something to fear, rather it is something to embrace.

AI in radiology can:

- enable you to respond to the **growing demands** for your diagnostic imaging services
- address potential **staff shortages**
- **enhance** your overall **imaging workflow**.

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FDA (2023) → 692 AI-enabled medical devices

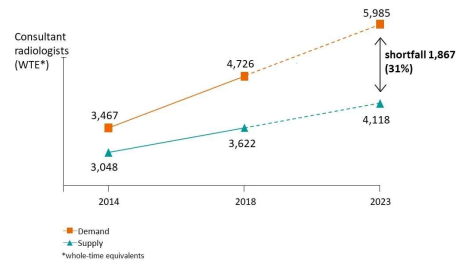
Zu 2022 → Anstieg von knapp +30%

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Why using AI in radiology?

Exponential growth of data from increase in radiology examinations.

While the number of examinations is skyrocketing, the number of radiologists is not keeping up with the trend.



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My personal motivation to use AI in radiology

- Cost reduction
- Increase of efficiency, higher sensitivity
- Reduction of bias/ misinterpretation/ errors

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Why using AI in radiology?

Increased risk of errors due to increased workload.

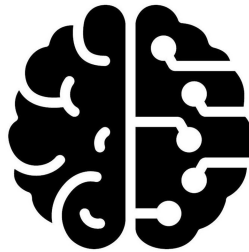
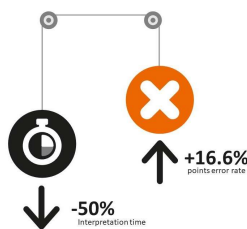
Cutting interpretation time by half may increase error rate by 16.6%.

Bsp. 15.06. 62'000 images

→ 104 images/ minute

→ 1.74 images/ second

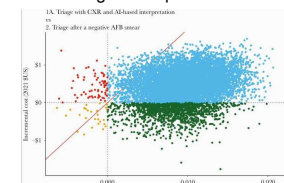
AI can help reduce workflow by doing monotonous tasks in less time



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My motivation to use AI assisted chest x-ray interpretation

- Cost reduction
- AI-based CXR triage in TB patients can reduce costs.



Nsengiyumva NP et al. Triage of Persons With Tuberculosis Symptoms Using Artificial Intelligence-Based Chest Radiograph Interpretation: A Cost-Effectiveness Analysis. Open Forum Infect Dis. 2021 Dec 15;8(12):ofab567. doi: 10.1093/ofid/ofab567.

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My motivation to use AI assisted chest x-ray interpretation

- Cost reduction
 - With the available evidence, it is not possible to assess the clinical and cost benefits or risks of using the technology in the NHS.
- Potential benefits:
 - Reduction in time for reporting
 - Improved workflow
 - Higher sensitivity but potentially lower specificity

NICE National Institute for Health and Care Excellence

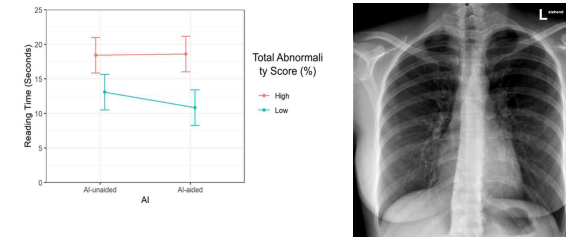


National Institute for Health and Care Excellence (NICE) (2023) Artificial intelligence-derived software to analyse chest X-rays for suspected lung cancer in primary care referrals: early value assessment.

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My motivation to use AI assisted chest x-ray interpretation

- Increase of efficiency
 - Overall reading times shortened when radiologists referred to AI. However, abnormalities detected by AI could lengthen reading times.

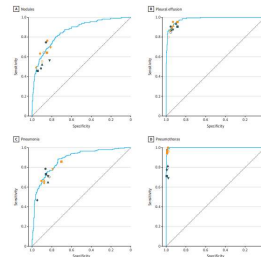


Shin HJ et al. The impact of artificial intelligence on the reading times of radiologists for chest radiographs. NPJ Digit Med. 2023 Apr 29;6(1):82. doi: 10.1038/s41746-023-00829-4.

