AI IN DE RADIOLOGIE

Dr. J.J. Visser, radiologist, health economist, epidemiologist

CMIO
Assistant-professor Value-based radiology AI

Erasmus MC

"People should stop training radiologists now. It's just completely obvious that within five years deep learning is going to do better than radiologists."

— AI researcher Geoffrey Hinton, 2016

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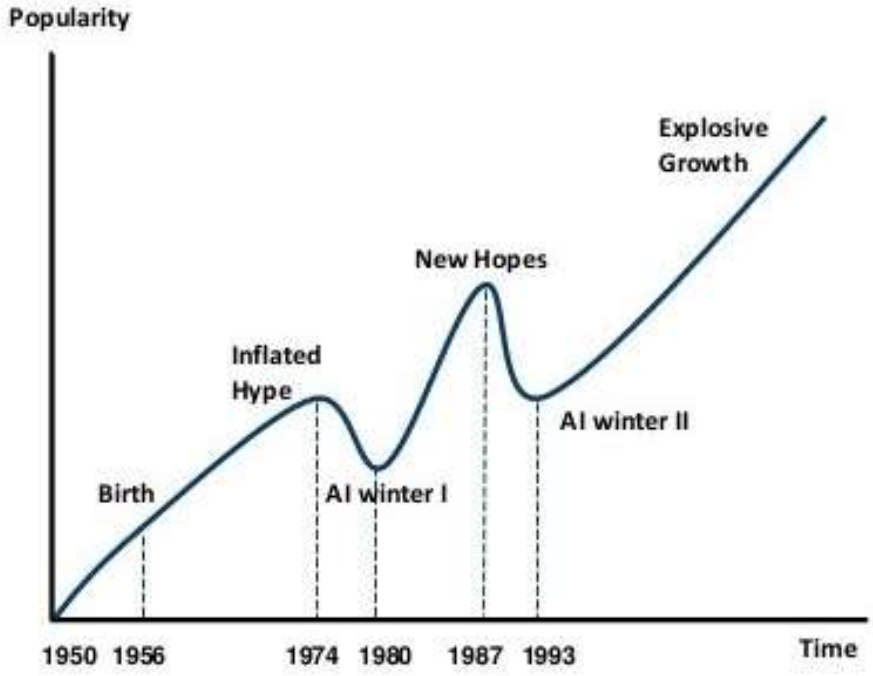
AI HAS A LONG HISTORY OF BEING "THE NEXT BIG THING"...



Timeline of AI Development

- **1950s-1960s**: First AI boom - the age of reasoning, prototype AI developed
- **1970s**: AI winter I
- **1980s-1990s**: Second AI boom: the age of Knowledge representation (appearance of expert systems capable of reproducing human decision-making)
- **1990s**: AI winter II
- **1997**: Deep Blue beats Gary Kasparov
- **2006**: University of Toronto develops Deep Learning
- **2011**: IBM's Watson won Jeopardy
- **2016**: Go software based on Deep Learning beats world's champions

1. Radiology AI
2. Deployment / integration
3. Monitoring
4. Now: market / governance

Interactieve casusworkshop

RADIOLOGY AI

There are now more than 520 marker-cleared artificial intelligence (AI) medical algorithms available in the United States, according to the U.S. Food and Drug Administration (FDA) as of January 2023. The vast majority of these are related to medical imaging.

Here is the breakdown for the number of FDA-cleared algorithms across specialties:

- Radiology 396
- Cardiology 58
- Hematology 14
- Neurology 10
- Clinical chemistry 7
- Ophthalmic 7
- Gastroenterology and urology 5
- General and plastic surgery 5
- Pathology 4
- Microbiology 4
- Anesthesiology 4
- General Hospital 3
- Orthopedic 1
- Dental 1

https://healthexec.com/topics/artificial-intelligence/fda-has-now-cleared-more-500-healthcare-ai-algorithms

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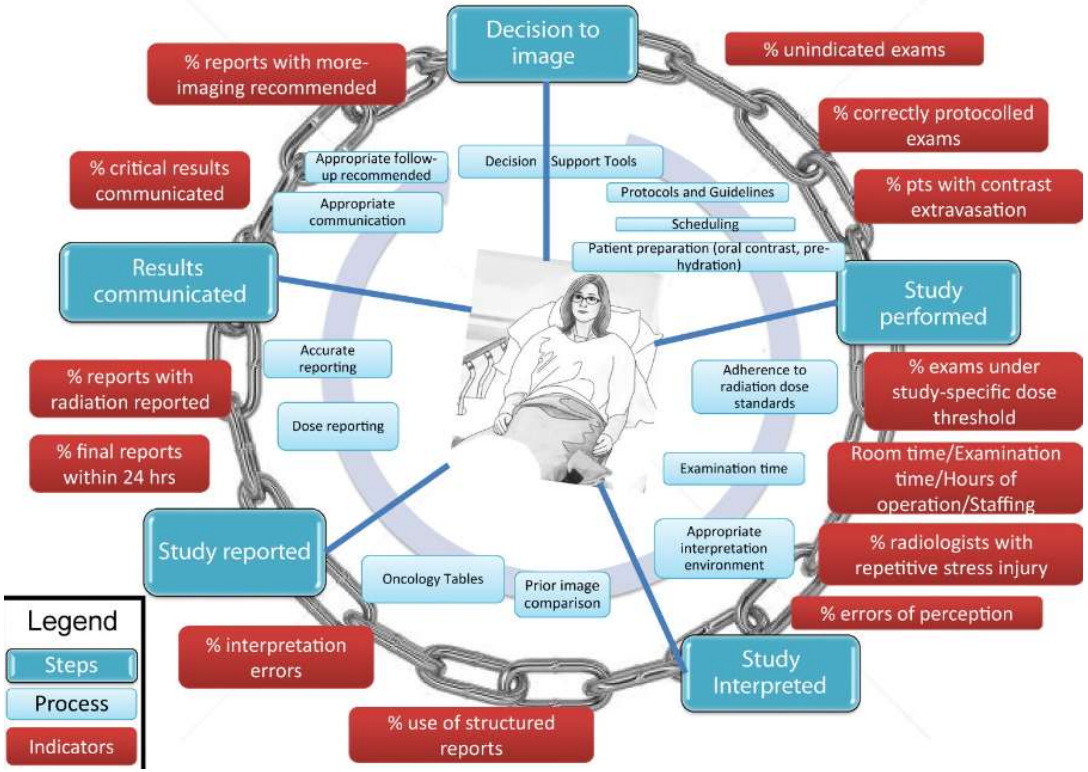

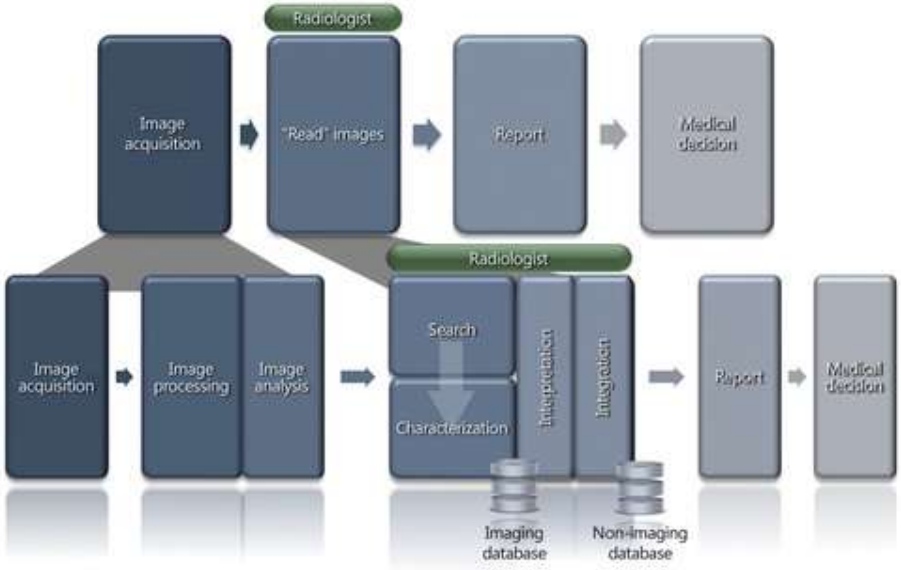

Enzmann DR. Radiology's value chain. Radiology. 2012 Apr;263(1):243-52. doi: 10.1148/radiol.12110227. PMID: 22438447.
Sarwar A, Boland G, Monks A, Kruskal JB. Metrics for Radiologists in the Era of Value-based Health Care Delivery. Radiographics. 2015 May-Jun;35(3):866-76. doi: 10.1148/rg.2015140221. Epub 2015 Apr 3. PMID: 25839737.

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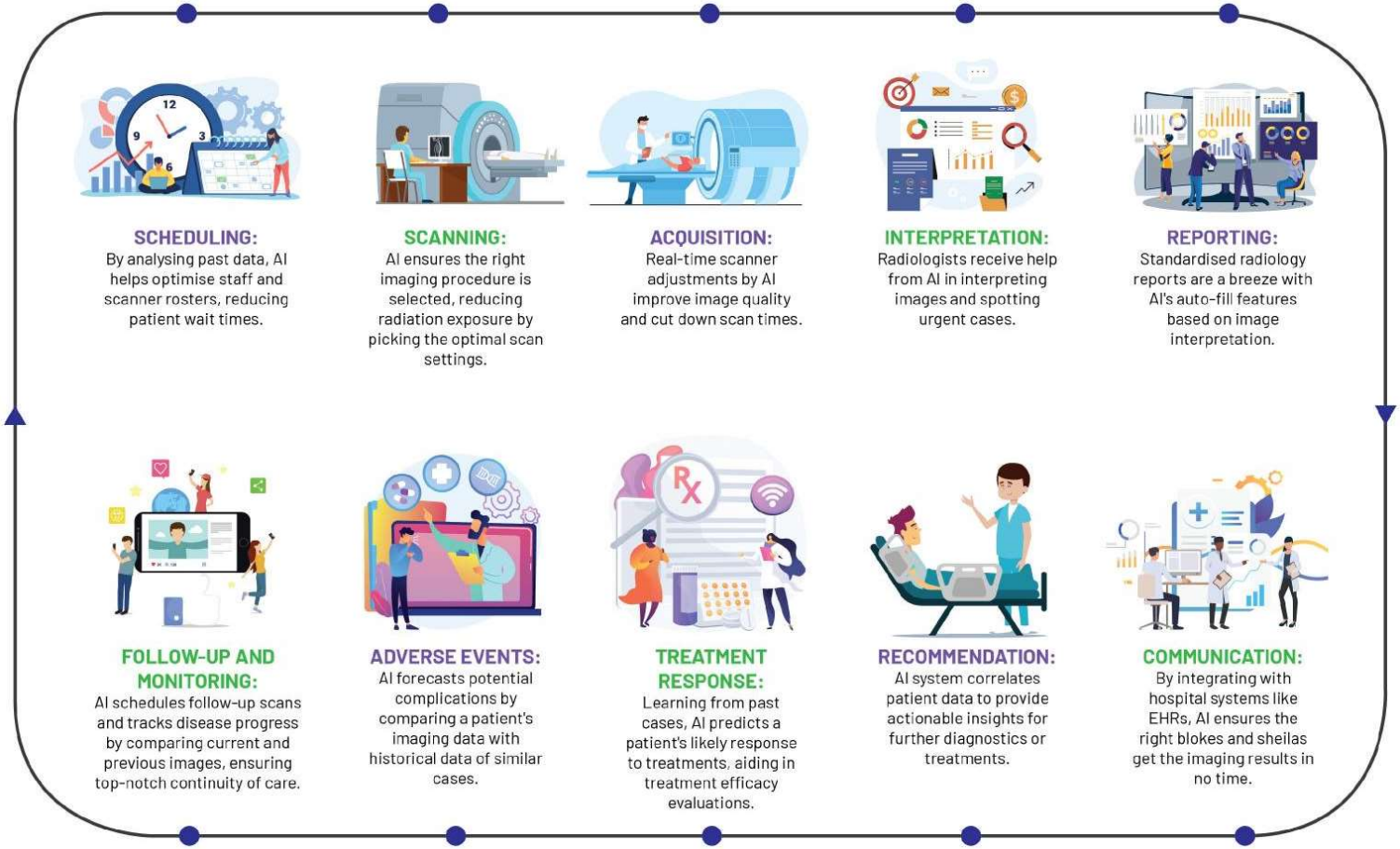
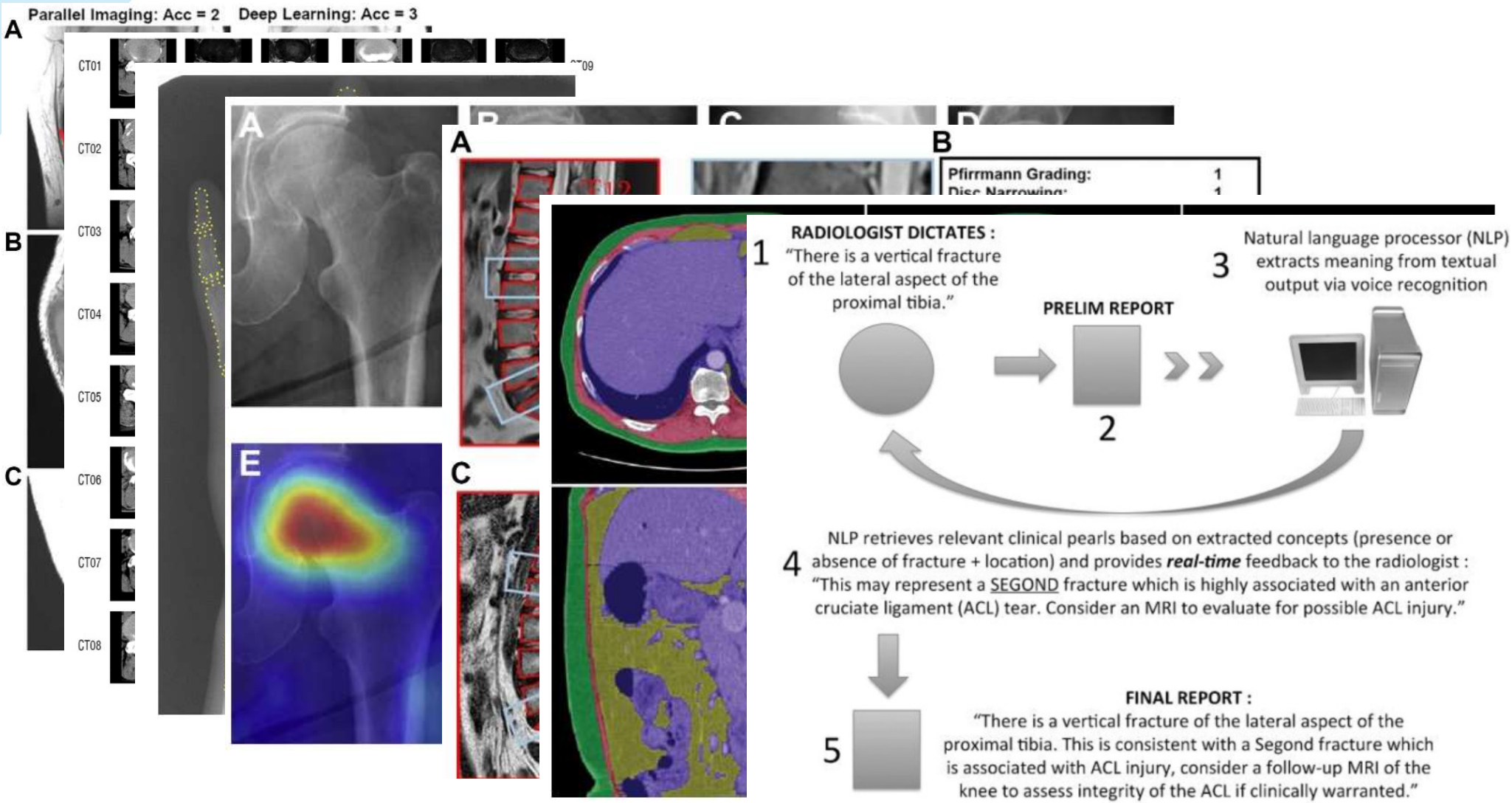
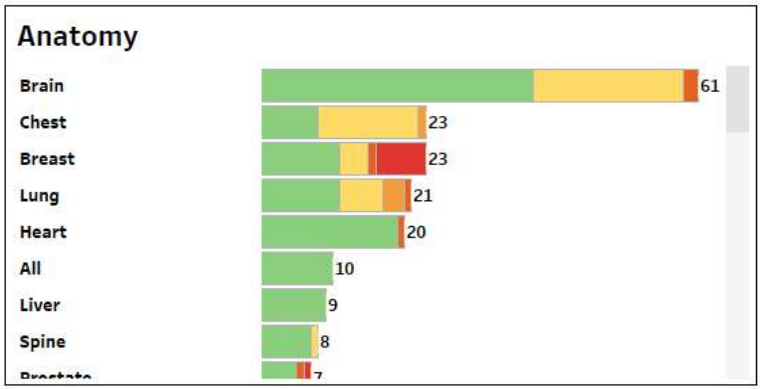


Najjar R. Redefining Radiology: A Review of Artificial Intelligence Integration in Medical Imaging. Diagnostics (Basel). 2023 Aug 25;13(17):2760. doi: 10.3390/diagnostics13172760. PMID: 37685300; PMCID: PMC10487271.



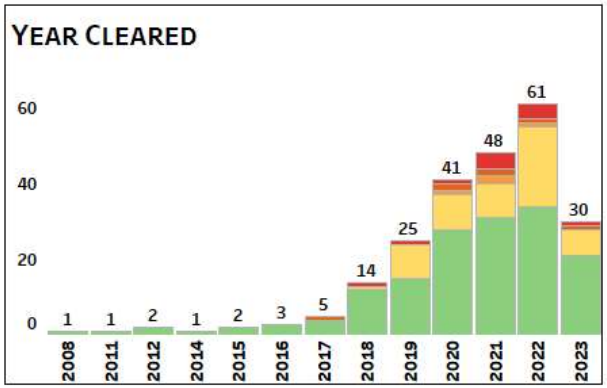
Gorelik N, Gyftopoulos S. Applications of Artificial Intelligence in Musculoskeletal Imaging: From the Request to the Report. Can Assoc Radiol J. 2021 Feb;72(1):45-59. doi: 10.1177/0846537120947148. Epub 2020 Aug 18. PMID: 32809857.

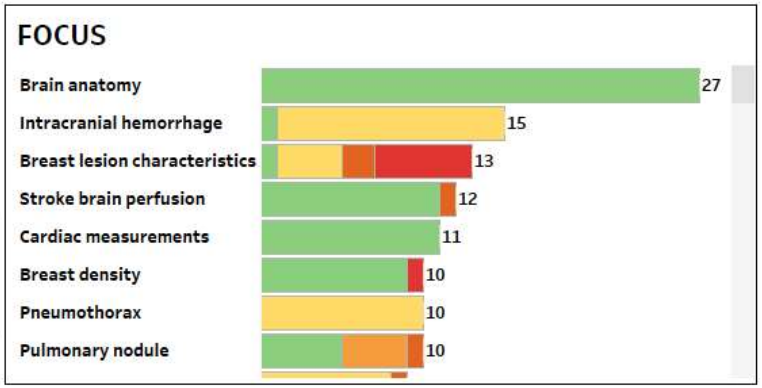
Subspecialty	CT	MR	PET	US	XRAY/MAM
Abdominal	14	20		2	3
Cardiac	24	10	1	9	4
Chest	37	5		2	22
Musculoskeletal	12	6		2	12
Neuroradiology	56	32	2		4
Breast Imaging	5	3		4	22

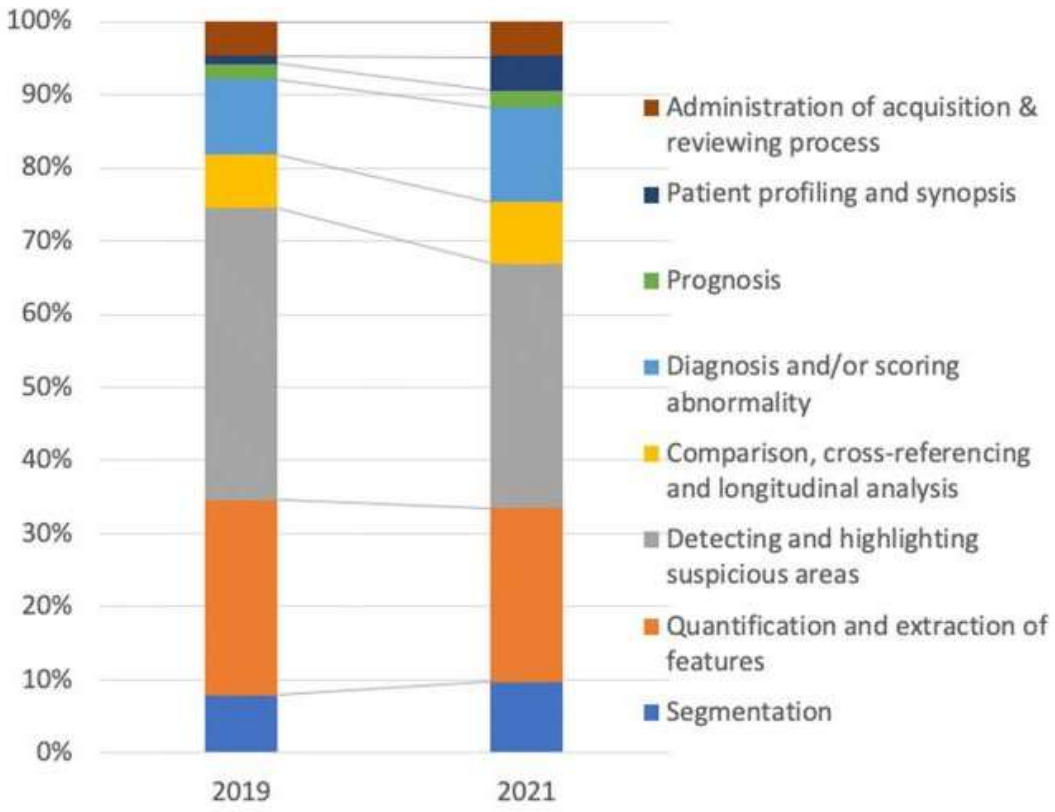


FDA CLEARED PRODUCTS

Date Cleared	Product	Company
15-5-2008	IB Neuro	Imaging Biometrics, LLC
28-12-2011	DeltaView Model 2.1	Riverain Technologies
13-4-2012	AlphaPoint Imaging Soft..	RadLogics, Inc.
27-12-2012	ClearRead +Confirm	Riverain Technologies
17-9-2014	Lung Density Analysis	Imbio LLC
4-2-2015	Neuroreader	Brainreader ApS
10-10-2015	Vitrea CT Lung Density A..	Vital Images, Inc.
20-1-2016	Stroke VCAR	GE Medical Systems







Mehrizi MHR, Gerritsen SH, de Klerk WM, Houtschild C, Dinnessen SMH, Zhao L, van Sommeren R, Zerfu A. How do providers of artificial intelligence (AI) solutions propose and legitimize the values of their solutions for supporting diagnostic radiology workflow? A technography study in 2021. Eur Radiol. 2023 Feb;33(2):915-924. doi: 10.1007/s00330-022-09090-x. Epub 2022 Aug 18. PMID: 35980427; PMCID: PMC9889424.