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My motivation to use AI assisted chest x-ray interpretation

- Increase of efficiency
 - improved reader performance and efficiency for identifying major thoracic findings on a chest radiography.

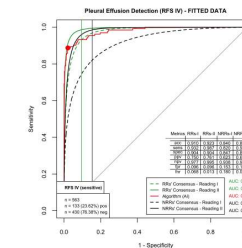


Ahn JS et al. Association of Artificial Intelligence-Aided Chest Radiograph Interpretation With Reader Performance and Efficiency. JAMA Netw Open. 2022;5(8):e2229289. doi:10.1001/jamanetworkopen.2022.29289

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My motivation to use AI assisted chest x-ray interpretation

- Increase of efficiency
 - In an EU setting without 24/7 radiology coverage, AI may be an excellent clinical support tool to non-radiologists, similar to a second reader, and allows for a more accurate primary diagnosis and thus earlier therapy initiation.



Rudolph J et al. Non-radiology Healthcare Professionals Significantly Benefit from AI-Assistance in Emergency-Related Chest Radiography Interpretation. Chest. 2024 Jan 29:S0012-3692(24)00131-4. doi: 10.1016/j.chest.2024.01.039.

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[illegible][illegible]

Unpublished data

size	density	TP	FP	FN	TN	FPR	sens	spec	ACC
3	1	0	9	0	30	0.23	0	0.77	0.77
	2	0	12	0	30	0.29	0	0.71	0.71
	3	0	7	0	30	0.19	0	0.81	0.81
	all	0	28	0	90	0.24	0	0.763	0.763
5	1	0	3	0	30	0.09	0	0.91	0.91
	2	0	0	0	30	0	0	1	1
	3	0	5	0	30	0.14	0	0.86	0.86
	all	0	8	0	90	0.08	0	0.918	0.918
8	1	29	0	1	0	0	0.97	0	0.97
	2	0	7	0	30	0.19	0	0.81	0.81
	3	0	6	0	30	0.17	0	0.83	0.83
	all	29	13	1	60	0.18	0.97	0.822	0.864
10	1	29	5	1	0	1	0.97	0	0.83
	2	1	6	0	29	0.17	1	0.83	0.83
	3	0	5	0	30	0.14	0	0.86	0.86
	all	30	16	1	59	0.21	0.97	0.787	0.840
12	1	30	7	0	0	1	1	0	0.51
	2	0	2	0	30	0.06	0	0.94	0.94
	3	0	9	0	30	0.23	0	0.77	0.77
	all	30	18	0	60	0.23	1	0.769	0.833
all	1	88	24	2	60	0.29	1	0.71	0.85
	2	1	27	0	149	0.15	1	0.85	0.85
	3	0	32	0	150	0.18	1	0.82	0.82
	all	89	83	2	359	0.19	1	0.812	0.841


























































My motivation to use AI assisted chest x-ray interpretation

- Reduction of bias/ interpretation errors
- Type 2 thinking is an analytical, slow, deliberate, and effortful approach to decision making

The diagram illustrates the thought processes for chest x-ray interpretation. It starts with an 'Image to report requires thought processes:' leading to a brain scan image. A vertical box labeled 'Find the abnormality Normal vs abnormal' is connected to the image. This leads to a large arrow labeled 'PROCESS' which splits into two paths: 'TYPE 1 THINKING' and 'TYPE 2 THINKING'. The 'TYPE 1 THINKING' path includes a box 'GENERATE HYPOTHESES' and a sub-box 'Use heuristics to generate likely Dx'. The 'TYPE 2 THINKING' path includes a box 'INTERPRET DATA' and a sub-box 'Reconsider in light of history, other tests...'. Both paths lead to a final box 'VERIFY'. To the right, a sample radiology report is shown, detailing findings and recommendations.

Image to report requires thought processes:

Find the abnormality Normal vs abnormal

PROCESS

TYPE 1 THINKING

GENERATE HYPOTHESES

Use heuristics to generate likely Dx

TYPE 2 THINKING

INTERPRET DATA

Reconsider in light of history, other tests...

VERIFY

STOP or look for more evidence, Occam's razor

Sample Radiology Report

CLINICAL HISTORY: 65-year-old male with chronic obstructive pulmonary disease (COPD) and a long history of smoking. He presents with a 2-week history of cough and sputum production, which has worsened in the last few days. He also reports shortness of breath and chest pain. He has no fever, chills, or night sweats. He is on long-term inhalers and has no recent travel or contact with sick individuals.

PHYSICAL EXAMINATION: Vitals are stable. Lung exam shows hyperinflation with decreased breath sounds and hyperresonance on percussion. There is no crackles, wheezes, or rhales. Cardiac exam is normal. Abdominal exam is unremarkable. Neurological exam is intact.

RADIOLOGY FINDINGS: The chest x-ray shows hyperinflation of the lungs with flattened diaphragms. There is no evidence of consolidation, pleural effusion, or pneumothorax. The heart size is within normal limits. The bony structures are unremarkable.

IMPRESSION: Hyperinflated lungs consistent with COPD. No acute pulmonary pathology identified.

RECOMMENDATIONS: Continue medical management for COPD. Consider further evaluation if symptoms persist or worsen.

CLINICAL CORRELATION: The radiology findings are consistent with the clinical history and physical exam. The hyperinflation of the lungs is a common finding in patients with COPD. The absence of consolidation or pleural effusion is reassuring.

CLINICAL ACTION: The patient's symptoms are likely related to his underlying COPD. He should continue with his inhaler therapy and follow up with his primary care physician if symptoms persist.

CLINICAL OUTCOME: The patient's symptoms improved after a short course of oral corticosteroids. He was discharged home on his regular inhalers and a follow-up appointment was scheduled for two weeks later.

CLINICAL LESSONS: This case highlights the importance of a thorough clinical history and physical exam in the evaluation of patients with respiratory symptoms. A chest x-ray can be helpful in identifying underlying lung pathology, but it is not always definitive. Clinical correlation is essential for accurate diagnosis and management.

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CLINICAL DISCUSSION: This case illustrates the importance of a thorough clinical history and physical exam in the evaluation of patients with respiratory symptoms. A chest x-ray can be helpful in identifying underlying lung pathology, but it is not always definitive. Clinical correlation is essential for accurate diagnosis and management. The patient's symptoms improved after a short course of oral corticosteroids, which is consistent with the diagnosis of COPD. The hyperinflation of the lungs seen on the chest x-ray is a common finding in patients with COPD. The absence of consolidation or pleural effusion is reassuring. The patient's symptoms are likely related to his underlying COPD. He should continue with his inhaler therapy and follow up with his primary care physician if symptoms persist.

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bias

Table 2: Types of Cognitive Biases		
Cognitive Bias	Definition	Strategies to Counteract Bias
Anchoring bias	Failing to adjust an initial impression, despite receiving additional information	Gather all available clinical data before making a diagnosis, seek to disprove one's initial diagnosis, and seek a second opinion
Confirmation bias	Searching for data to reaffirm an existing hypothesis	Reexamine and seek new evidence, particularly that which supports alternate hypotheses Be conscious of the psychological impact of retracting an initial diagnosis
Availability bias	Judging the probability of an event by the ease with which it comes to mind	Use objective data on the base rates of disease to correlate with one's own rates of diagnosis, and create a differential diagnosis
Satisfaction of report	Perpetuating an impression from a prior report	Review the examination and generate an impression before reviewing the prior report, and consider a second opinion
Framing bias	Drawing different conclusions from the same information, depending on how the information is presented	Consider other organ systems or causes Read an image first while the clinical history and the side of concern are masked, and then review the history Review the patient's chart if the provided history substantially impacts the diagnosis
Attribution bias	Attributing findings to patient characteristics or stereotypes	Be aware of this bias Read an image first while the clinical history is masked, and then review the history Review the patient's chart if the demographic information impacts how the diagnosis is formulated
Satisfaction of search	Decreasing vigilance and/or awareness for additional abnormalities after differentiating the first abnormality	Use a systematic or checklist approach, particularly for common and commonly missed diagnoses Initiate a secondary search after differentiating the first finding Remain aware of related diagnoses and common diagnostic combinations
Premature closure	Accepting a preliminary diagnosis as final	Keep an open mind when formulating a working diagnosis, and generate a differential diagnosis
Inattentional bias	Missing findings hiding in plain sight due to unsuspected location or name	Know one's own blind spots, and always step back to look at the big picture
Hindsight bias	Retrospectively de-emphasizing the difficulty in making the initial diagnosis	Do not lose confidence or become overconfident as a result of retrospective analysis, and try to understand a colleague's perspective