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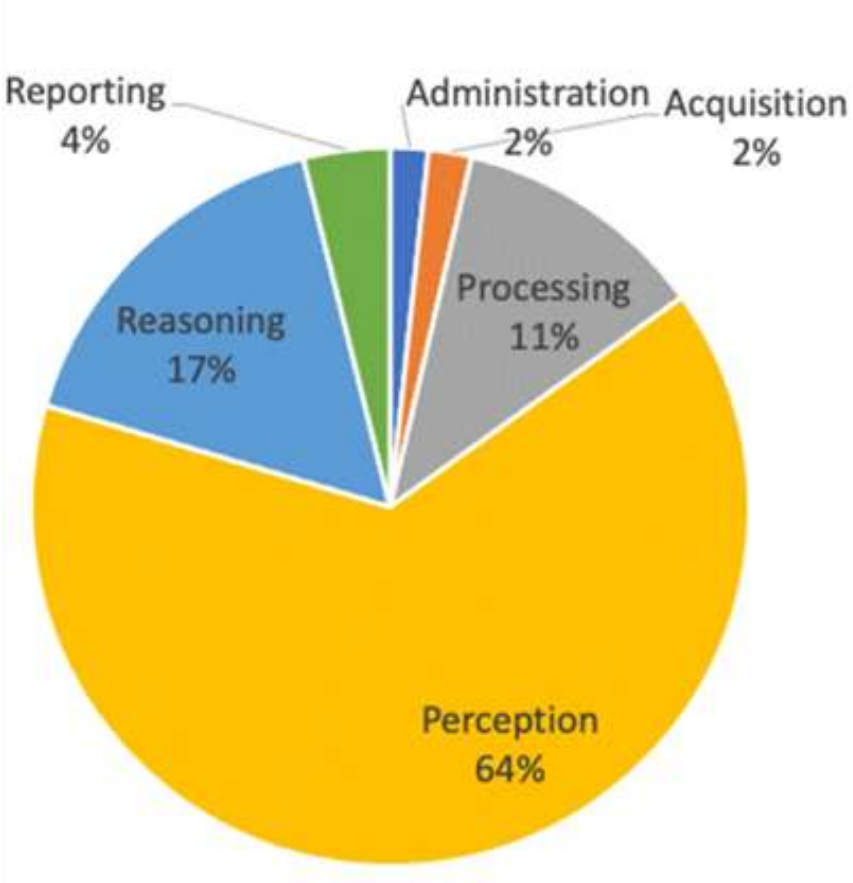

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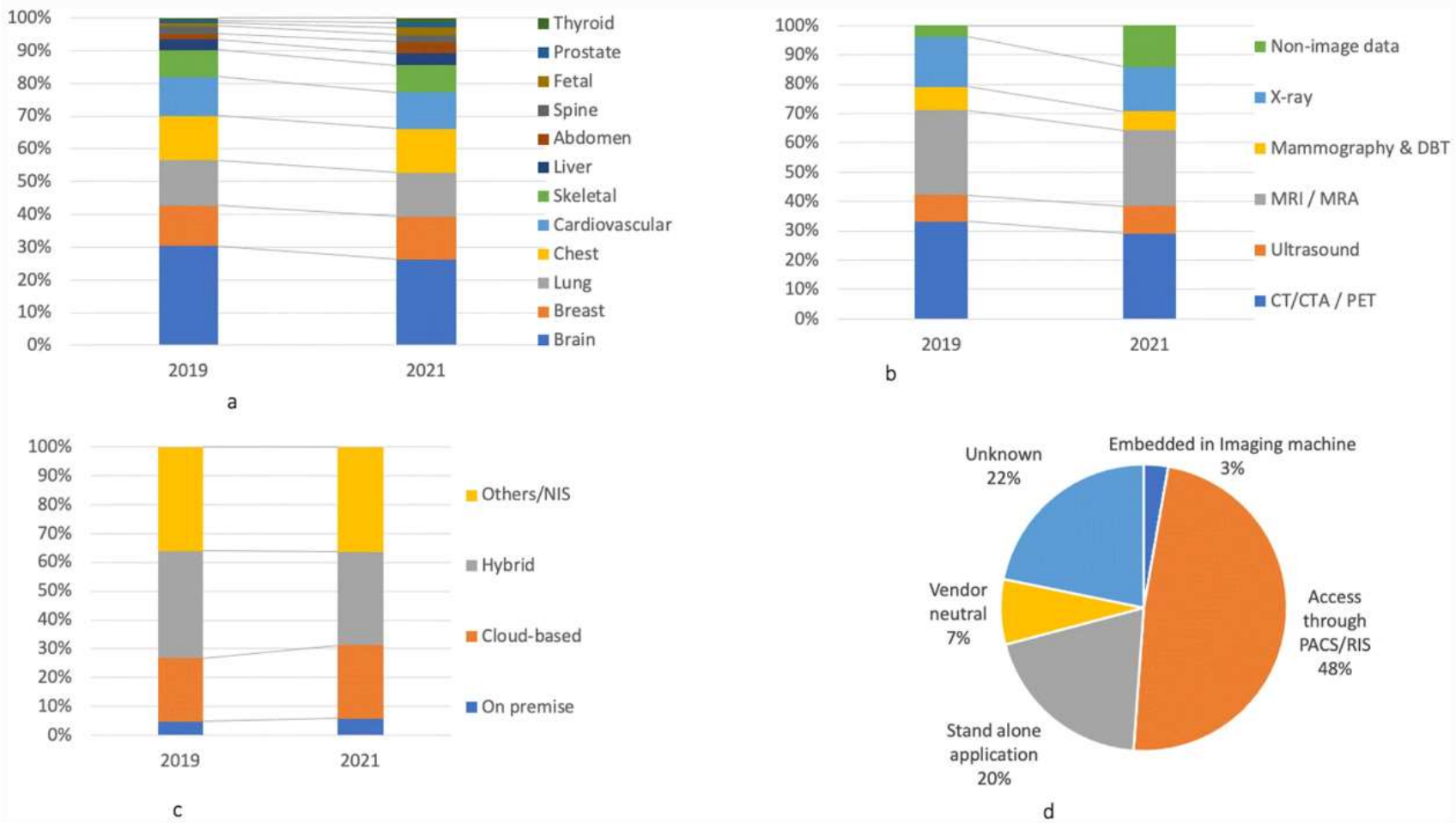

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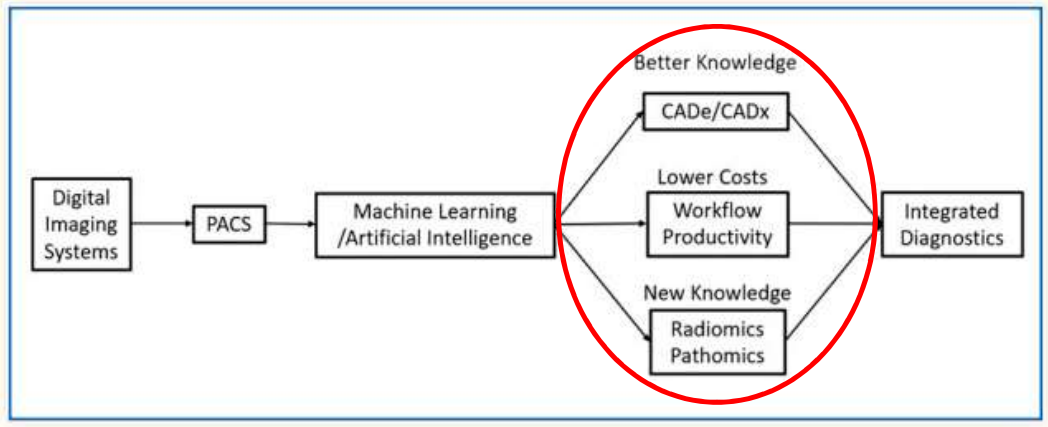
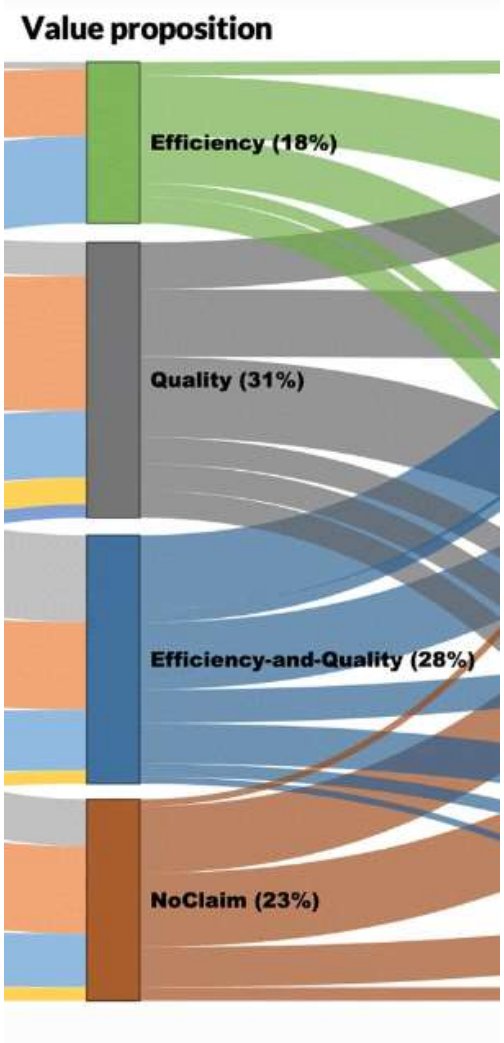
- Added value according to AI manufacturers:
  - Making better decisions (33%)
  - Higher quality care (31%)
  - Speeding up work (19%)
  - Reducing costs (10%)
  - Reduce workload (7%)





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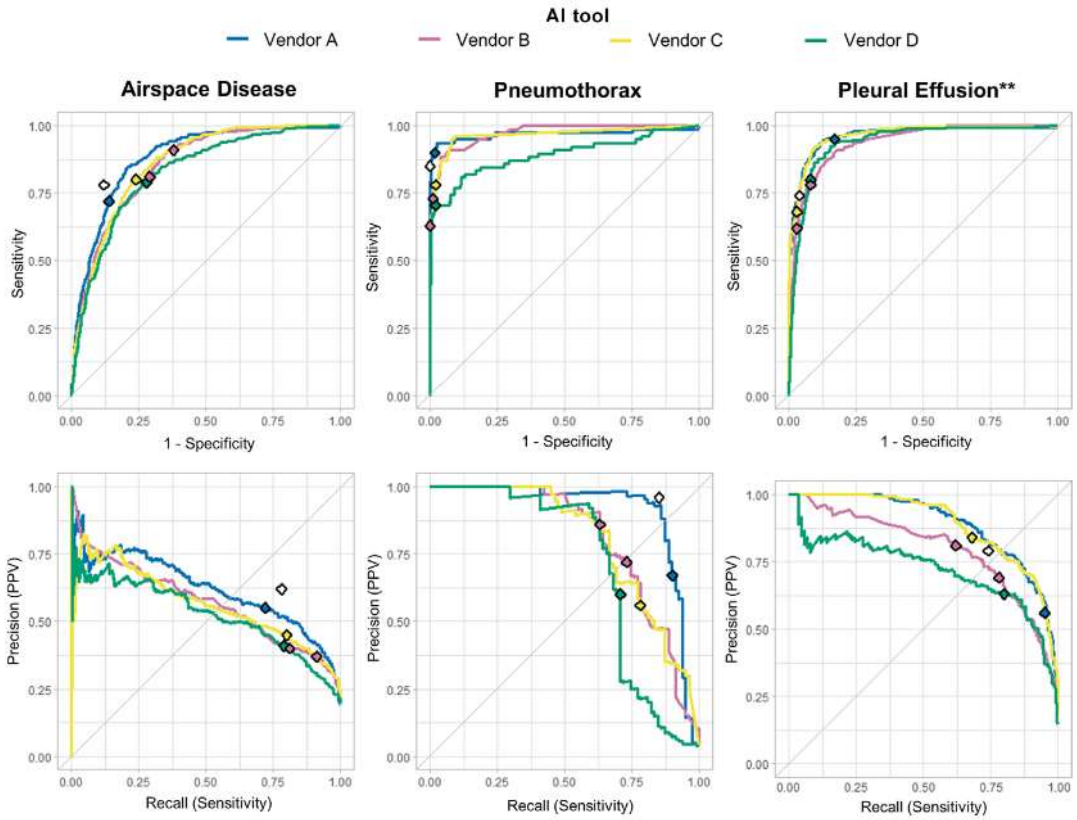
Mun SK, Wong KH, Lo SB, Li Y, Bayarsaikhan S. Artificial Intelligence for the Future Radiology Diagnostic Service. Front Mol Biosci. 2021 Jan 28;7:614258. doi: 10.3389/fmolb.2020.614258. PMID: 33585563; PMCID: PMC7875875.

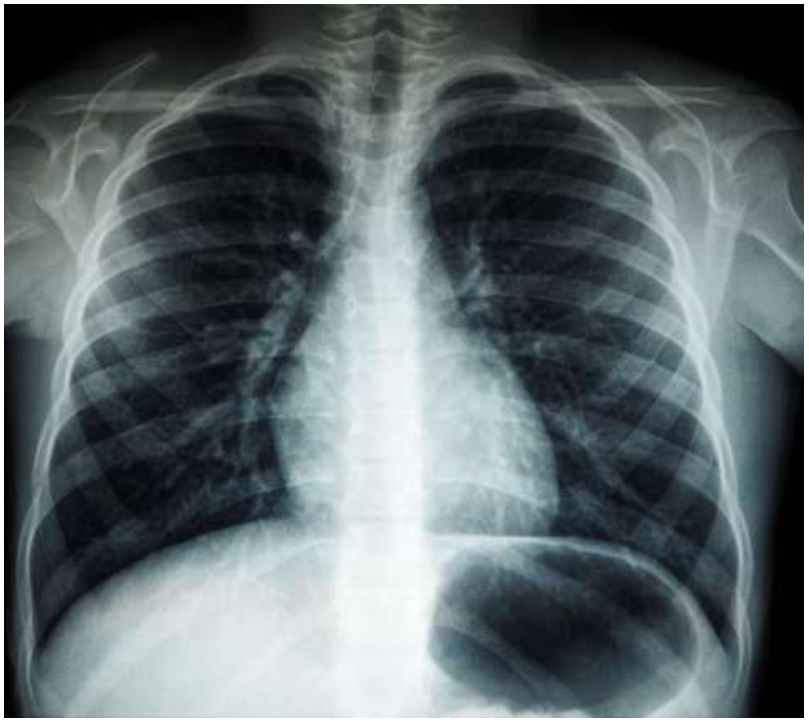
- Quality:
  - AI models can detect abnormalities and diseases that radiologists may overlook
  - Phenotype of a tumor can be determined using radiomics >> appropriate therapy
  - Identify population at risk >> patients with important incidental findings, coronary disease, emphysema, steatosis hepatis, osteoporosis
  - 2nd pair of eyes

- Efficiency:
  - At fees per DBC/DOT, any tool that increases efficiency can be valuable
  - AI that can automatically make a finding identify can alert clinical care teams to suspected stroke, pulmonary embolism, or other emergency conditions through an app
  - Many AI algorithms perform complex measurements, contours of anatomy, or other time-consuming tasks

https://radiologybusiness.com/topics/artificial-intelligence/what-roi-ai-adoption-radiology?utm_source=newsletter&utm_medium=rb_news

Algorithm (accuracy)





Lind Plesner L, Müller FC, Brejnebøl MW, Laustrup LC, Rasmussen F, Nielsen OW, Boesen M, Brun Andersen M. Commercially Available Chest Radiograph AI Tools for Detecting Airspace Disease, Pneumothorax, and Pleural Effusion. Radiology. 2023 Sep;308(3):e231236. doi: 10.1148/radiol.231236. PMID: 37750768.

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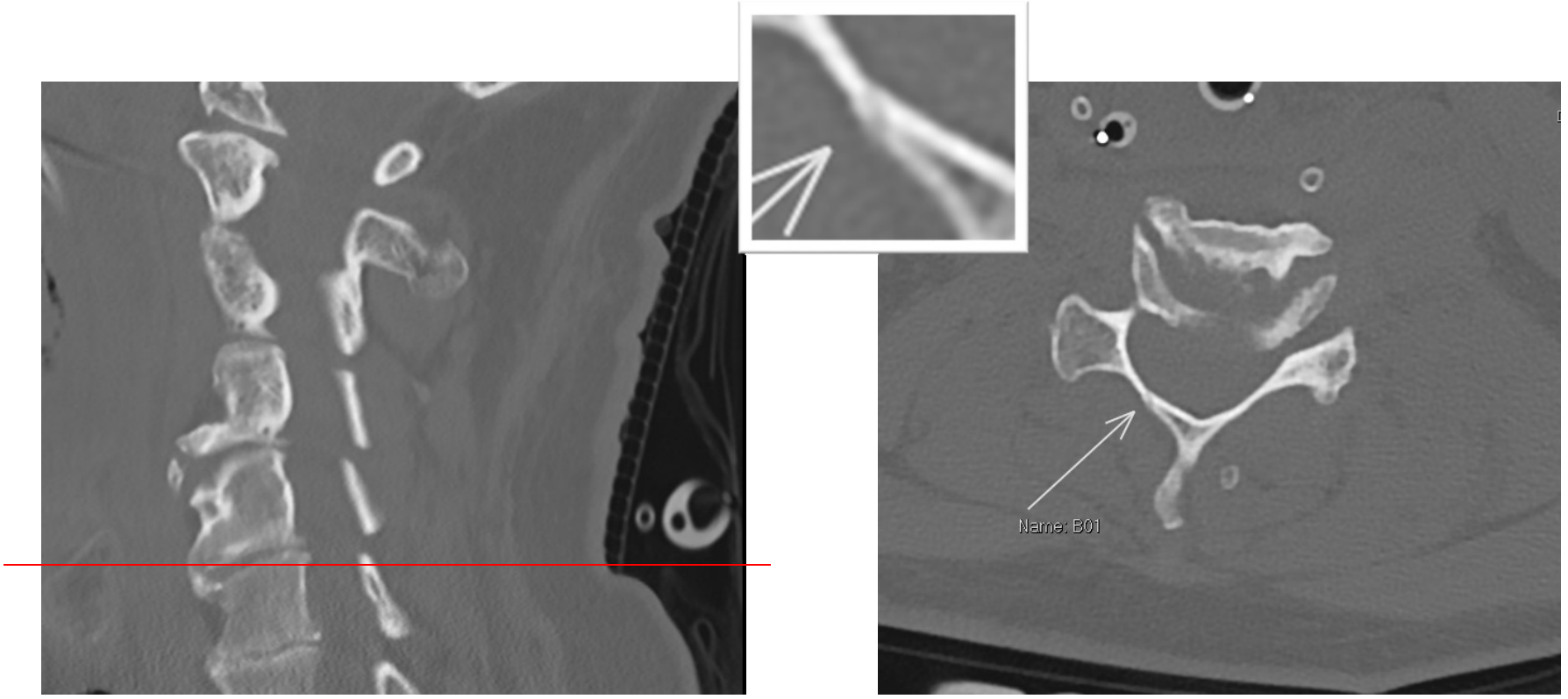
Acute C-Spine Fractures

510(k) Triage and notification software indicated for use in the analysis of cervical spine CT images; flags and communicates suspected positive findings of linear lucencies in the cervical spine bone in patterns compatible with fractures.