Busby LP, Courtier JL, Glastonbury CM. Bias in Radiology: The How and Why of Misses and Misinterpretations. Radiographics. 2018 Jan-Feb;38(1):236-247. doi: 10.1148/rng.2018170107. PMID: 29194009

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bias

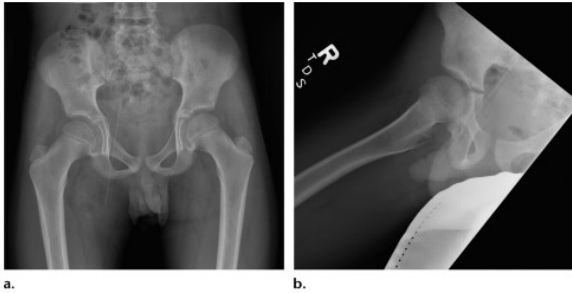


Figure 7. Inattentional blindness and hindsight bias. A child presented to the emergency department with a limp and denied a history of trauma. (a, b) Frontal (a) and right frog-leg lateral (b) radiographs show a normal pelvis and right hip, as interpreted by the radiologist.

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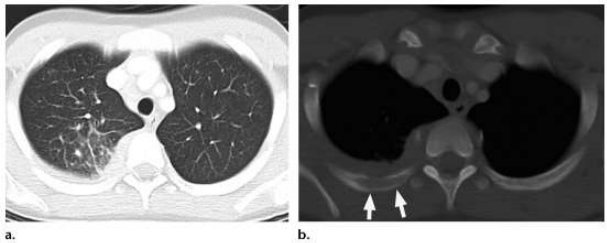


Figure 6. Satisfaction of search compounded by premature closure. A 17-year-old boy presented with fever of unknown origin. (a) Axial nonenhanced CT image of the chest demonstrated pneumonia in the posterior segment of the right upper lobe. Antibiotic therapy was started, but the fever persisted. Images were further reviewed at the referred institution. (b) Axial nonenhanced CT image (bone window) shows cortical rib erosions (arrows). Tuberculosis with rib involvement was diagnosed. In this case, the secondary rib findings were missed after the pulmonary findings were identified. In addition, the initial diagnostic evaluation did not consider tuberculosis, although it should have been included as a differential diagnosis for the pulmonary findings.

Busby LP, Courtier JL, Glastonbury CM. Bias in Radiology: The How and Why of Misses and Misinterpretations. Radiographics. 2018 Jan-Feb;38(1):236-247. doi: 10.1148/rng.2018170107. PMID: 29194009

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bias



Figure 7. Inattentional blindness and hindsight bias. A child presented to the emergency department with a limp and denied a history of trauma. (a, b) Frontal (a) and right frog-leg lateral (b) radiographs show a normal pelvis and right hip, as interpreted by the radiologist. (c, d) Axial (c) and coronal (d) nonenhanced CT images of the pelvis show a pencil (arrows), which was present due to self-inflicted trauma. This finding was outside the traditional search pattern and demonstrates inattentional bias during radiographic review. The radiologist interpreting the CT images (c, d) could not believe the finding was missed during the initial review, which is an example of hindsight bias.

Busby LP, Courtier JL, Glastonbury CM. Bias in Radiology: The How and Why of Misses and Misinterpretations. Radiographics. 2018 Jan-Feb;38(1):236-247. doi: 10.1148/rng.2018170107. PMID: 29194009

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My motivation to use AI assisted chest x-ray interpretation

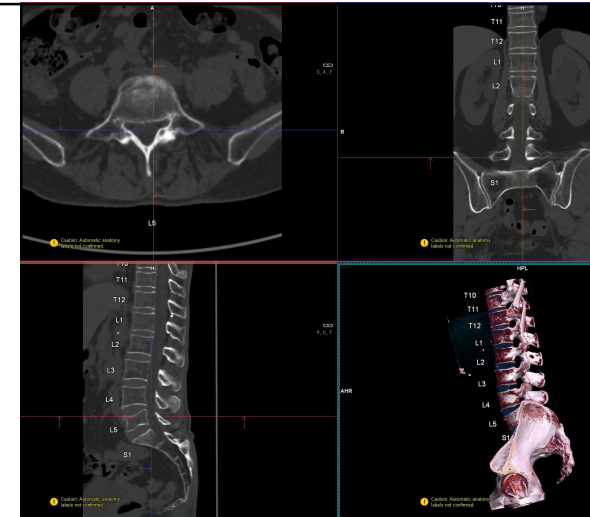
- Reduction of bias/ interpretation errors
- The report draws attention to the utility of AI clinical decision-support tools in overcoming human cognitive biases.
- We should envision AI as a powerful ally to augment and support clinicians rather than a replacement.



Brown C, Nazeer R, Gibbs A, Le Page P, Mitchell AR. Breaking Bias: The Role of Artificial Intelligence in Improving Clinical Decision-Making. Cureus. 2023 Mar 20;15(3):e36415. doi: 10.7759/cureus.36415. PMID: 37090406

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Clinical examples Fracture?



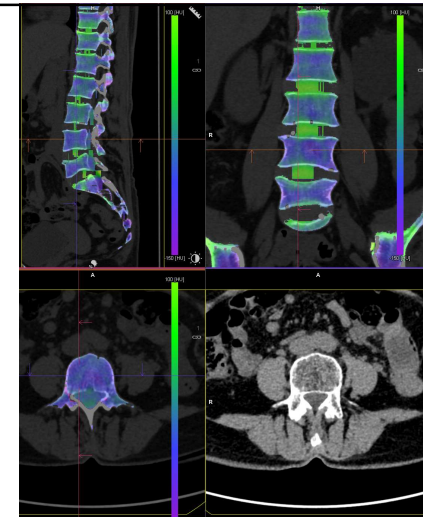
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Clinical examples Fracture?



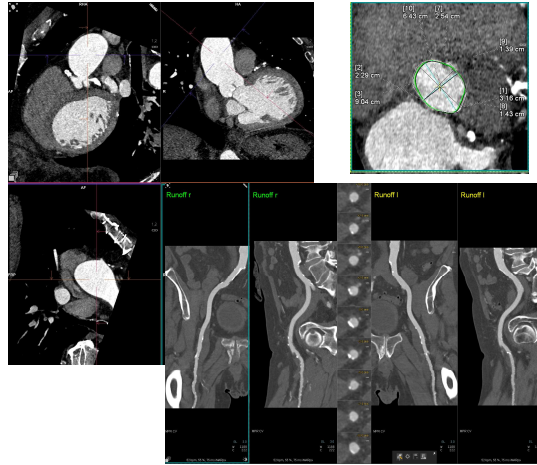
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Clinical examples Fracture?