	Fracture +	Fracture -	Total	
AI+	204	92	296	PPV 68.9%
AI-	23	2654	2677	NPV 99.1%
Total	227	2746	2973	
	Sens 89.9%	Spec 96.7%		

	Fracture +	Fracture -	Total	
AI+	204	92	296	PPV 68.9%
AI-	23	2654	2677	NPV 99.1%
Total	227	2746	2973	
	Sens 89.9%	Spec 96.7%		

Total	**23 / 2677** **AI negative**
Fracture and stabilizing therapy	5
Fracture and no stabilizing therapy	18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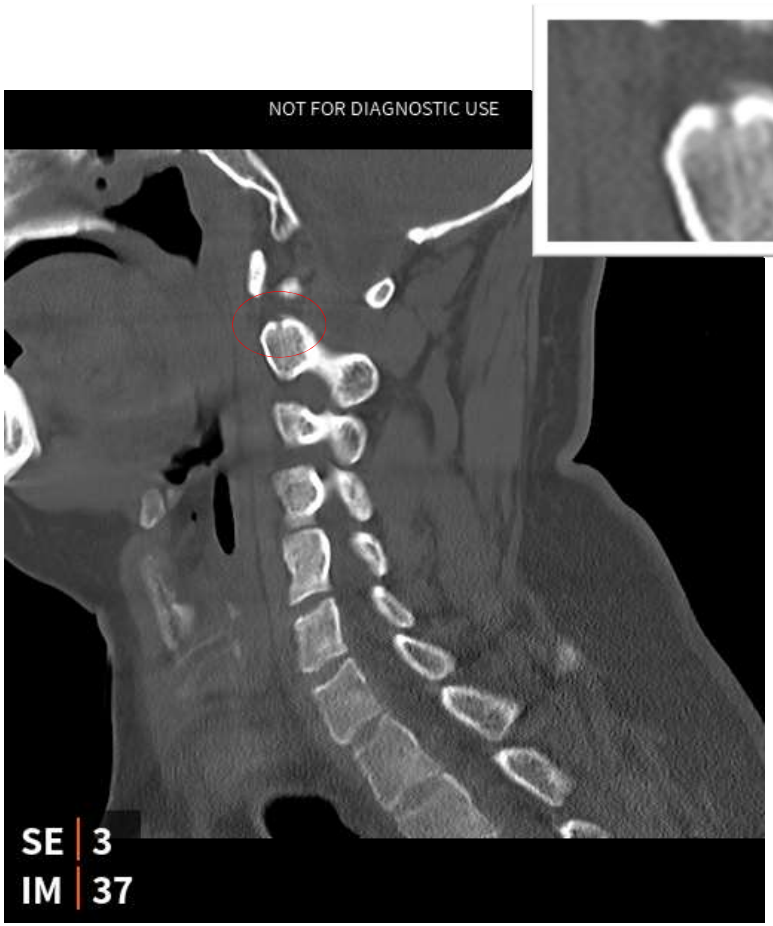
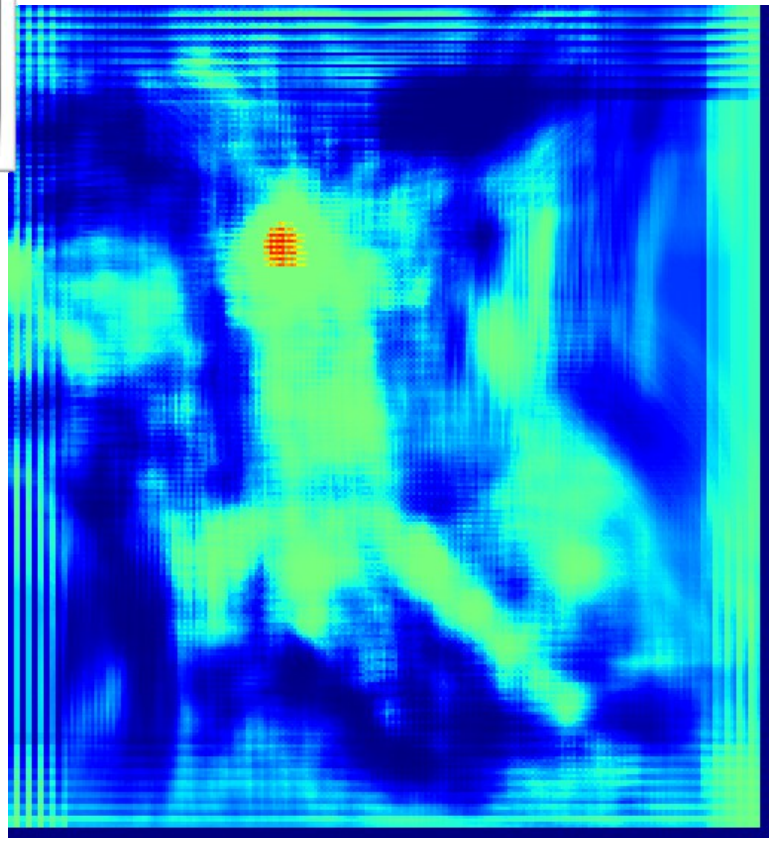
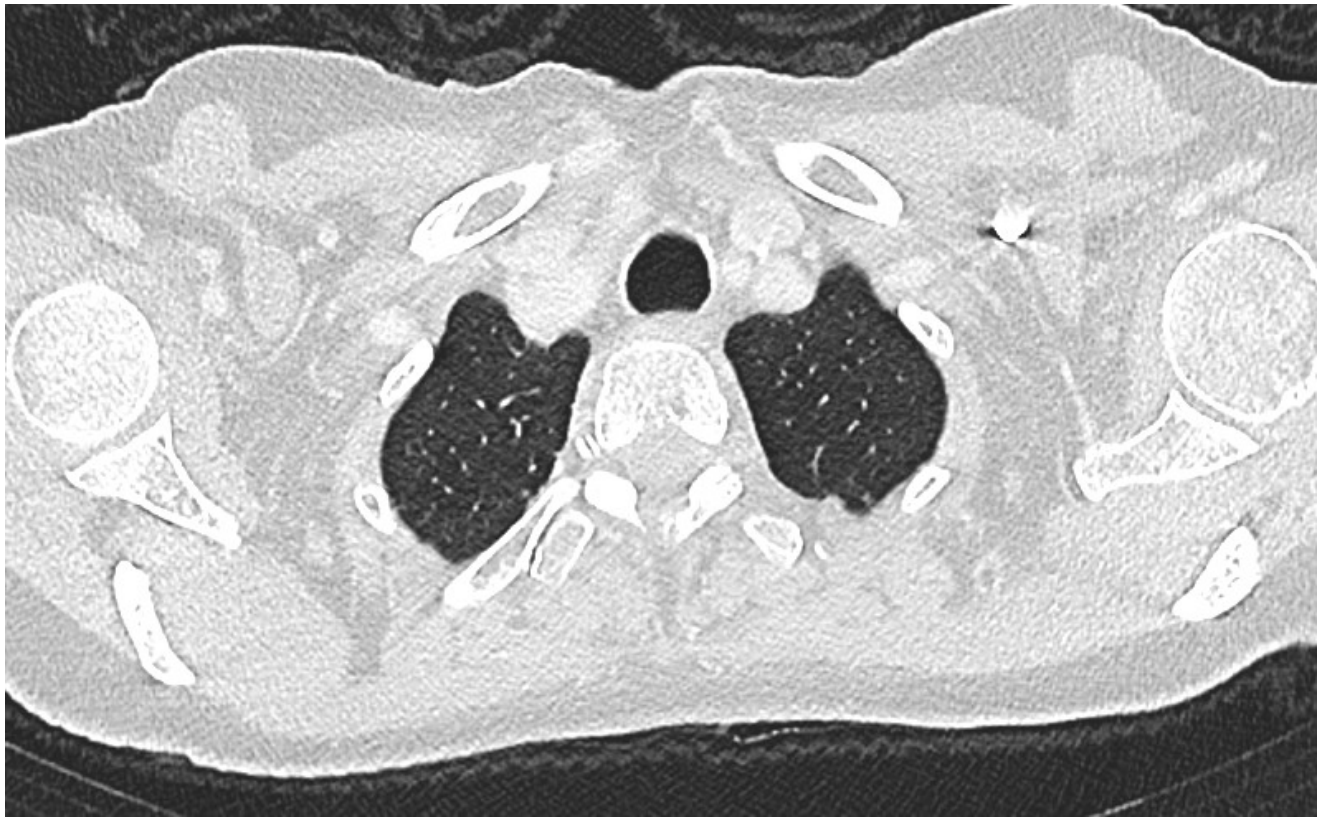
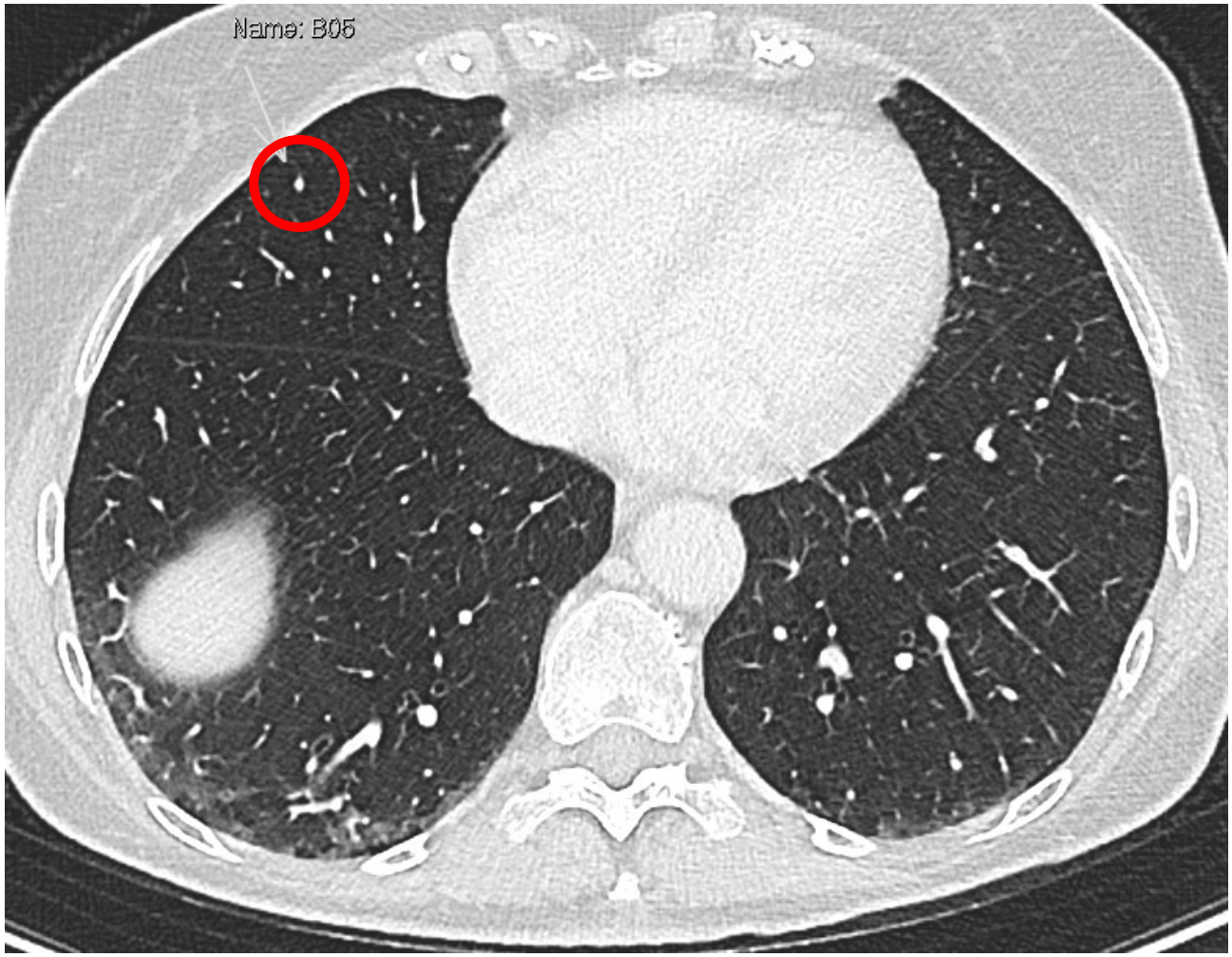

NOT FOR DIAGNOSTIC USE
SE 3
IM 37






Deze voorlopige resultaten (inclusief de resultaten van de eerdere scan) moeten nog door een radioloog beoordeeld worden.
Waarschuwing: controleer de volumemetingen. De VDT-berekening kan minder nauwkeurig zijn door acquisitieverschillen tussen de huidige en de vorige scan.
GEEN NODI GEVONDEN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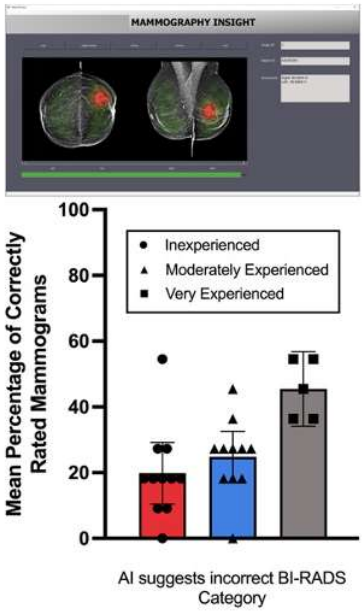
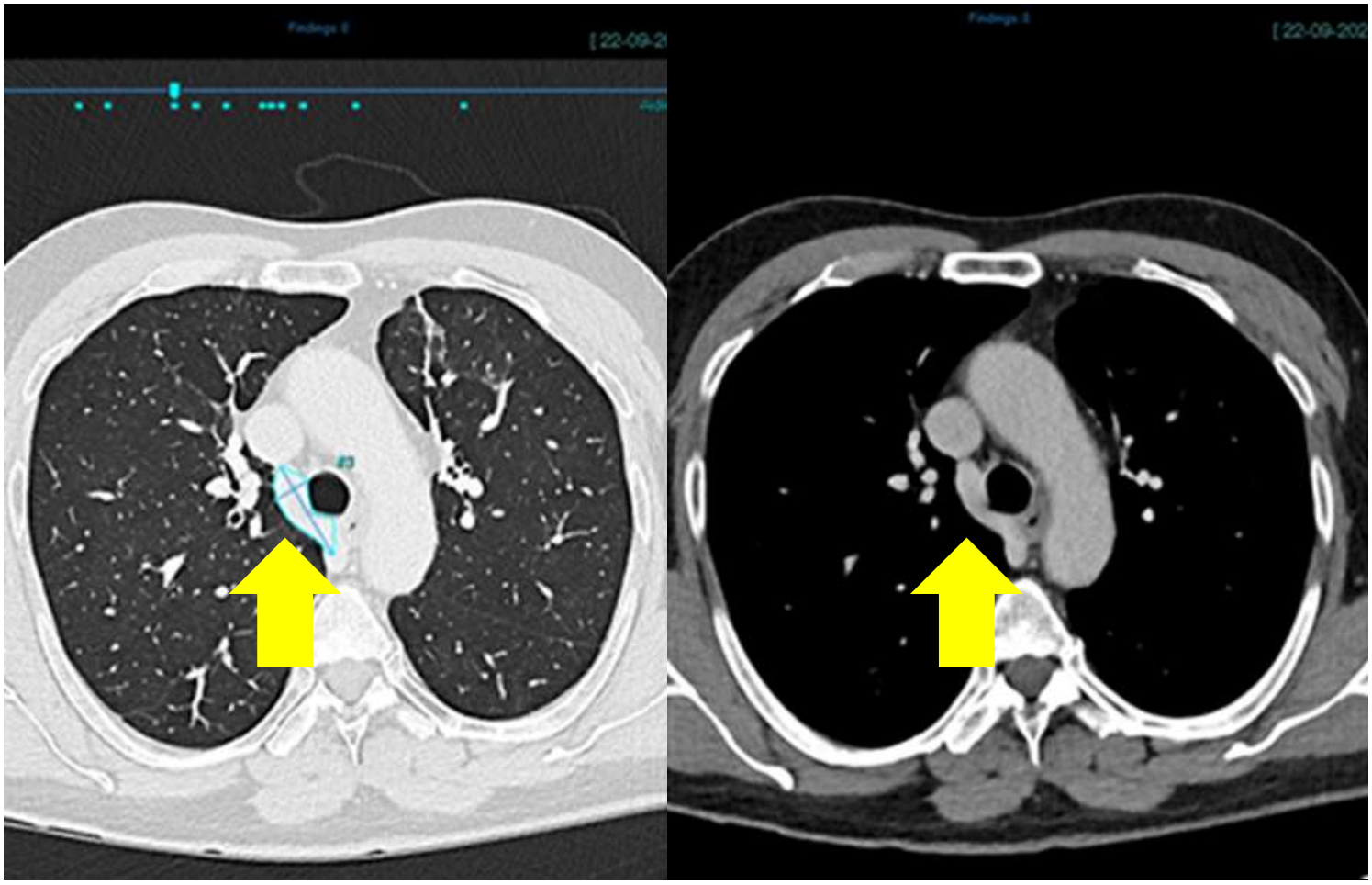
Automation Bias in Mammography: Impact of AI on Reader Performance



- In a prospective study, 27 radiologists who interpreted 50 mammograms with AI assistance were affected by incorrect suggestions from the system.
- Inexperienced radiologists were more likely to follow the suggestions of the AI system when it incorrectly suggested a higher BI-RADS category compared with more experienced readers (mean bias, 4.0 ± 1.8 vs 1.2 ± 0.8).

Dratsch T and Chen X et al. Published Online: May 2, 2023
https://doi.org/10.1148/radiol.222176

Radiology



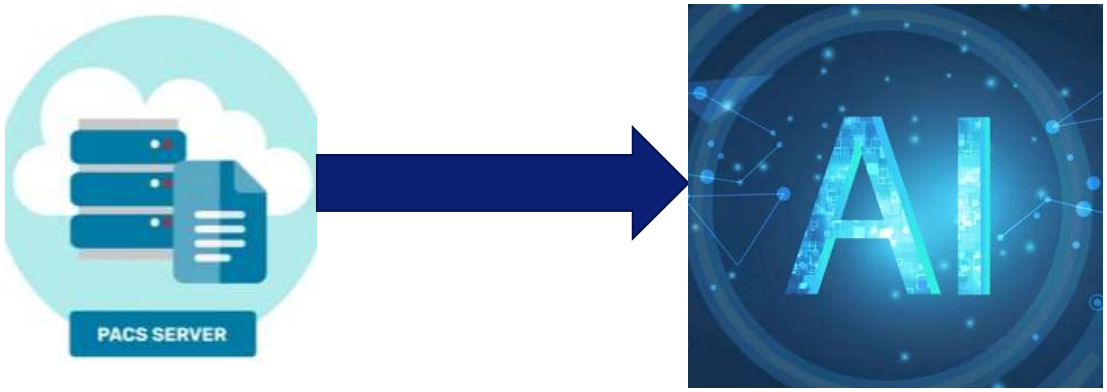
DEPLOYMENT / INTEGRATION

DEPLOYMENT / INTEGRATION

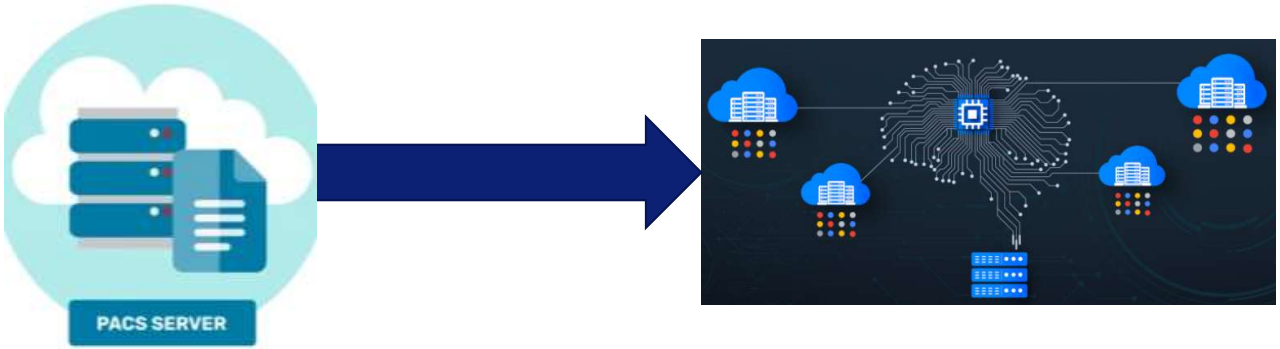
AI connection

Modality

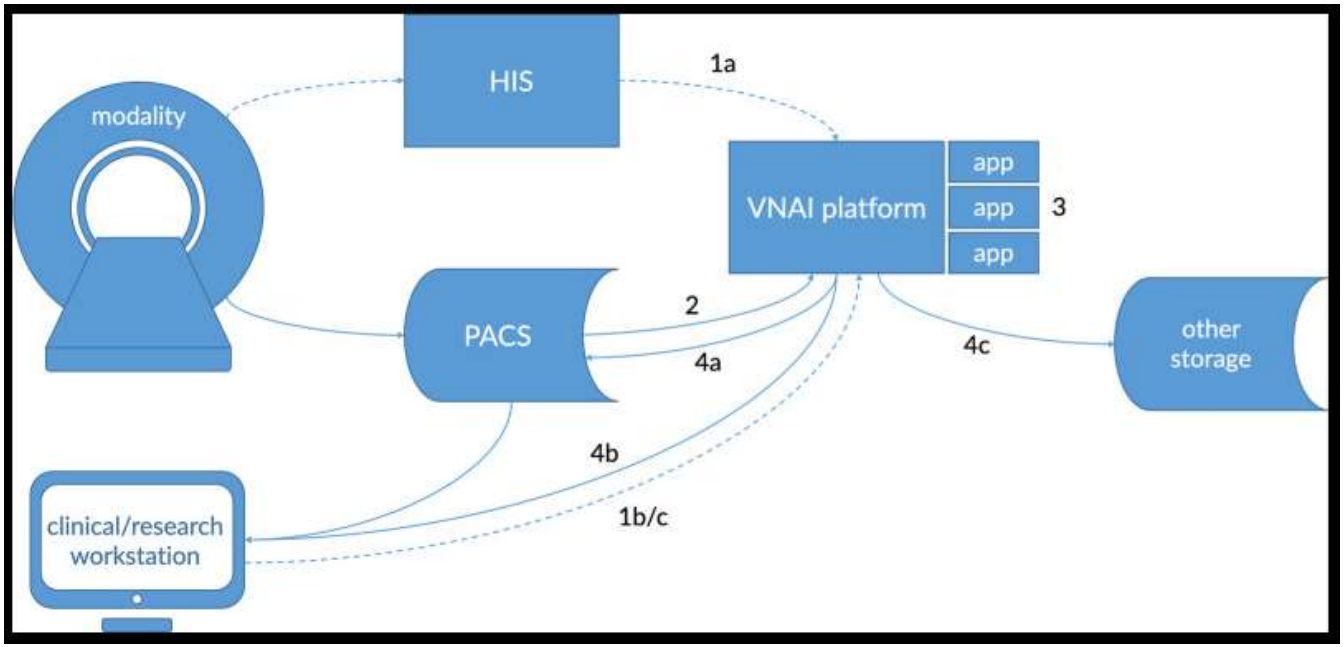
PACS



Platform



AIFI
Artificial Intelligence
for Imaging



Leiner T, Bennink E, Mol CP, Kuijf HJ, Veldhuis WB. Bringing AI to the clinic: blueprint for a vendor-neutral AI deployment infrastructure. Insights Imaging. 2021 Feb 2;12(1):11. doi: 10.1186/s13244-020-00931-1. PMID: 33528677; PMCID: PMC7855120.