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Clinical examples complex measurements, e.g. TAVI



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White paper

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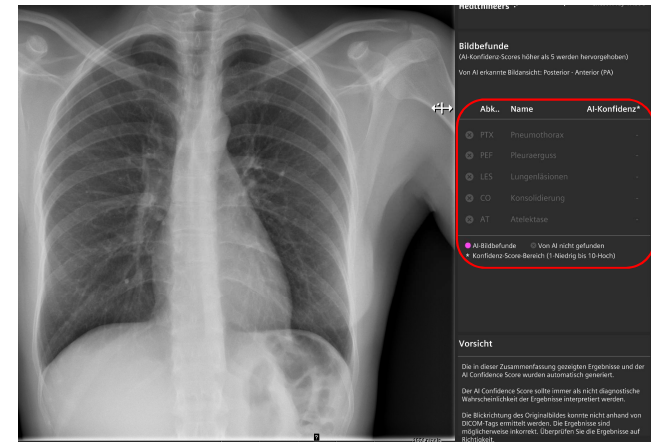


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André Euler, MD, MHBA, EBCR
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Prof. Tilo Niemann, EBCR, MHBA

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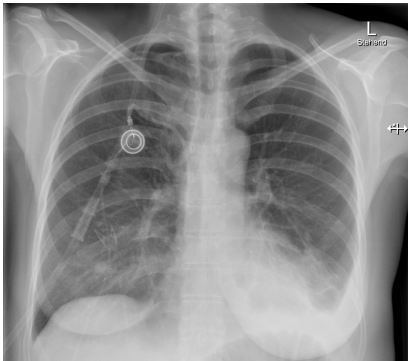
AI-Rad Companion Chest X-ray



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Clinical examples 2

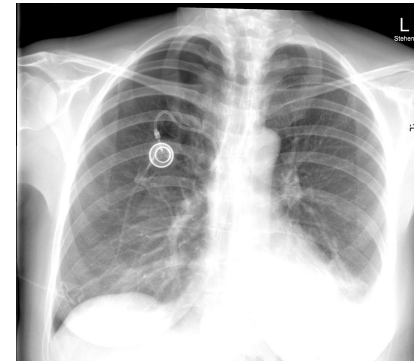
Pneumothorax



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Clinical examples 2

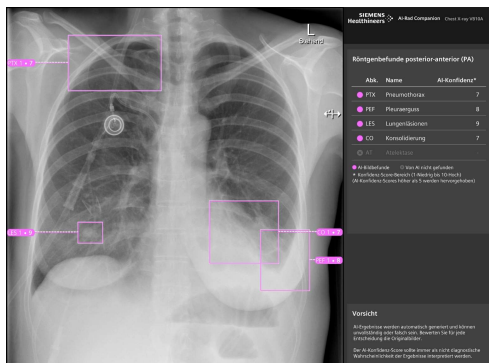
Pneumothorax



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Clinical examples 2

Pneumothorax

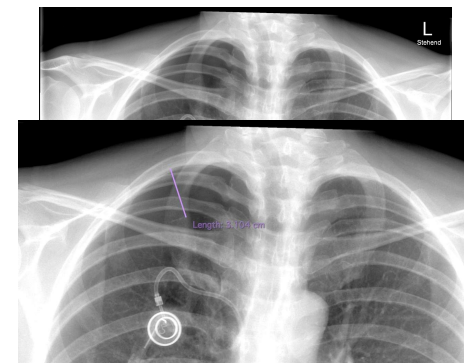


AI-Rad Companion Chest X-Ray is not commercially available in all countries. Its future availability cannot be ensured.

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Clinical examples 2

Pneumothorax



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Clinical examples 3

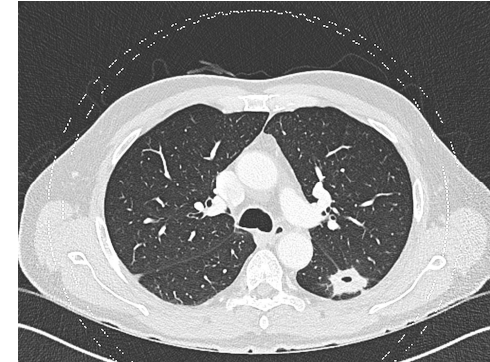
Nodule



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Clinical examples 3

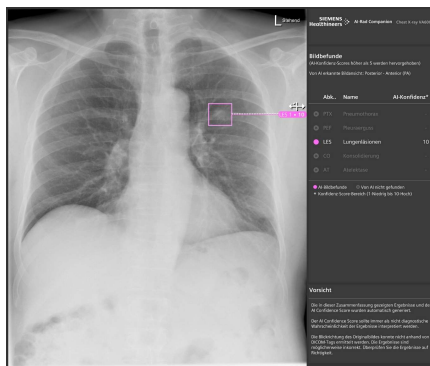
Nodule



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Clinical examples 3

Nodule

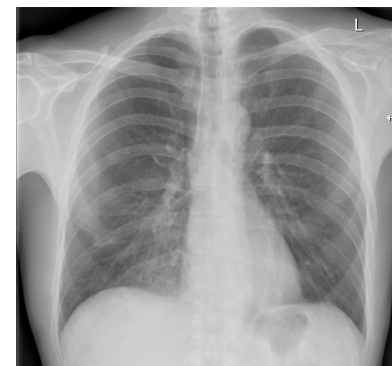


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Clinical examples 6

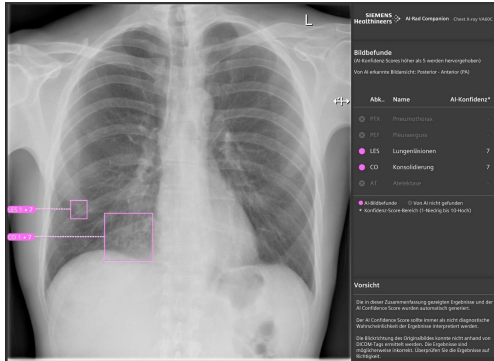
infiltration



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Clinical examples 6

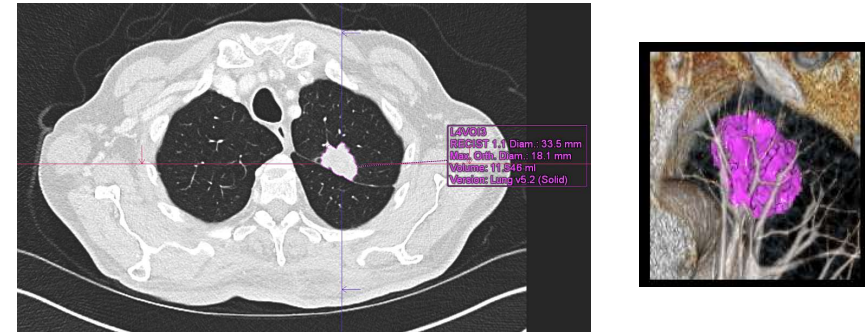
infiltration



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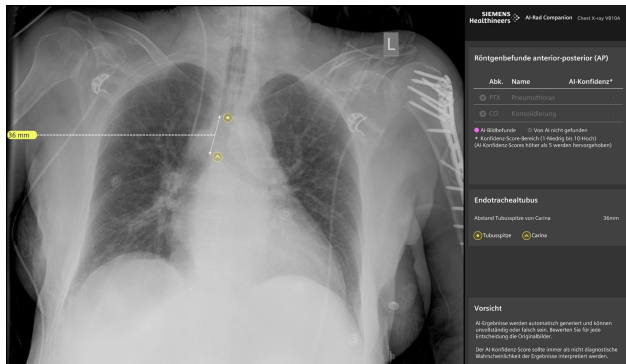
Lung nodule volume estimation



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Clinical examples 7

endotracheal tube control



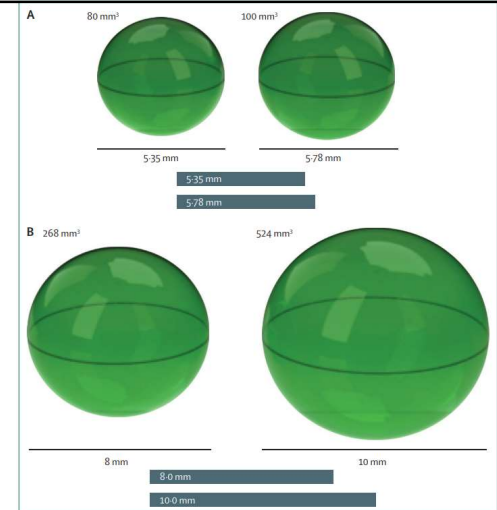
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Lung nodule volume estimation