DEPLOYMENT / INTEGRATION

AI workflow integration

Relevant studies to be processed by algorithm

Study Description	Alle CT's die horen bij (zie bijgevoegd overzicht CT protocollen): NeuroNeuro KNO Hals/Thorax/Abdomen; KNO Hals/Thorax; Thorax; Thorax CTA; CT thorax/abdomen; CT hals/thorax/abdomen' CT thor/abd Dual Energy (HPB/LTX). Daarnaast van Vasculair CTAb_CTVb de CT CTAb Ao ThAd_FL_zonder ECG (5), CTAb_CTA Arteria bronchialis (8) en van de CardiovasculairCardio+ECG Car Acute Dissectie+ECG (1), Car_Aorta_Art_ Pulmonalis_ECG_FL_Systole (2), Car_ Aorta Thoracalis_ECG_FL_ Systole (3); Car AortaTotaal_ECG_FL_Systole (4); Car AortaTotaal_Blanco_ECG_FL_Systole_Klin_Genetica (5); Car_Dual rule out (Dissectie+Coronair) (17); Car_Dual rule out (Longembolie+Dissectie) (18); Car_Dual Ruleout_Longembolie+Coronair) (19); Car_ 3x_Dual rule out (Longembolie+Dissectie+Coronair) (20), CTAb_ThAo_abdomen _ perifeer (26), CTAb_ThAo_Cor_perifeer_Emboliebron (27)

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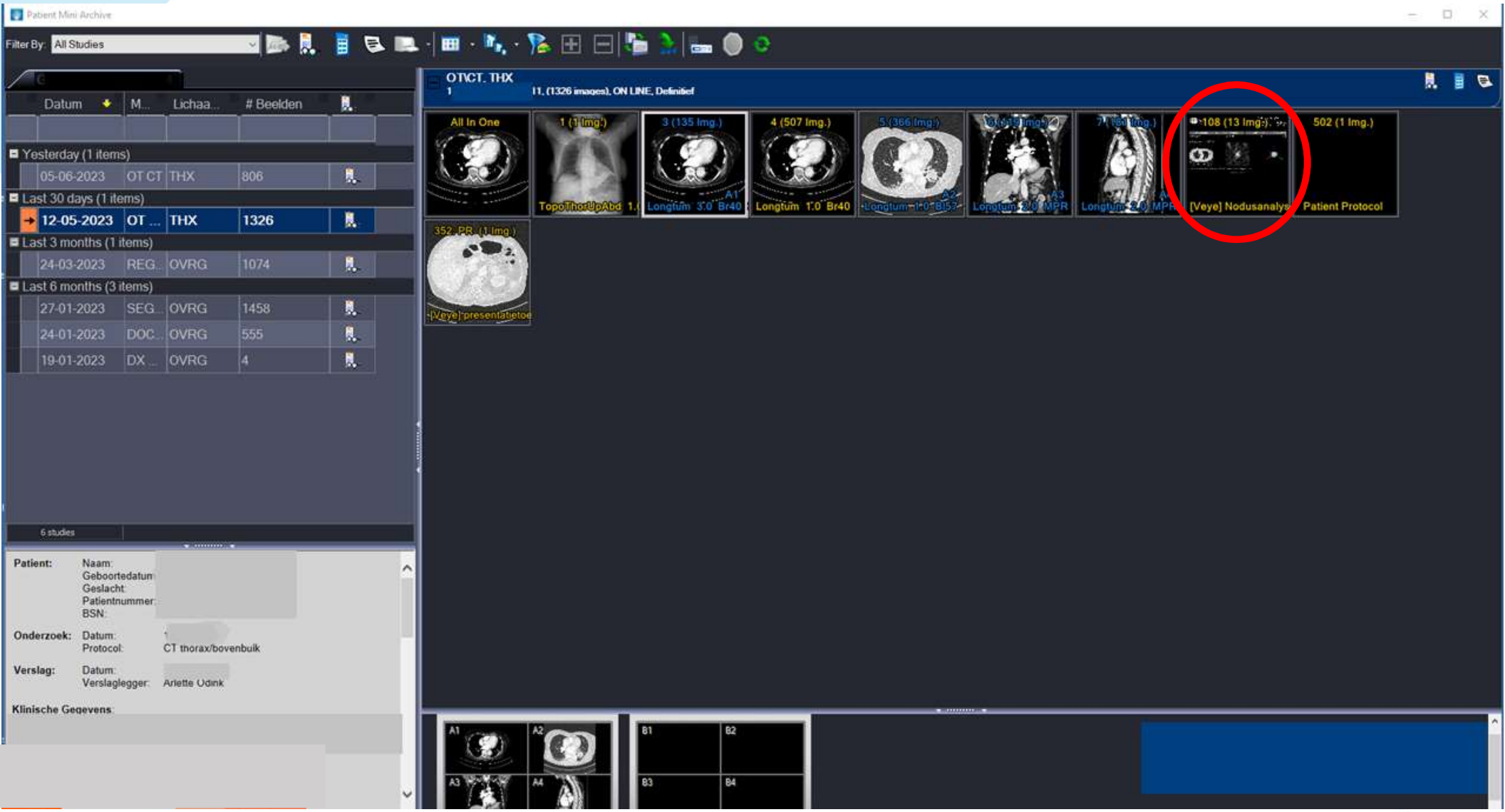
Patient Mini Archive
Filter By: All Studies
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Beelden
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05-06-2023 OT CT THX 806
Last 30 days (1 items)
12-05-2023 OT ... THX 1326
Last 3 months (1 items)
24-03-2023 REG... OVRG 1074
Last 6 months (3 items)
27-01-2023 SEG... OVRG 1458
24-01-2023 DOC... OVRG 555
19-01-2023 DX ... OVRG 4
6 studies
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Naam:
Geboortedatum:
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Protocol: CT thorax/bovenbuik
Verslag:
Datum:
Verslaglegger: Ariette Odink
Klinische Gegevens:
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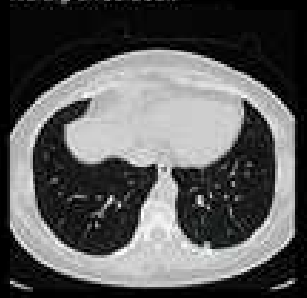
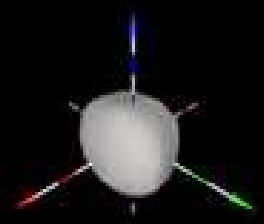
Datum onderzoek	nr	Coupe	Compositie	Diameter (mm)	Volume (mm³)
	2	228	Solide	7x6 (7)	116

Huidig onderzoek





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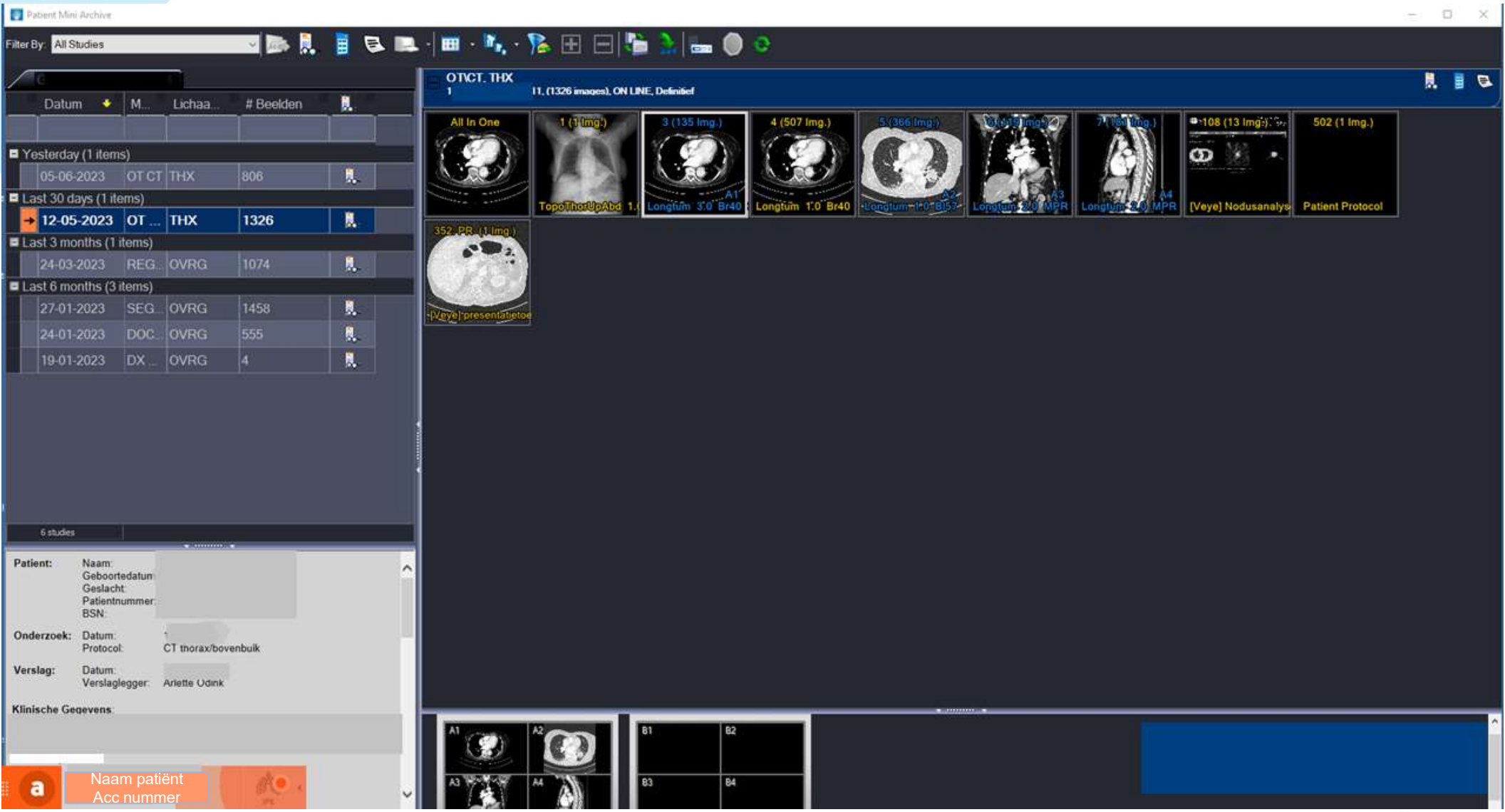
- pagina 2 van 5 -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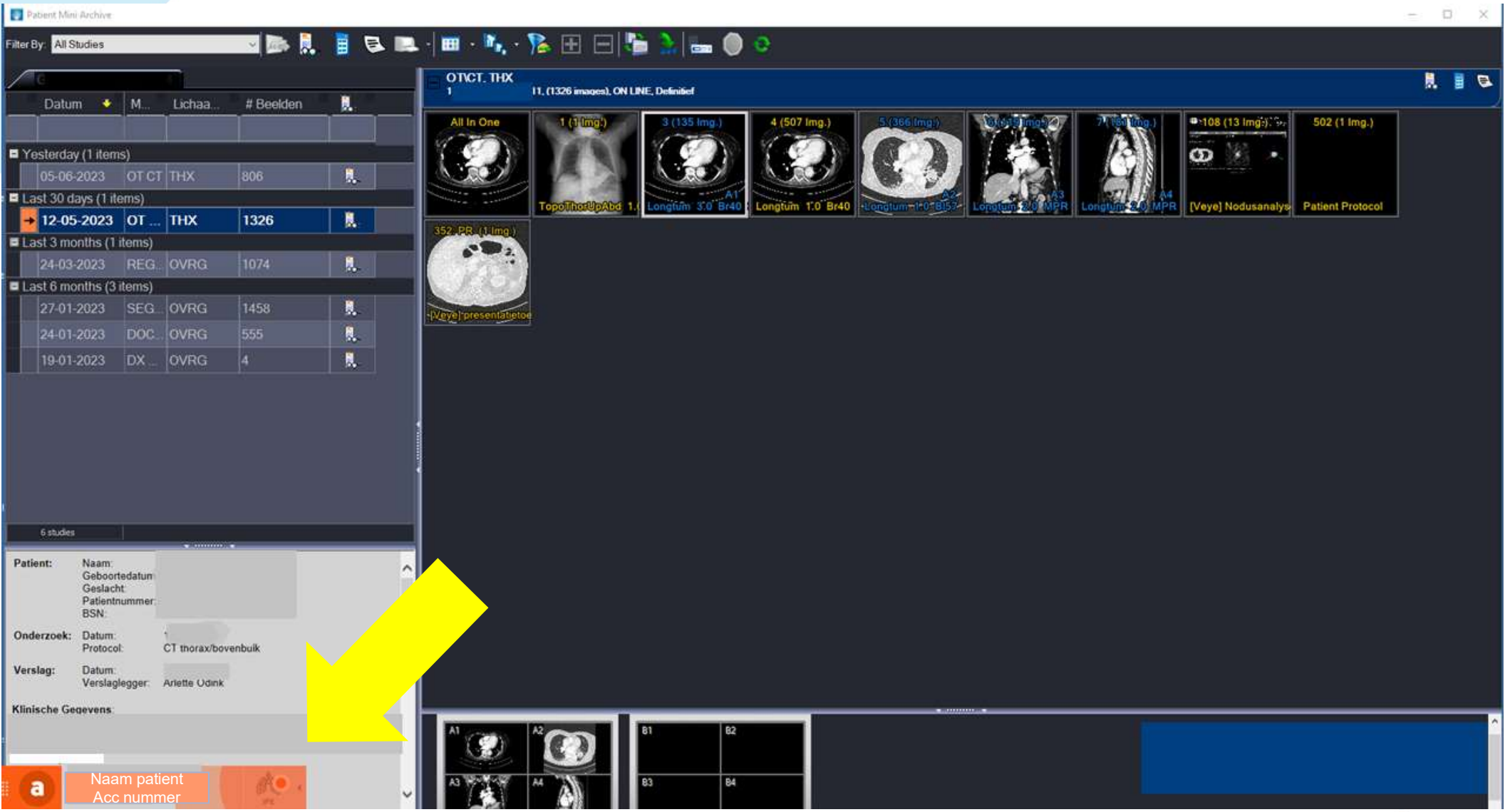
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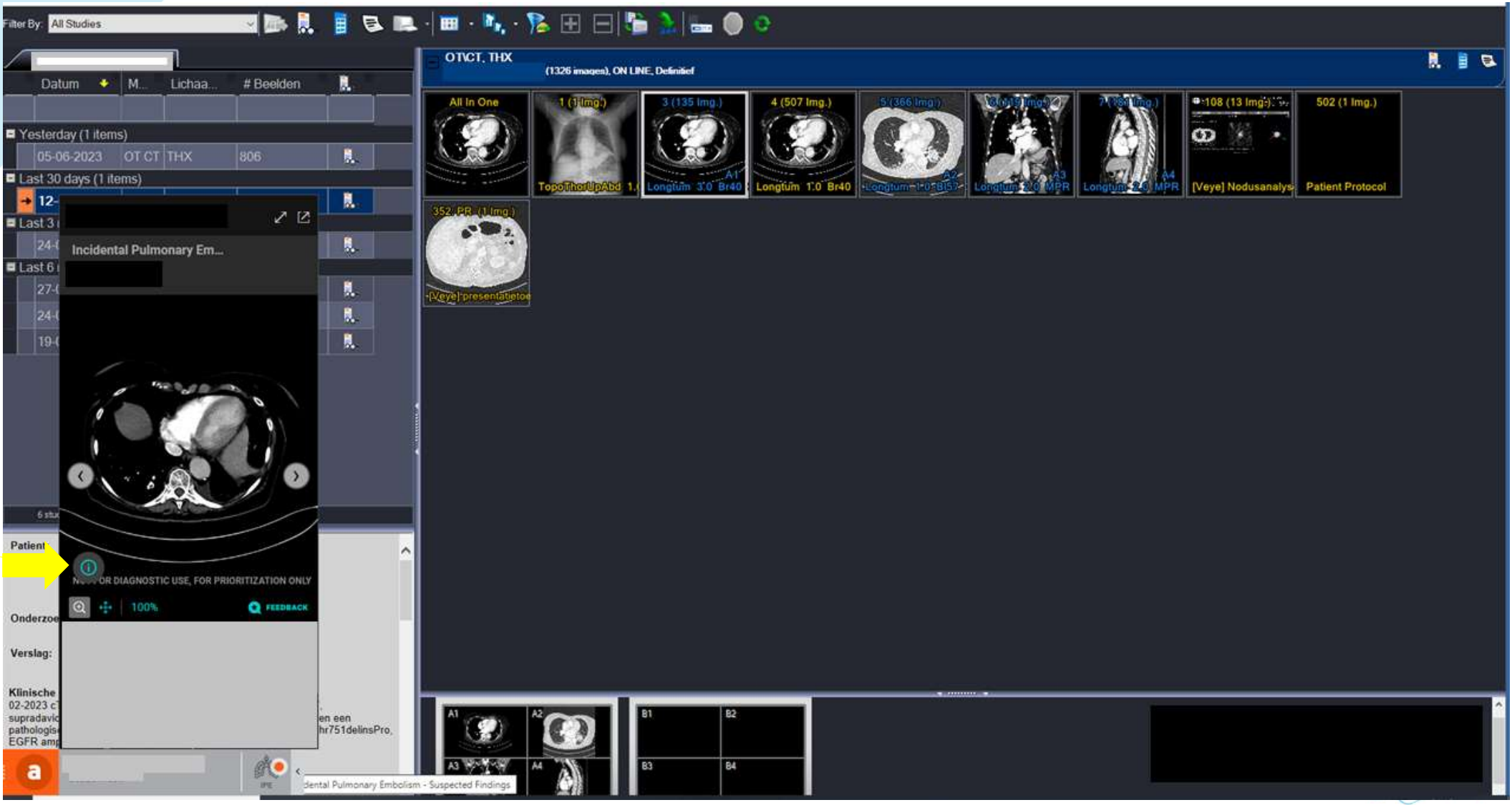
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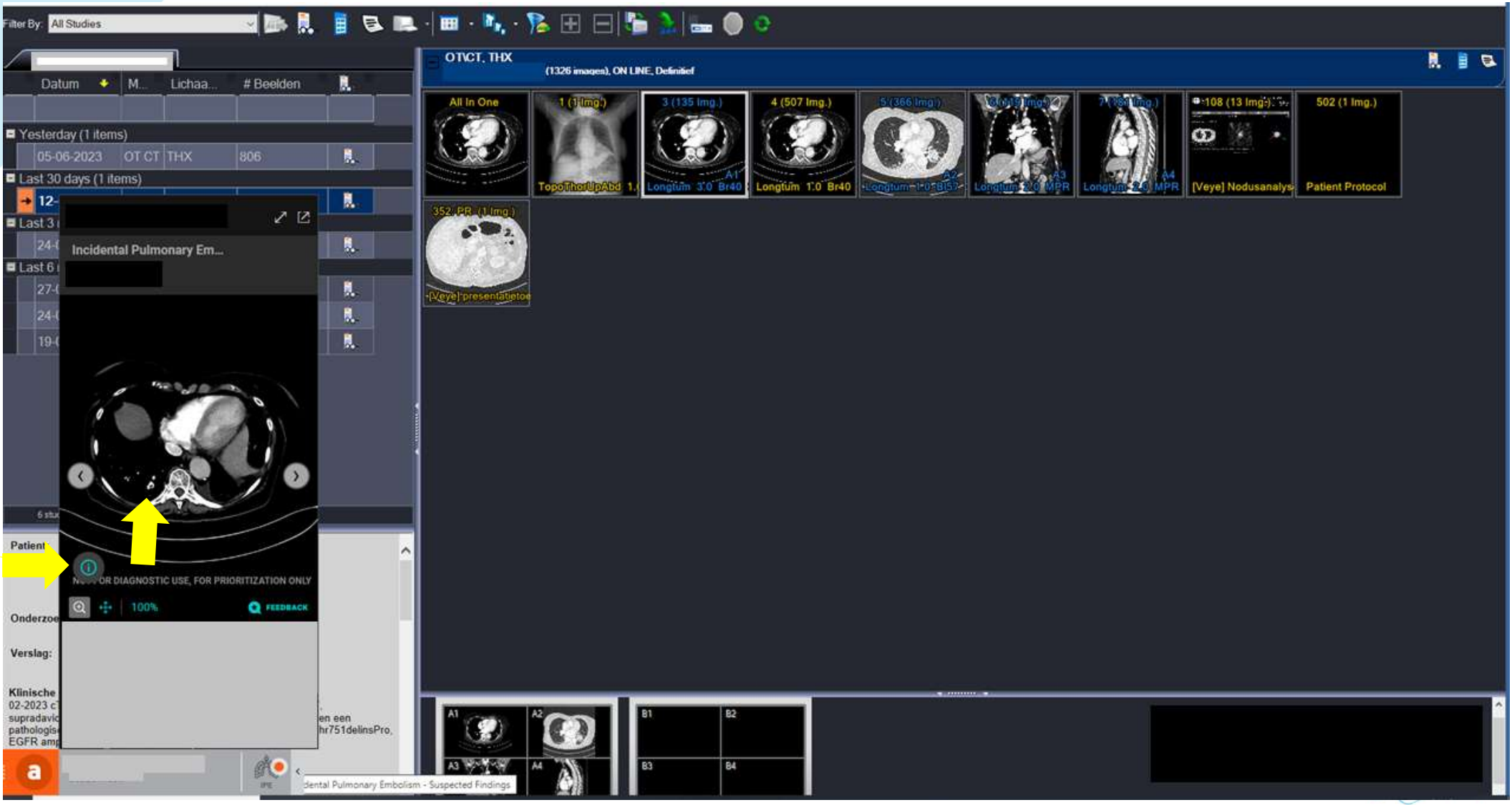
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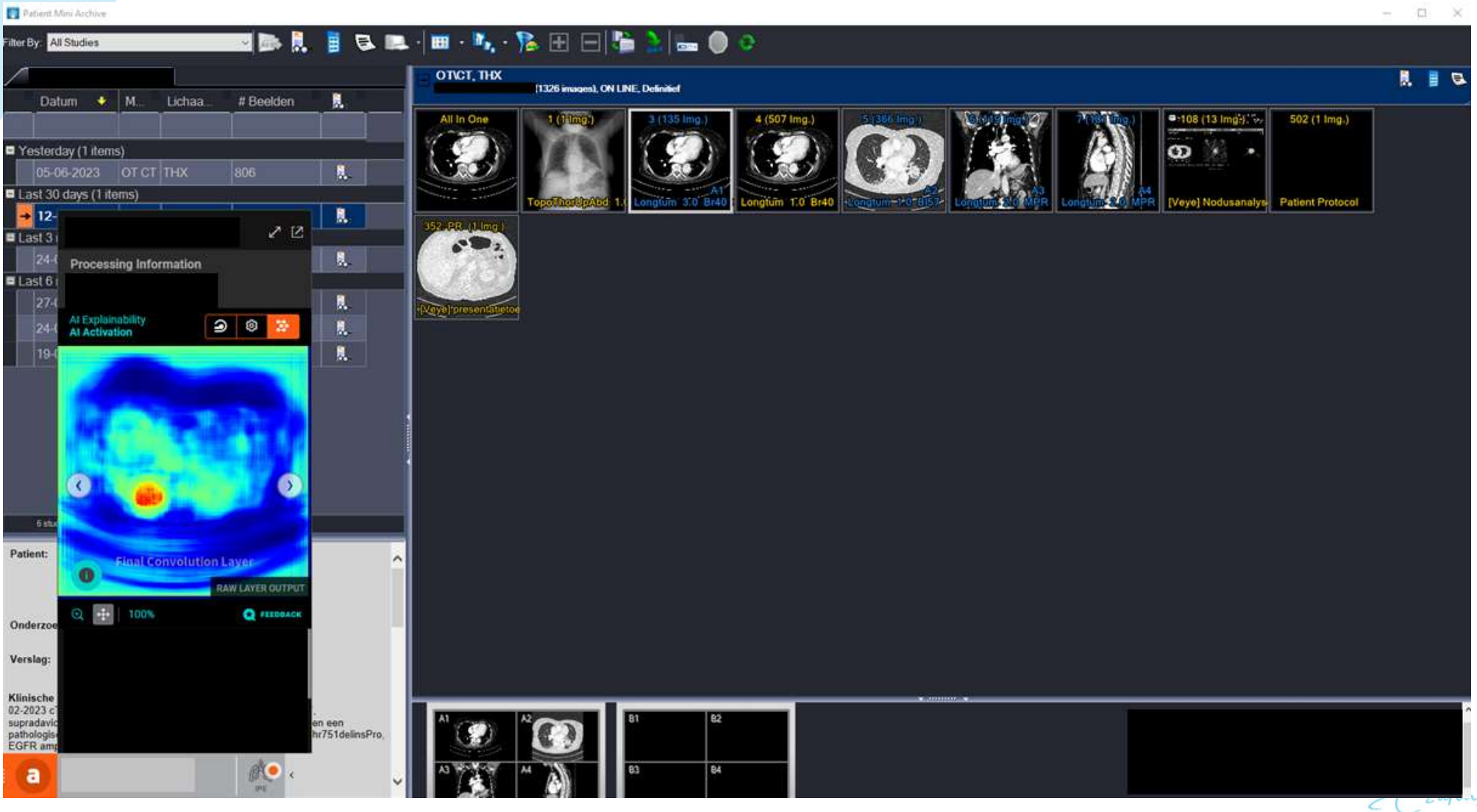
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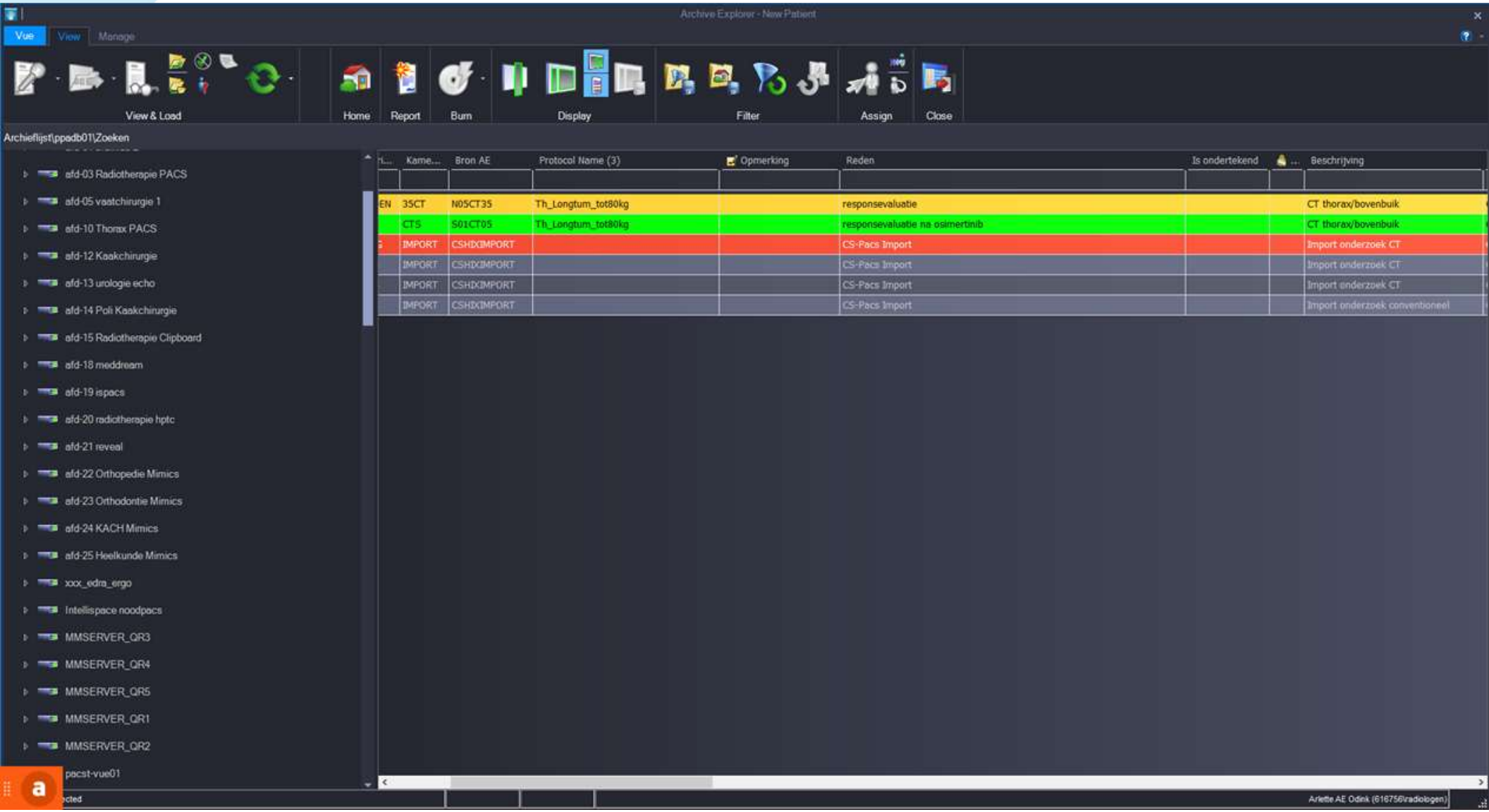
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Arlette AE Odink (616756\radiologen)

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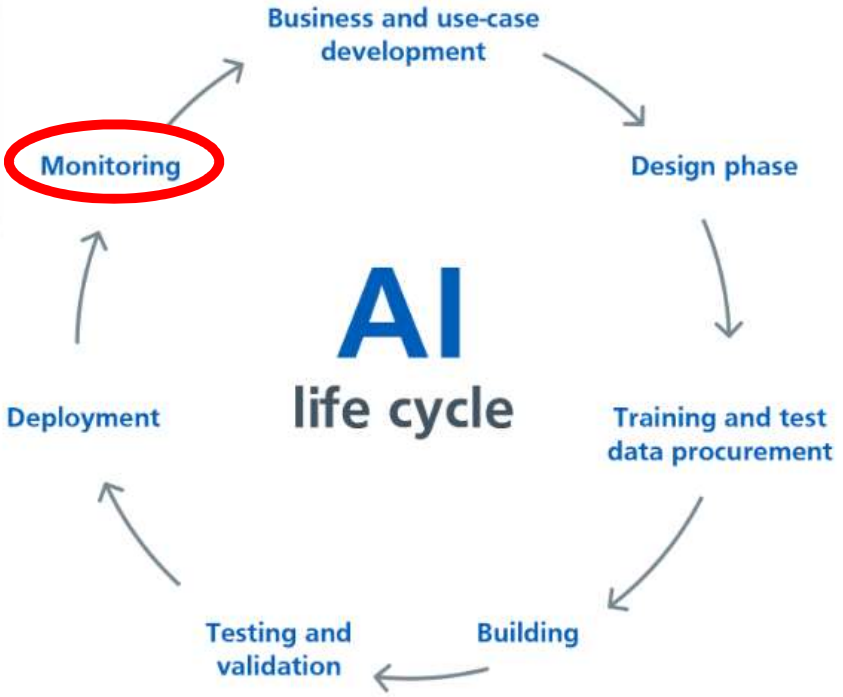
Ezafung

MONITORING

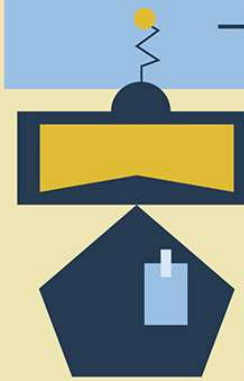


Roski, Joachim & Maier, Ezekiel & Vigilante, Kevin & Kane, Elizabeth & Matheny, Michael. (2021). Enhancing trust in AI through industry self-governance. Journal of the American Medical Informatics Association. 28. 10.1093/jamia/ocab065.
https://transform.england.nhs.uk/ai-lab/explore-all-resources/understand-ai/creating-international-approach-ai-healthcare/

What is the best way to address model drift in a radiology machine learning model?

The accuracy of machine learning (ML) models degrades over time

—called "model drift."



Assessed baseline model performance

Compared model accuracy after retraining

Final performance was evaluated using measures of precision (PPV), recall (sensitivity, TP) and F1 score

↓ Baseline model **performance** steadily decreased over time

↔ The baseline model **retrained with new data** was not significantly different from baseline *(precision=0.83 and recall=0.54)*

A new **random forest (RF)** model trained with augmented data had:

↑ significantly **better recall** vs. the baseline model *(0.80 vs. 0.66, p=0.04)*

↔ **comparable precision** *(0.90 vs. 0.86)*

Recalibration or refitting models may be sufficient in some cases, but training new models may be necessary to address model drift.

JACR VISUAL ABSTRACT

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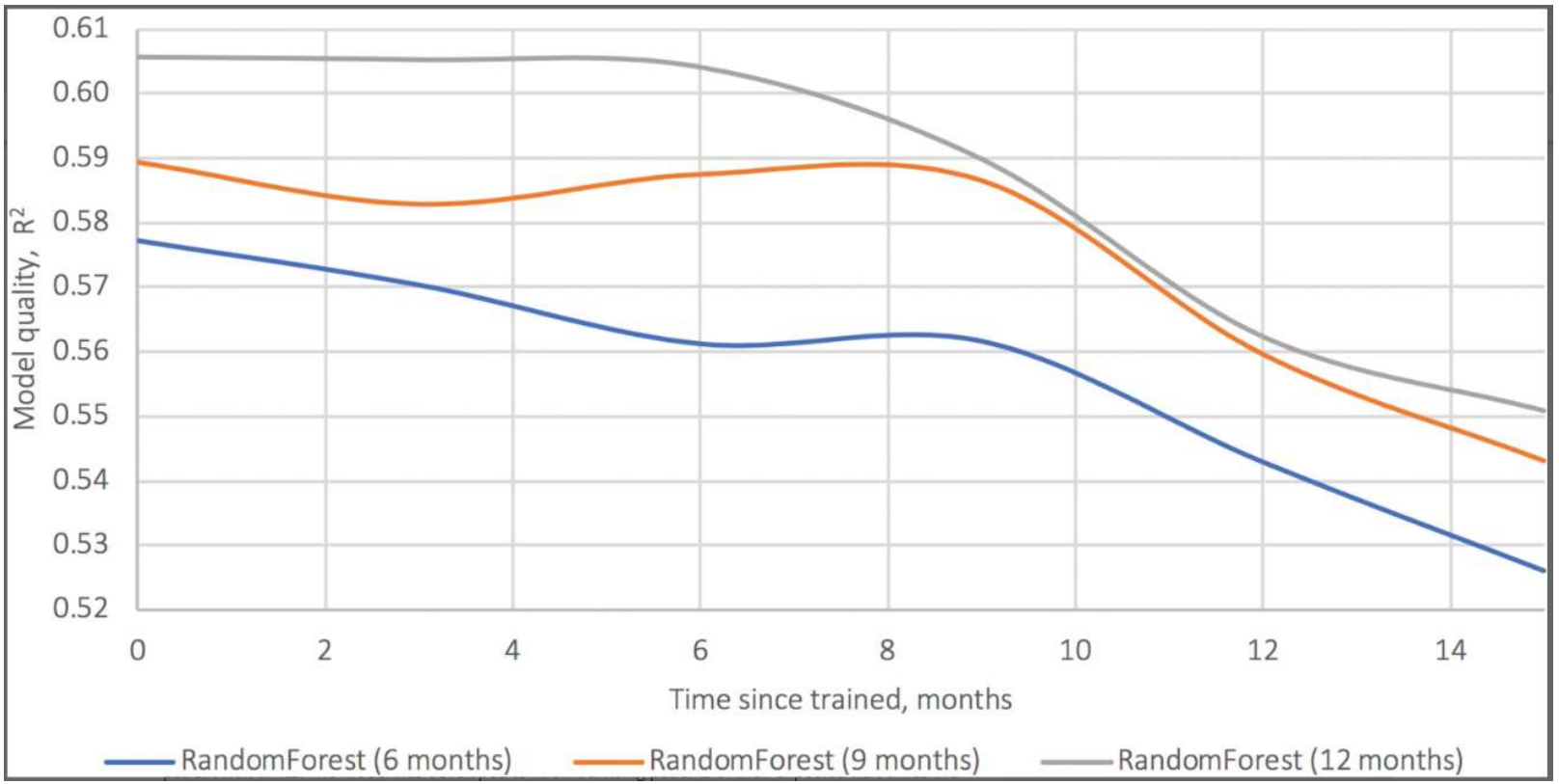
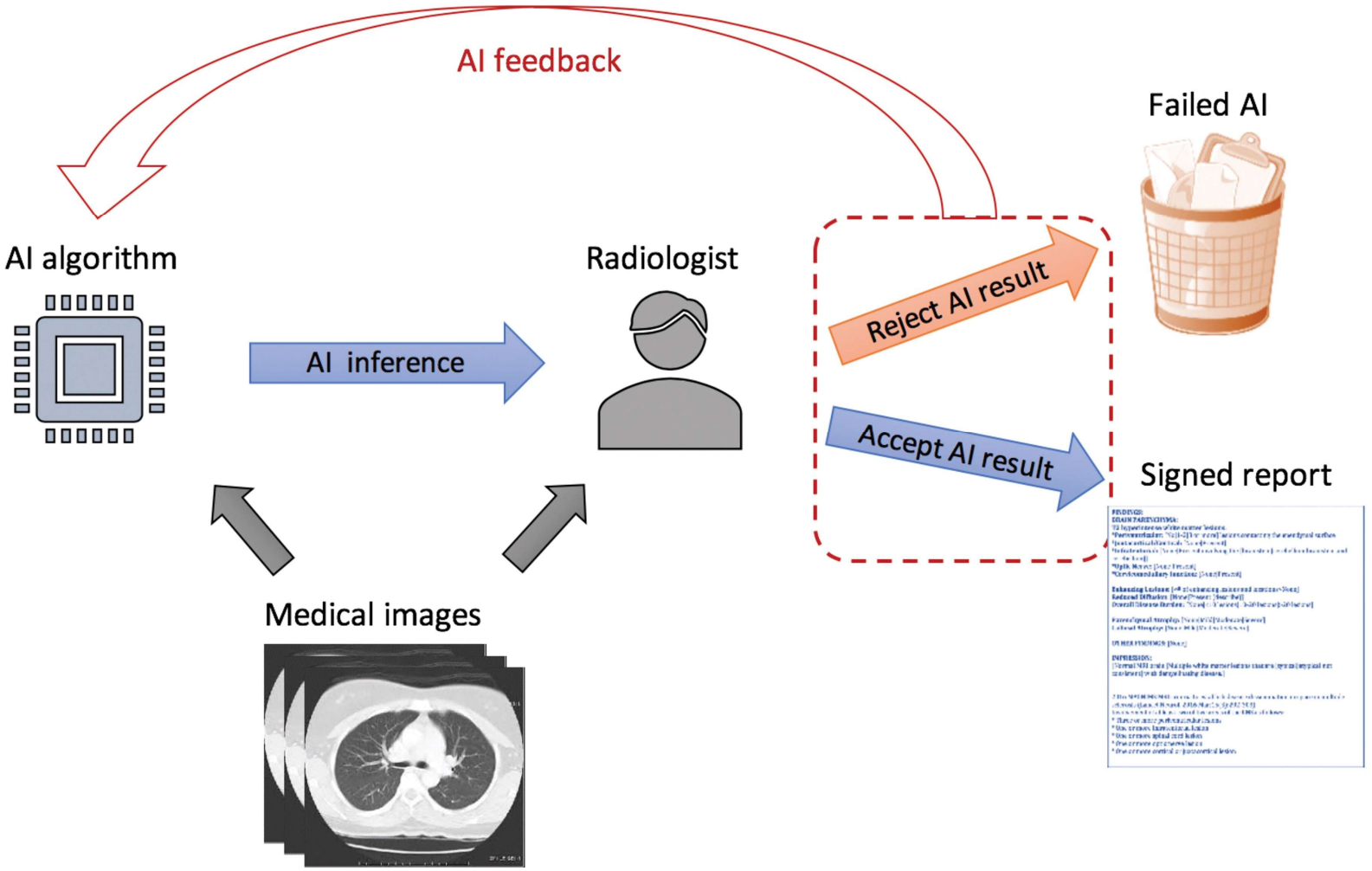
Lacson R, Eskian M, Licaros A, Kapoor N, Khorasani R. Machine Learning Model Drift: Predicting Diagnostic Imaging Follow-Up as a Case Example. J Am Coll Radiol. 2022 Oct;19(10):1162-1169. doi: 10.1016/j.jacr.2022.05.030. Epub 2022 Aug 16. PMID: 35981636.



Pianykh OS, Langs G, Dewey M, Enzmann DR, Herold CJ, Schoenberg SO, Brink JA. Continuous Learning AI in Radiology: Implementation Principles and Early Applications. Radiology. 2020 Oct;297(1):6-14. doi: 10.1148/radiol.2020200038. Epub 2020 Aug 25. PMID: 32840473.