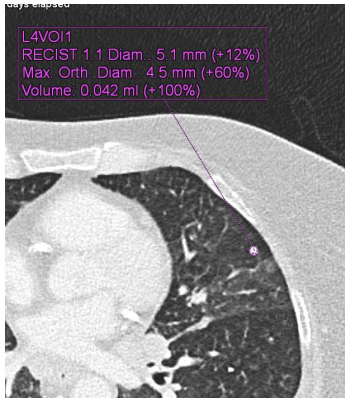
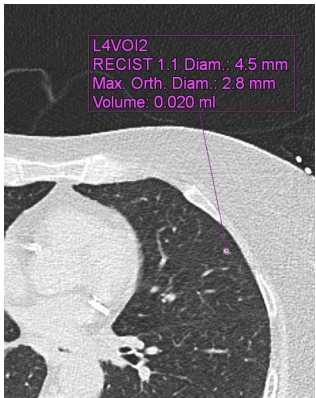
(A) A volume growth of 25%, defined as growth by NELSON criteria, is hardly appreciable by diameter measurement (8% diameter increase, which is no growth according to existing criteria).

(B) A 25% diameter increase (ie, the threshold for growth definition) reflects almost a doubling in volume (95%), highlighting the insensitivity of diameter measurement for growth.



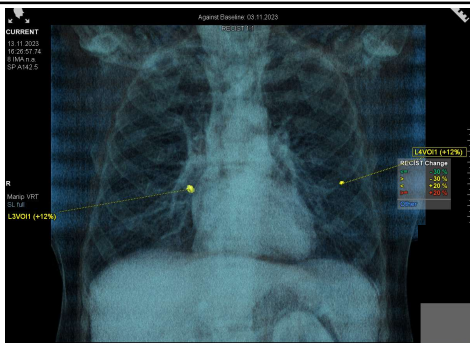
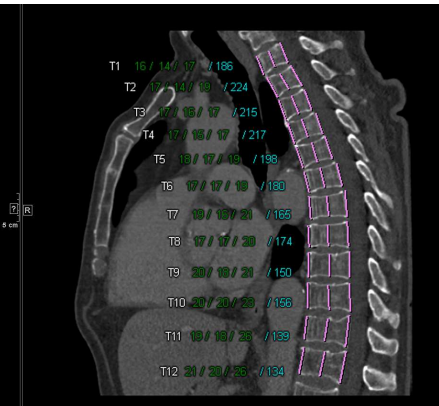
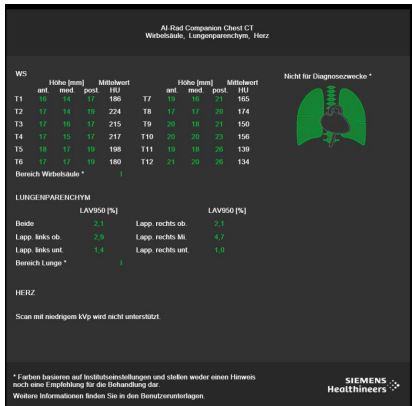
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Lung CAD



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AI Rad Companion Chest CT



		Change Rate Baseline / Current absolute (%)	13.11.2023 Current	03.11.2023 Baseline
Tumor Burden	RECIST 1.1 (mm)	+1.5 (+11.9%)	13.6	12.1
	Orth. Diam. (mm)	+3.1 (+39.2%)	11.2	8.1
	WHO (mm2)	+27.3 (+51.9%)	79.9	52.6
	Volume (ml)	+0.050 (+33.6%)	0.199	0.149
	Vol. Time (days)	24		
Lesion L4 Target Lung	RECIST 1.1 (mm)	+0.6 (+12%)	5.1	4.5
	Orth. Diam. (mm)	+1.7 (+60%)	4.5	2.8
	WHO (mm2)	+10.1 (+79%)	22.8	12.7
	Volume (ml)	+0.021 (+105%)	0.042	0.020
	Vol. Time (days)	10		