Pianykh OS, Langs G, Dewey M, Enzmann DR, Herold CJ, Schoenberg SO, Brink JA. Continuous Learning AI in Radiology: Implementation Principles and Early Applications. Radiology. 2020 Oct;297(1):6-14. doi: 10.1148/radiol.2020200038. Epub 2020 Aug 25. PMID: 32840473.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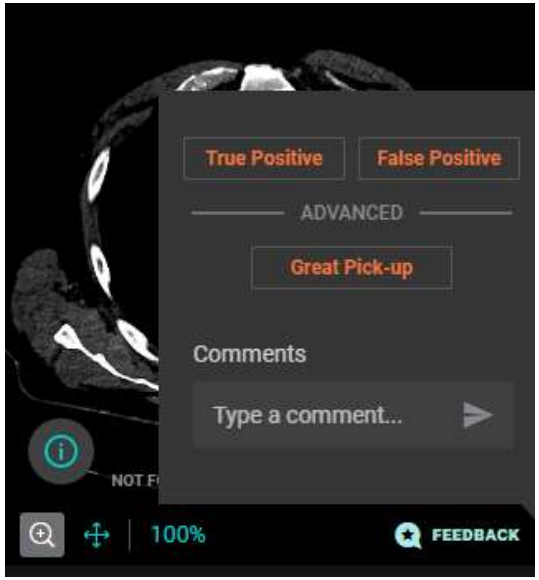
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NOW: MARKET / GOVERNANCE


SMART REPORTING
Medexprim
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median
OSIMIS
QLARITY IMAGING
image biopsy lab
12sigma
Therapixel
seno
CuraCloud
enlitic
QMENTA
PaxeraHealth
qure.ai
ai analysis inc.
Blackford
CureMetrix
JLK INSPECTION
quibim
zebra
WEKA.IO
terarecon
VAREX IMAGING
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BOLD BRAIN VENTURES
DNP
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GE Healthcare
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DeepRadiology
HEALTHMYNE
MEDICVISION
RADLogics
COMBINOSTICS
VIDA
DeepTek
BioMind
onyx
SOPHiA
BALZANO
contextflow
densitas
IBM Watson
mirada
RADIOBOTICS
SHUKUN
Fraunhofer MEVIS
icometrix
acadamian
COLLECTIVE MINDS RADIOLOGY
deepwise
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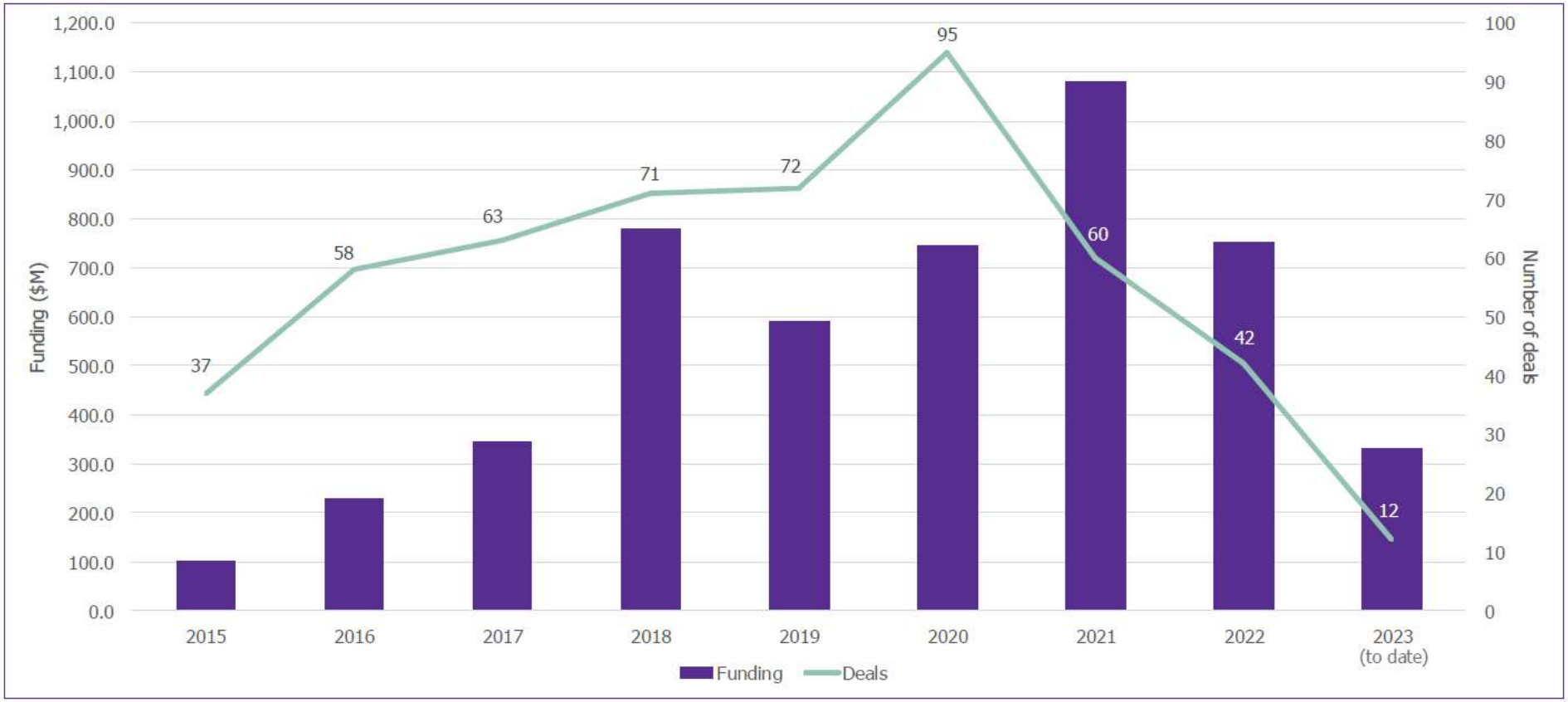
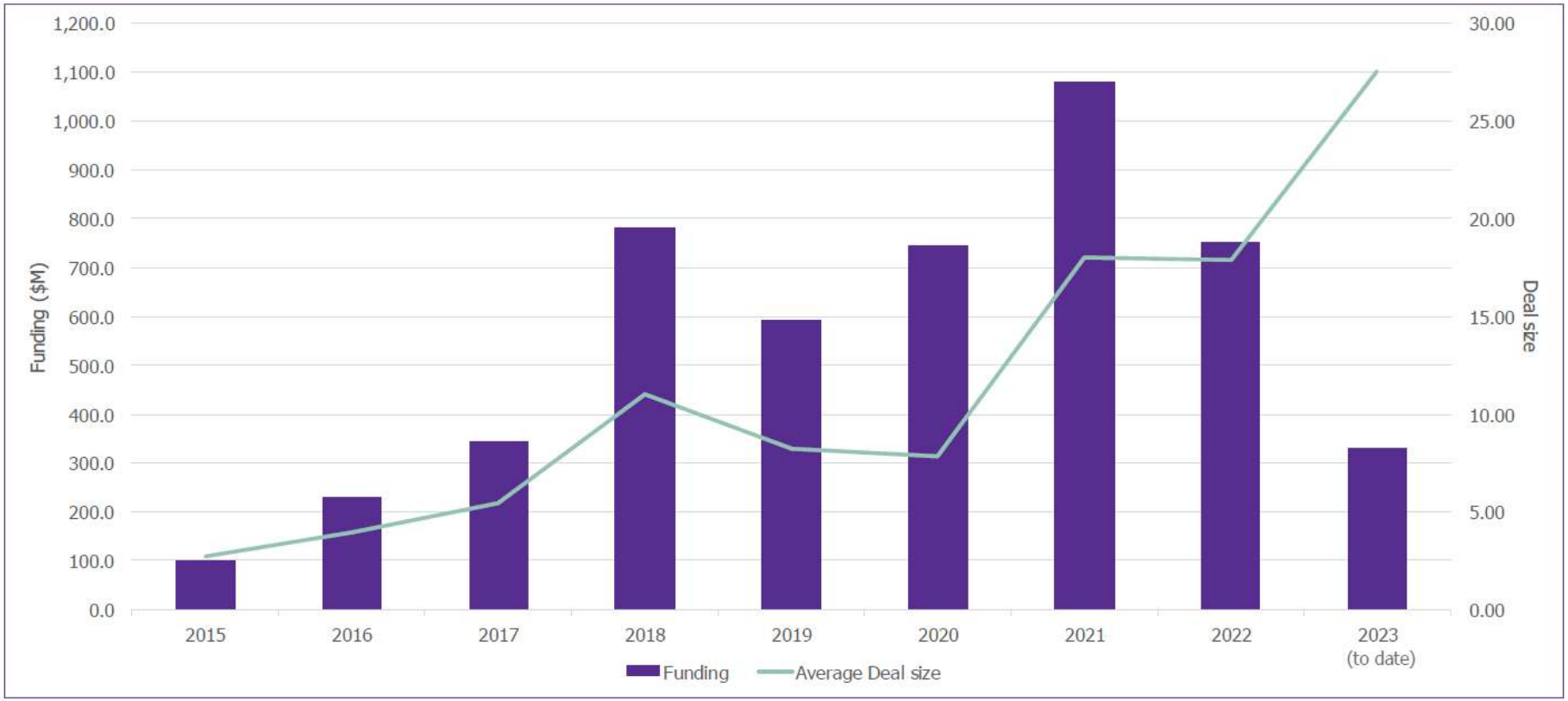
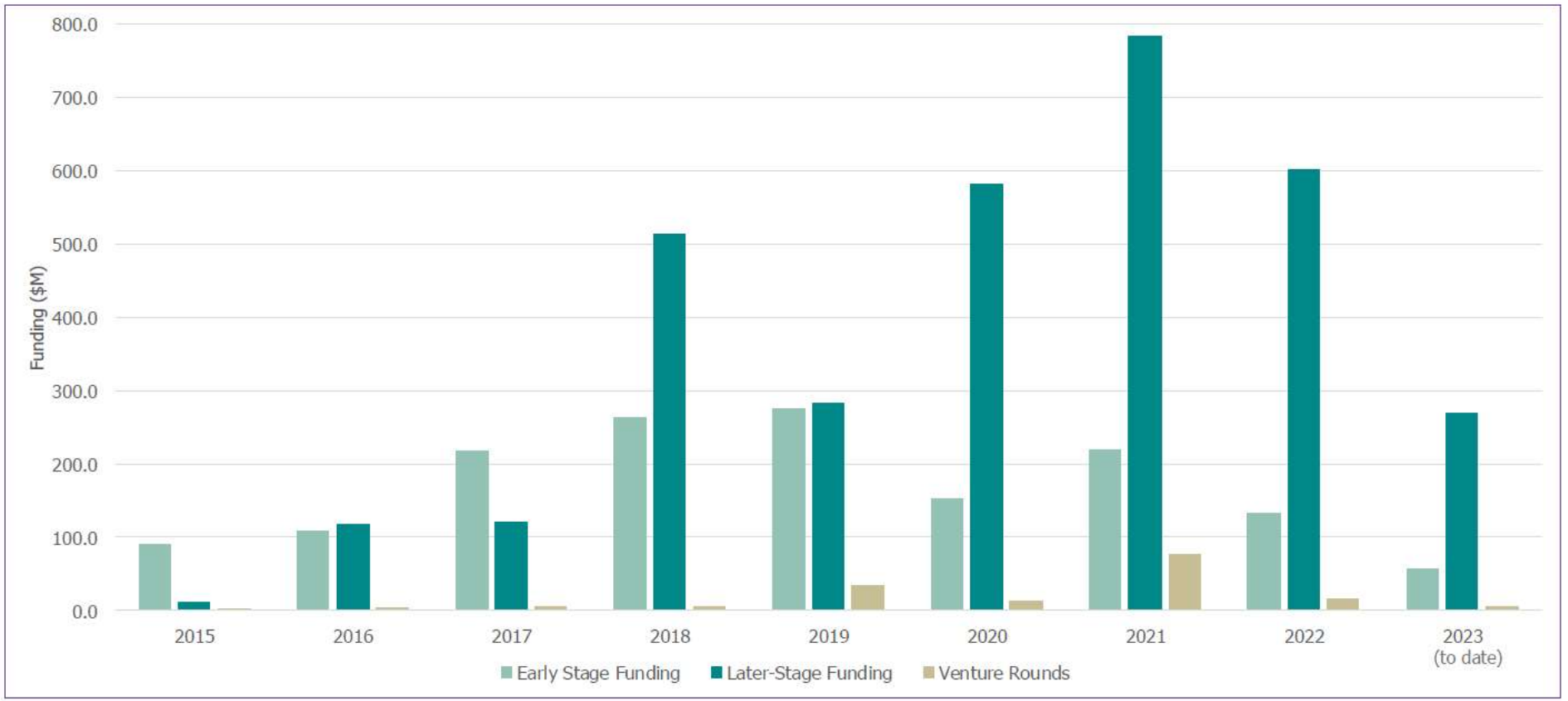
VC funding peaked at almost $1.1Bn in 2021; deal volume has declined since it peaked in 2020

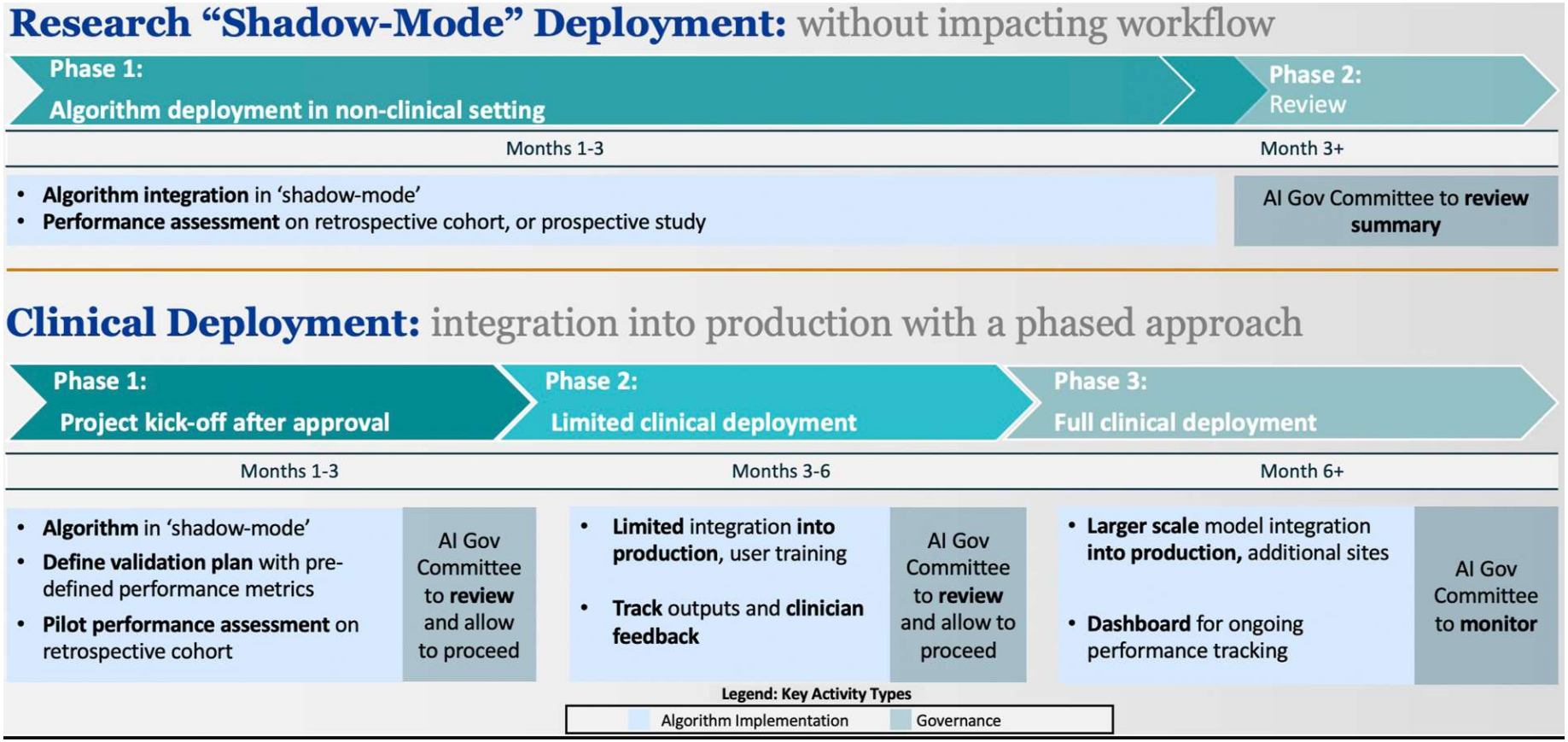


Average deal size has grown, more than tripling from $8m in 2020 to $28m in 2023



Early stage funding (pre-Series B) peaked in 2019; it has been surpassed by later-stage funding (Series B onwards) since 2018





Bizzo BC, Dasegowda G, Bridge C, Miller B, Hillis JM, Kalra MK, Durniak K, Stout M, Schultz T, Alkasab T, Dreyer KJ. Addressing the Challenges of Implementing Artificial Intelligence Tools in Clinical Practice: Principles From Experience. J Am Coll Radiol. 2023 Mar;20(3):352-360. doi: 10.1016/j.jacr.2023.01.002. PMID: 36922109.

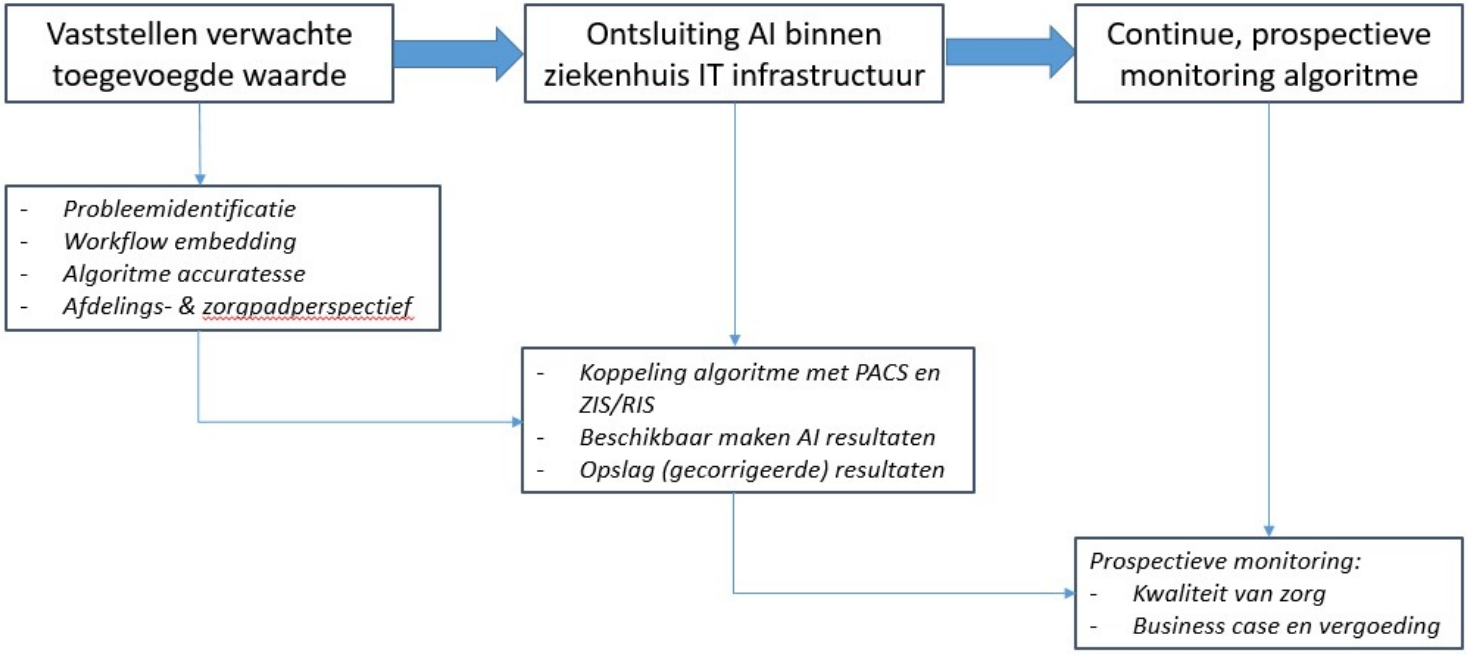
KUNSTMATIGE INTELLIGENTIE (AI)

AI: wat is de business case en hoe is AI te implementeren?

Jan-Jaap Visser

Wouter Veldhuis

Onder veel radiologen leeft de vraag hoe om te gaan met kunstmatige intelligentie (AI). Moeten we ermee aan de slag? En als we het willen gaan gebruiken, waar moeten we dan op letten? In dit artikel bespreken de auteurs een aantal zaken die van belang zijn om te overwegen voordat tot implementatie van AI kan worden overgegaan.



CONCLUSIONS

- Radiology AI
  - Imaging value chain
  - Which problem will be solved?
  - Agorithm performance
- Deployment / integration
  - How to connect algorithm?
  - How to integrate algorithm into the workflow?
- Monitoring
  - How to address model drift?
  - Possibilities for feedback / continuous input?
- Now: Market / governance
  - Consolidation to be expected
  - Local policy required

INTERACTIEVE CASUSWORKSHOP

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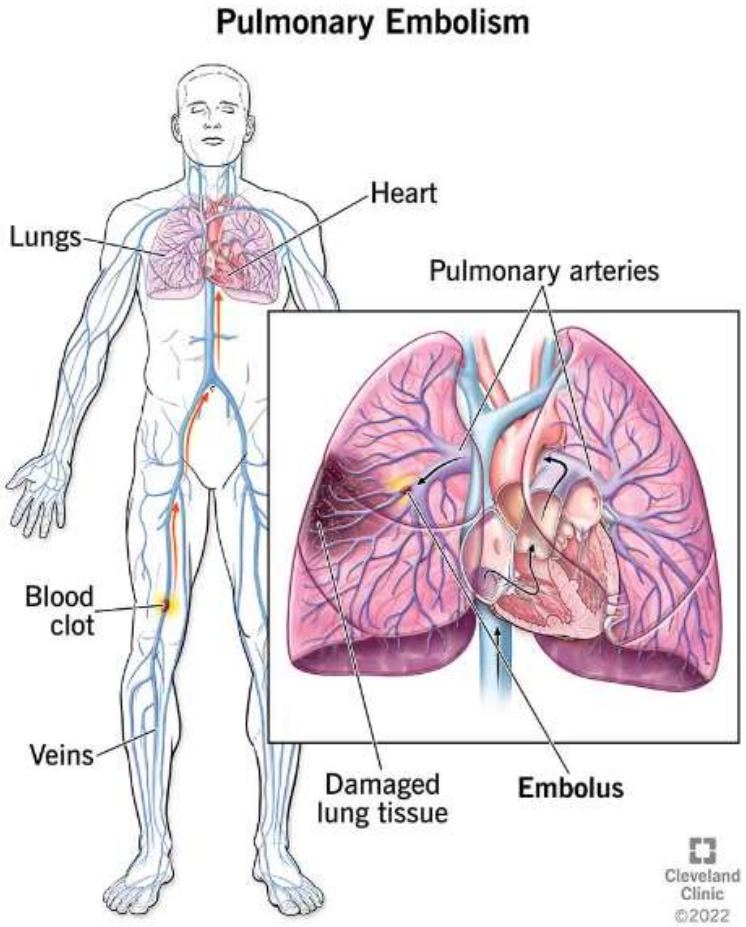
Pulmonary Embolism
Heart
Lungs
Pulmonary arteries
Blood clot
Veins
Damaged lung tissue
Embolus
Cleveland Clinic
©2022

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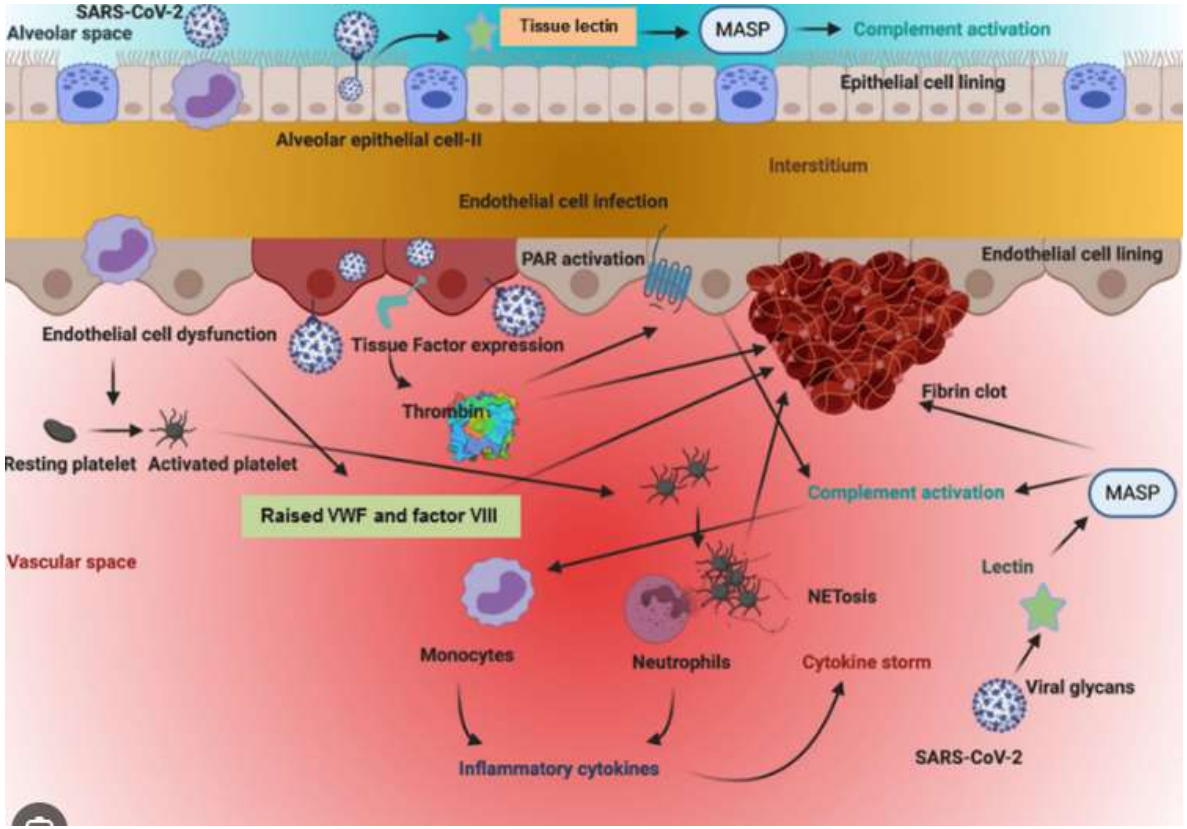
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MASP
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Alveolar epithelial cell-II
Interstitium
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PAR activation
Endothelial cell lining
Endothelial cell dysfunction
Tissue Factor expression
Thrombin
Fibrin clot
Resting platelet
Activated platelet
Raised VWF and factor VIII
Complement activation
MASP
Vascular space
Lectin
NETosis
Monocytes
Neutrophils
Cytokine storm
Viral glycans
SARS-CoV-2
Inflammatory cytokines

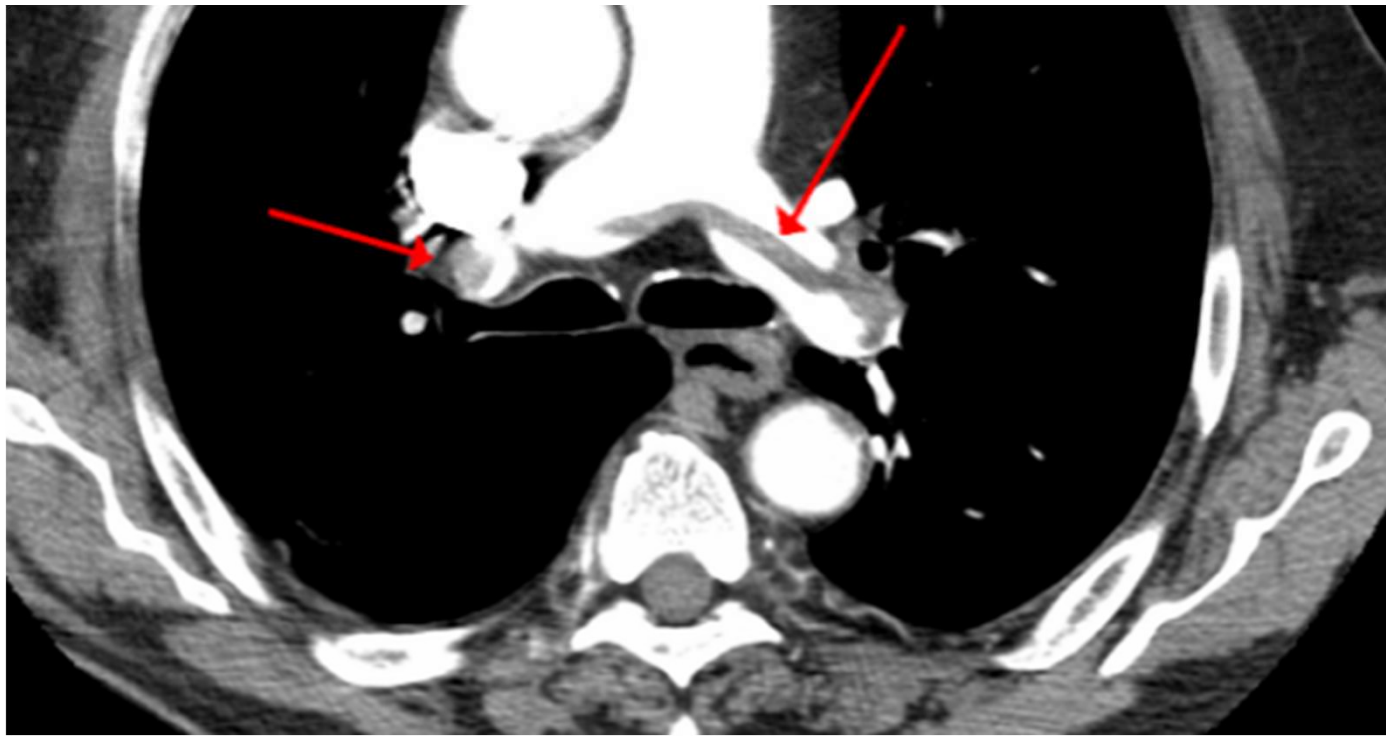
PULMONARY EMBOLISM (PE)

- symptomatic

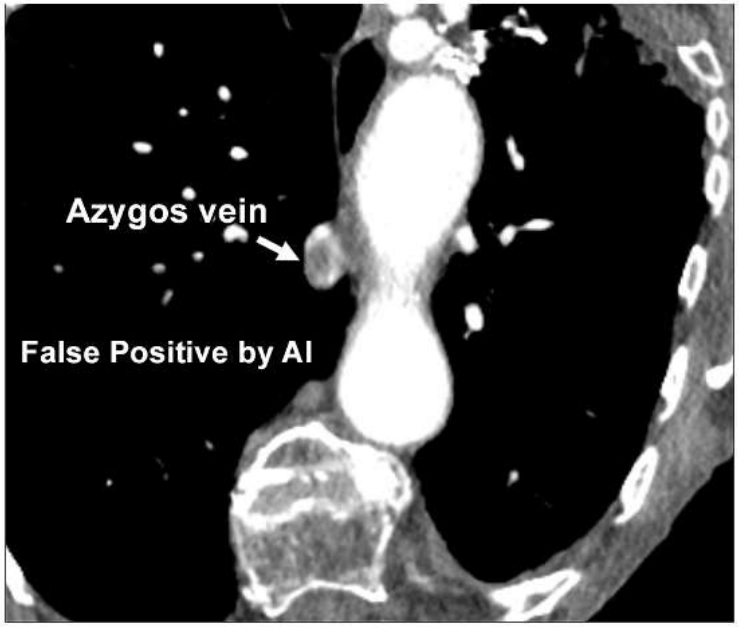
- incidental
  - >> prevalence 1-4%

SYMPTOMATIC PE

- CTA > scanning delay 20-30 seconds after contrast administration



Prospective Evaluation of AI Triage of Pulmonary Emboli at CTPA



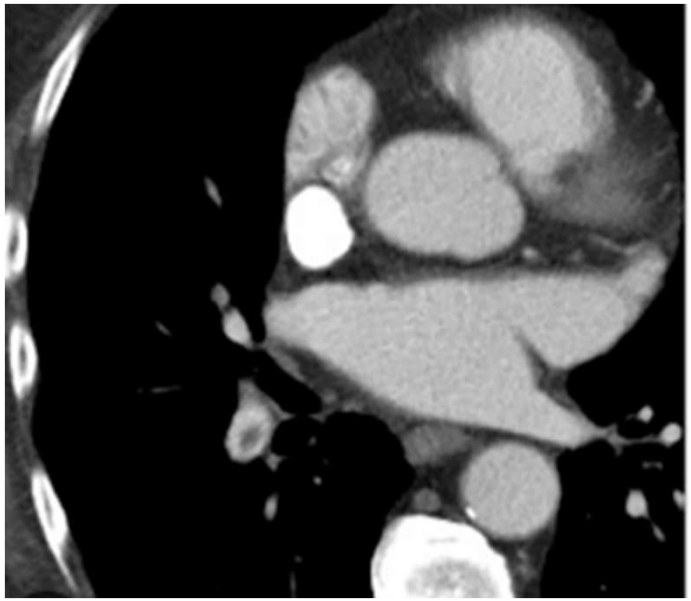
- Prospective study of 1436 participants undergoing 1526 consecutive CTPA examinations for suspected PE with a 16% positive rate.
- The accuracy and miss rates for radiologists were 98% and 12%, respectively, which were similar to those of radiologists aided by AI (99% and 6%, respectively).
- Radiologist miss rate for nonclinically significant PE was 33% (seven of 21) without AI and decreased to 14% (nine of 66) with AI.

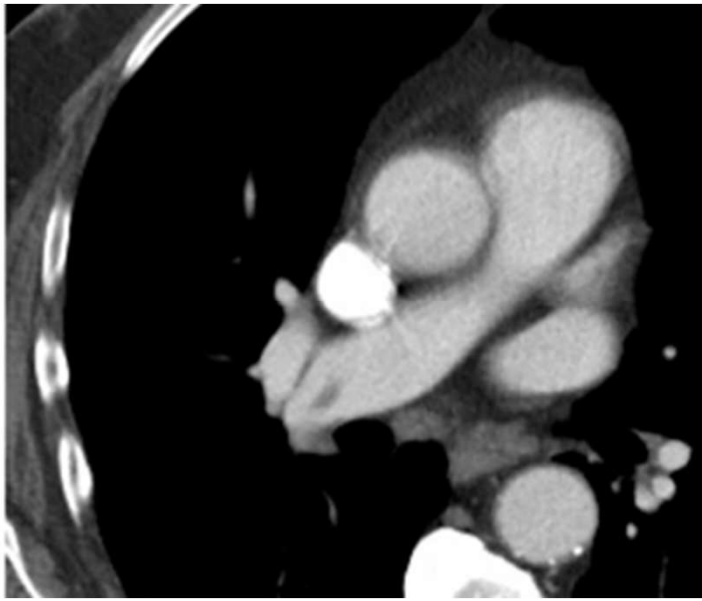
Rothenberg SA et al. Published Online: October 3, 2023
https://doi.org/10.1148/radiol.230702

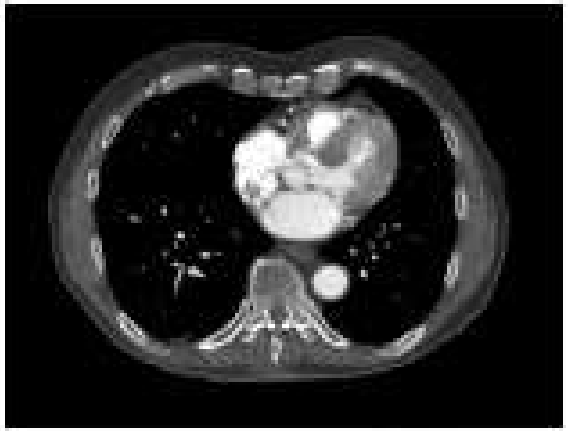
Radiology

INCIDENTAL PE

- CTA > scanning delay 60-90 seconds after contrast administration

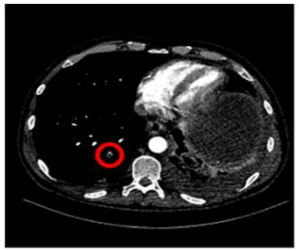


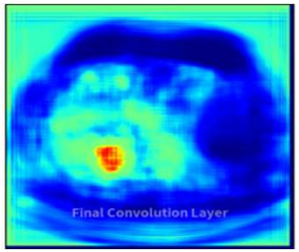




Incidental PE

510(k) Triage and notification software indicated for use in the analysis of CT images (not dedicated CTPA protocol) ; flags and communicates incidental Pulmonary Embolism (PE).





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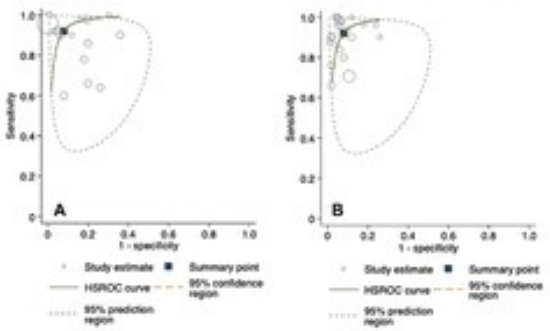
Artificial Intelligence in Fracture Detection: A Systematic Review and Meta-Analysis



Hierarchical summary receiver operating characteristic (HSROC) curves for **(A)** fracture detection algorithms and **(B)** clinicians with external validation test sets.

- In a meta-analysis of 42 studies (37 with radiography and five with CT), the pooled diagnostic performance using AI to detect fractures had a sensitivity of 92% and 91% and specificity of 91% and 91% on internal and external validation, respectively.
- Clinician performance was comparable to AI in fracture detection (sensitivity 91%, 92%; specificity 94%, 94%).
- Only 13 studies externally validated results, and only one study evaluated AI performance in a prospective clinical trial.

Kuo RYL et al. Published Online: March 29, 2022
https://doi.org/10.1148/radiol.211785
Radiology

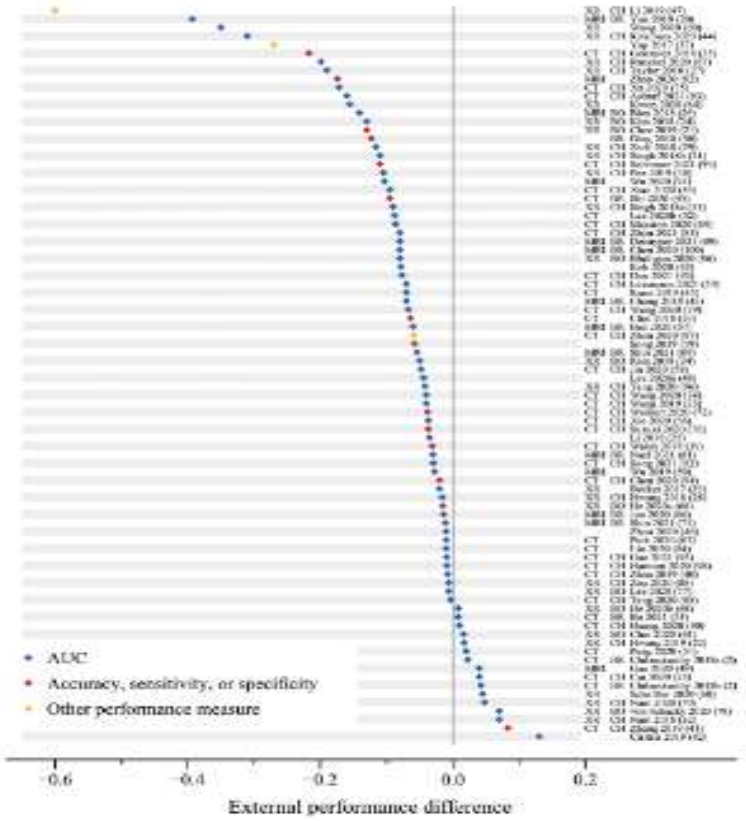
Lauritzen AD, Rodríguez-Ruiz A, von Euler-Chelpin MC, Lynge E, Vejborg I, Nielsen M, Karssemeijer N, Lillholm M. An Artificial Intelligence-based Mammography Screening Protocol for Breast Cancer: Outcome and Radiologist Workload. Radiology. 2022 Apr 19:210948. doi: 10.1148/radiol.210948. Epub ahead of print. PMID: 35438561.
https://pubs.rsna.org/doi/10.1148/ryai.210115
Kuo RYL, Harrison C, Curran TA, Jones B, Freethy A, Cussons D, Stewart M, Collins GS, Furniss D. Artificial Intelligence in Fracture Detection: A Systematic Review and Meta-Analysis. Radiology. 2022 Mar 29:211785. doi: 10.1148/radiol.211785. Epub ahead of print. PMID: 35348381.

Table 2. Study Design Characteristics of Articles Analyzed

Design Characteristic	All Articles (n = 516)	Articles Published in Medical Journals (n = 437)
External validation		
Used	31 (6.0)	27 (6.2)
Not used	485 (94.0)	410 (93.8)

Key Points

- Studies of deep learning algorithms for radiologic diagnosis infrequently include an external dataset, with our systematic review identifying 83 published studies that performed external validation over a 6-year period.
- Nearly half of studies that performed external validation reported at least a modest decrease in external performance, with nearly a quarter reporting a substantial decrease.



Yu AC, Mohajer B, Eng J. External Validation of Deep Learning Algorithms for Radiologic Diagnosis: A Systematic Review. Radiol Artif Intell. 2022 May 4;4(3):e210064. doi: 10.1148/ryai.210064. PMID: 35652114; PMCID: PMC9152694.

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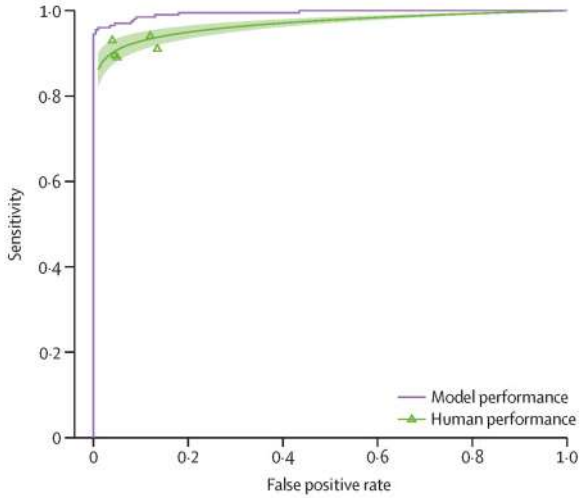
- Lack of diversity of datasets in AI poses risks
  - Algorithm detects proximal femur fractures
    - Model better than human
      - Operating point had to be changed to external validation set
      - Unexpected algorithm behavior (Paget)



Oakden-Rayner L, Gale W, Bonham TA, Lungren MP, Carneiro G, Bradley AP, Palmer LJ. Validation and algorithmic audit of a deep learning system for the detection of proximal femoral fractures in patients in the emergency department: a diagnostic accuracy study. Lancet Digit Health. 2022 May;4(5):e351-e358. doi: 10.1016/S2589-7500(22)00004-8. Epub 2022 Apr 5. PMID: 35396184.

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Radiol Cardiothorac Imaging. 2023 Apr; 5(2): e220163.
Published online 2023 Apr 20. doi: 10.1148/ryct.220163

PMCID: PMC10141443
PMID: 37124638

Artificial Intelligence Tool for Detection and Worklist Prioritization Reduces Time to Diagnosis of Incidental Pulmonary Embolism at CT

Laurens Topff, MD,✉ Erik R. Ranschaert, MD, PhD, Annemarieke Bartels-Rutten, MD, PhD, Adina Negoita, MD, Renee Menezes, PhD, Regina G. H. Beets-Tan, MD, PhD, and Jacob J. Visser, MD, PhD

Diagnostic Accuracy in Detection of IPE by the AI Software Alone

Table 2: Diagnostic Accuracy in Detection of IPE by the AI Software Alone

Variable	IPE Present	IPE Absent	Inconclusive	Total
AI positive	131	31	3	165
AI negative	12	11 559	0	11 571
Total	143	11 590	3	11 736

Note.—Data are numbers of scans. AI = artificial intelligence, IPE = incidental pulmonary embolism.

Topff L, Ranschaert ER, Bartels-Rutten A, Negoita A, Menezes R, Beets-Tan RGH, Visser JJ. Artificial Intelligence Tool for Detection and Worklist Prioritization Reduces Time to Diagnosis of Incidental Pulmonary Embolism at CT. Radiol Cardiothorac Imaging. 2023 Apr 20;5(2):e220163. doi: 10.1148/ryct.220163. PMID: 37124638; PMCID: PMC10141443.

RSNA

Artificial Intelligence Tool for Detection and Worklist Prioritization Reduces Time to Diagnosis of Incidental Pulmonary Embolism at CT

Key Result

Artificial intelligence (AI)-assisted workflow prioritization of incidental pulmonary embolism (IPE) on chest CT scans significantly reduced time to diagnosis in patients with cancer.

Patients:

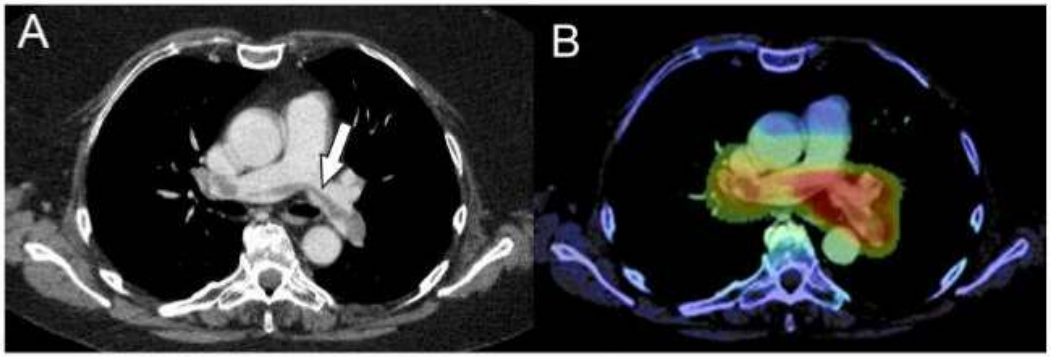
- 6447 adult oncology patients (n = 11,736 CT scans)

Methods:

- Regulatory-cleared AI software was evaluated to prioritize IPE on routine chest CT scans with intravenous contrast.
- Diagnostic accuracy metrics were calculated, and temporal endpoints were assessed at three time periods: routine workflow without AI, human triage without AI, and worklist prioritization with AI (prospective evaluation)

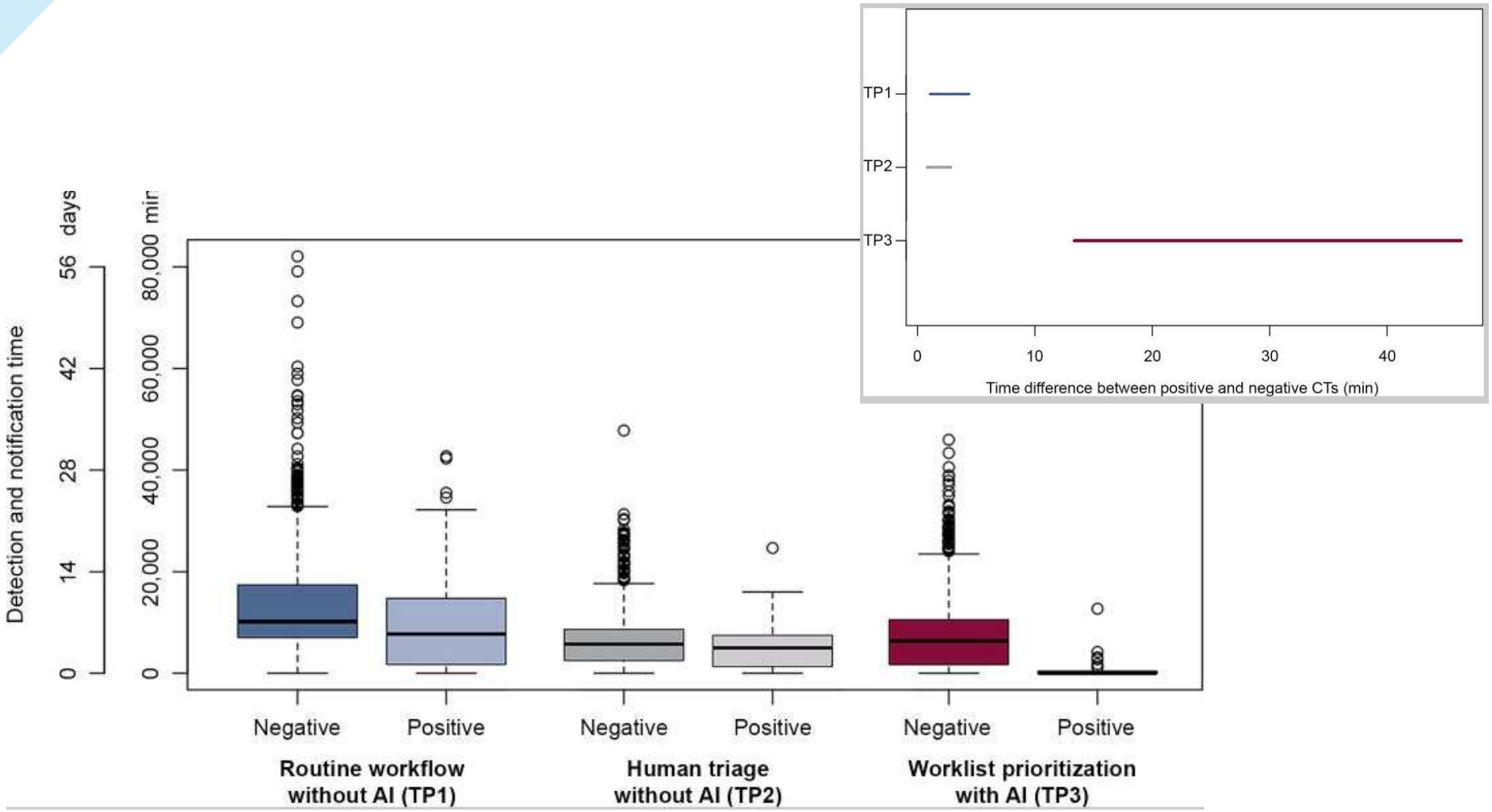
Results:

- The AI software achieved high diagnostic accuracy for IPE detection:
  - Sensitivity = 91.6%
  - Specificity = 99.7%
  - NPV = 99.9%
- Missed rate of IPE significantly reduced from 44.8% to 2.6% when radiologists were assisted by AI.
- Median detection and notification time of IPE reduced from several days to 1 hour in a practice with a backlog of unreported examinations.



Topff L et al. Published Online: April 20, 2023
https://doi.org/10.1148/ryct.220163

Radiology: Cardiothoracic Imaging



Topff L, Ranschaert ER, Bartels-Rutten A, Negoita A, Menezes R, Beets-Tan RGH, Visser JJ. Artificial Intelligence Tool for Detection and Worklist Prioritization Reduces Time to Diagnosis of Incidental Pulmonary Embolism at CT. Radiol Cardiothorac Imaging. 2023 Apr 20;5(2):e220163. doi: 10.1148/ryct.220163. PMID: 37124638; PMCID: PMC10141443.

Circulation Journal
doi:10.1253/circj.CJ-21-0457

Are We Overtreating Incidental Pulmonary Embolism?

The hazard of therapeutic doses of anticoagulants in patients with isolated subsegmental pulmonary embolism

Table 2 Treatment outcomes of patients with confirmed SSPE, excluding DVT and cancer patients

	Total ($N=69$)	Treated (N 61)	Not treated (N 8)
Type event (N; %)			
Provoked	37 (53.6)	33 (54.1)	4 (50)
Unprovoked	32 (46.4)	28 (45.9)	4 (50)
Bleeding events	8 (11.5)	7 (11.4)	1 (12.5)
Major	2 (2.8)	2 (fatal)	–
CRNMB	6 (86.9)	5	1
Death	6	4 (2 fatal bleeding)	2

LMWH low molecular weight heparin, *DOAC* direct oral anticoagulant. *VTE* venous thromboembolism, *CRNMB* clinically-relevant non major bleeding

Ceccato D, Di Vincenzo A, Rossato M, Pesavento R, De Conti G, Prandoni P, Vettor R. The hazard of therapeutic doses of anticoagulants in patients with isolated subsegmental pulmonary embolism. J Thromb Thrombolysis. 2023 Jul;56(1):207-209. doi: 10.1007/s11239-023-02815-9. Epub 2023 Apr 26. PMID: 37099075.

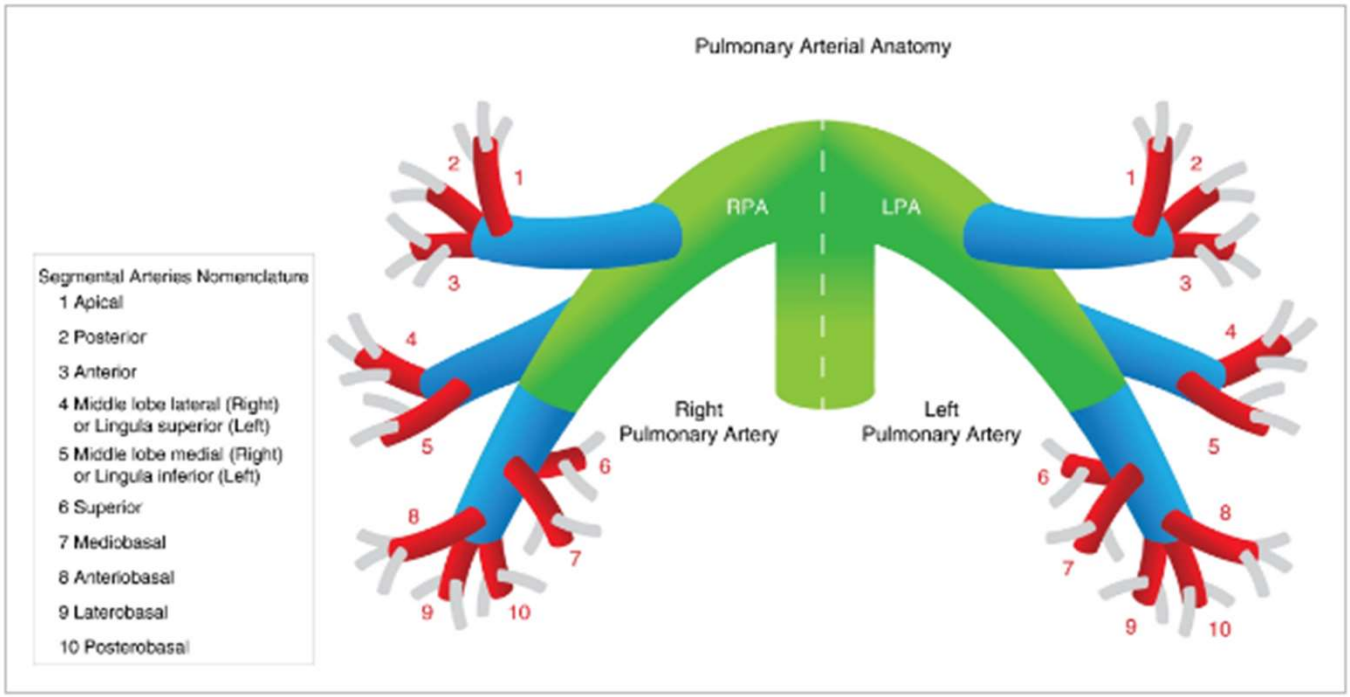
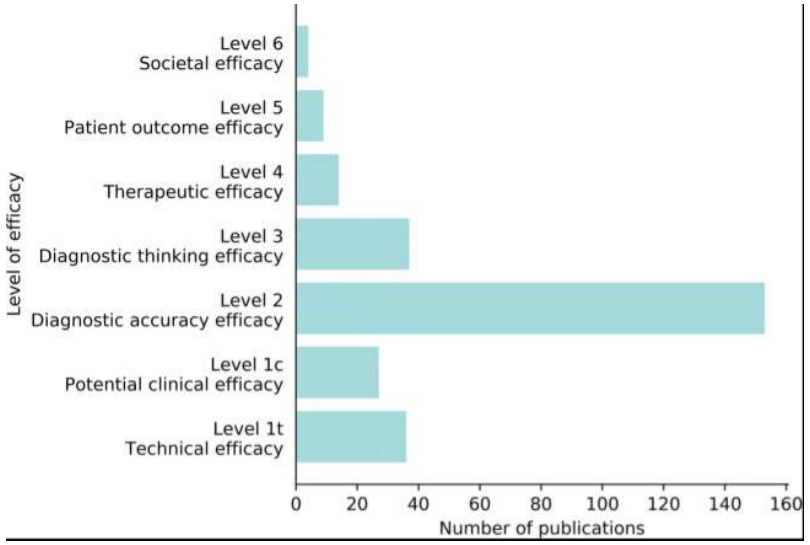


Figure 1

Open in figure viewer | PowerPoint

Schematic overview of anatomy of the pulmonary artery; green branches represent main and interlobar arteries, blue branches lobar arteries, red branches segmental arteries, and gray branches subsegmental arteries

Level	Example
1. Technical efficacy	Applicability
2 Diagnostic accuracy efficacy	Sensitivity, specificity
3. Diagnostic thinking efficacy	Impact on diagnosis
4. Therapeutic efficacy	Impact on treatment decisions
5. Patient outcomes efficacy	Overall survival
6. Societal efficacy	Cost-effectiveness



Fryback et al.; The efficacy of diagnostic imaging; MDM 1991
van Leeuwen KG, Schalekamp S, Rutten MJCM, van Ginneken B, de Rooij M. Artificial intelligence in radiology: 100 commercially available products and their scientific evidence. Eur Radiol. 2021 Jun;31(6):3797-3804. doi: 10.1007/s00330-021-07892-z. Epub 2021 Apr 15. PMID: 33856519; PMCID: PMC8128724.

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Review > Eur J Radiol Open. 2022;9:100438. doi: 10.1016/j.ejro.2022.100438. Epub 2022 Aug 18.

Artificial intelligence model on chest imaging to diagnose COVID-19 and other pneumonias: A systematic review and meta-analysis

Lu-Lu Jia [1], Jian-Xin Zhao [1], Ni-Ni Pan [1], Liu-Yan Shi [1], Lian-Ping Zhao [2], Jin-Hui Tian [3], Gang Huang [2]

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PREVIOUS NEXT

Original Research
Evidence-based Practice

Artificial Intelligence in Fracture Detection: A Systematic Review and Meta-Analysis

Rachel Y. L. Kuo, Conrad Harrison, Terry-Ann Curran, Benjamin Jones, Alexander Freethy, David Cussons, Max Stewart, Gary S. Collins, Dominic Furniss

Author Affiliations

Published Online: Mar 29 2022 | https://doi.org/10.1148/radiol.211785

Home > Radiology > Vol. 301, No. 3

PREVIOUS NEXT

Original Research
Pediatric Imaging

Free Access

Artificial Intelligence Algorithm Improves Radiologist Performance in Skeletal Age Assessment: A Prospective Multicenter Randomized Controlled Trial

David K. Eng, Nishith B. Khandwala, Jin Long, Nancy R. Fefferman, Shailee V. Lala, Naomi A. Strubel, Sarah S. Milla, Ross W. Filice, Susan E. Sharp, Alexander J. Towbin, Michael L. Francavilla, Summer L. Kaplan, Kirsten Ecklund. ... Show all authors

Author Affiliations

Published Online: Sep 28 2021 | https://doi.org/10.1148/radiol.2021204021

Home > Radiology > Vol. 307, No. 2

PREVIOUS NEXT

Original Research
Thoracic Imaging

AI Improves Nodule Detection on Chest Radiographs in a Health Screening Population: A Randomized Controlled Trial

Ju Gang Nam, Eui Jin Hwang, Jayoun Kim, Nanhee Park, Eun Hee Lee, Hyun Jin Kim, Miyeon Nam, Jong Hyuk Lee, Chang Min Park, Jin Mo Goo

Author Affiliations

Published Online: Feb 7 2023 | https://doi.org/10.1148/radiol.221894

Nevertheless, RCTs remain the most powerful type of experimental study. [4] In light of the AI revolution in radiology, we believe the time has come for RCTs and encourage further research in this important field.

https://www.researchgate.net/figure/Hierarchy-of-evidence-pyramid-The-pyramidal-shape-qualitatively-integrates-the-amount-of_fig1_311504831

Gorenstein L, Soffer S, Apter S, Konen E, Klang E. AI in radiology: is it the time for randomized controlled trials? Eur Radiol. 2023 Jun;33(6):4223-4225. doi: 10.1007/s00330-022-09381-3. Epub 2023 Jan 4. PMID: 36597003.

- Costs:
  - Costs AI model / algorithm
  - Costs infrastructure / hardware
  - Costs personnel
    - Implementation
    - Monitoring

  - Extra treatment (due to increased detection of pulmonary embolisms, extra detection of osteoporosis)

https://ai.myesr.org/articles/the-cost-of-ai-in-radiology-is-it-really-worth-it/

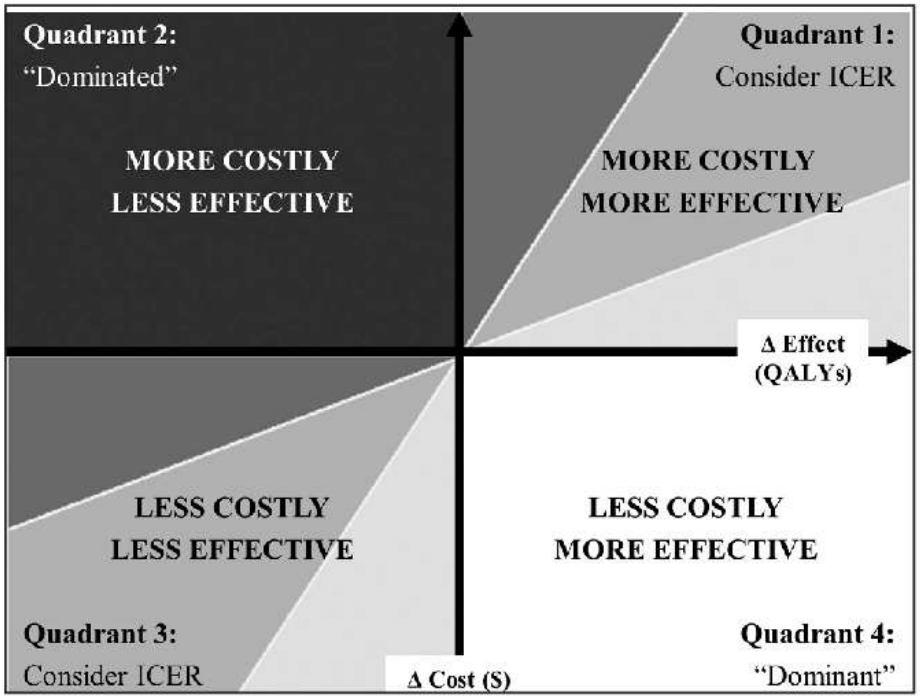
REVENUES VS COSTS

$$\text{Patient value} = \frac{\text{patient-relevant } \textbf{outcomes}}{\textbf{costs} \text{ per patient to achieve these outcomes}}$$

Incremental Cost-Effectiveness Ratio (ICER)

$$\text{ICER} = \frac{(C_1 - C_0)}{(E_1 - E_0)}$$

C_1 = cost in intervention group
C_0 = cost in control group
E_1 = effect in intervention group
E_0 = effect in control group



Cape, Jennifer D et al. "Introduction to Cost-Effectiveness Analysis for Clinicians." *University of Toronto Medical Journal* 90 (2013): 103-105.

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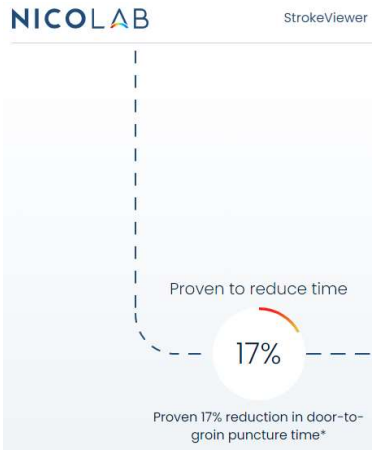
- Perspectives:
  - Micro > department level
    - Can we report faster?
  - Meso > care pathway level
    - Can turnaround times be accelerated?
    - Effect of additional detection of pulmonary embolisms?
  - Macro > societal level
    - Is the number of fractures decreasing?

Eur Radiol. 2023 Jan;33(1):360-367. doi: 10.1007/s00330-022-08973-3. Epub 2022 Jul 2.

Impact of a content-based image retrieval system on the interpretation of chest CTs of patients with diffuse parenchymal lung disease

Sebastian Röhrich [1], Benedikt H Heidinger [1], Florian Prayer [1], Michael Weber [1], Markus Krenn [2], Rui Zhang [2], Julie Sufana [2], Jakob Scheithe [2], Incifer Kanbur [1], Aida Korajac [1], Nina Pötsch [1], Marcus Raudner [1], Ali Al-Mukhtar [1], Barbara J Fueger [1], Ruxandra-Iulia Milos [1], Martina Scharitzer [1], Georg Langs [2 3], Helmut Prosch [4]



Osteoporos Int. 2022 Dec;33(12):2547-2561. doi: 10.1007/s00198-022-06491-y. Epub 2022 Aug 6.

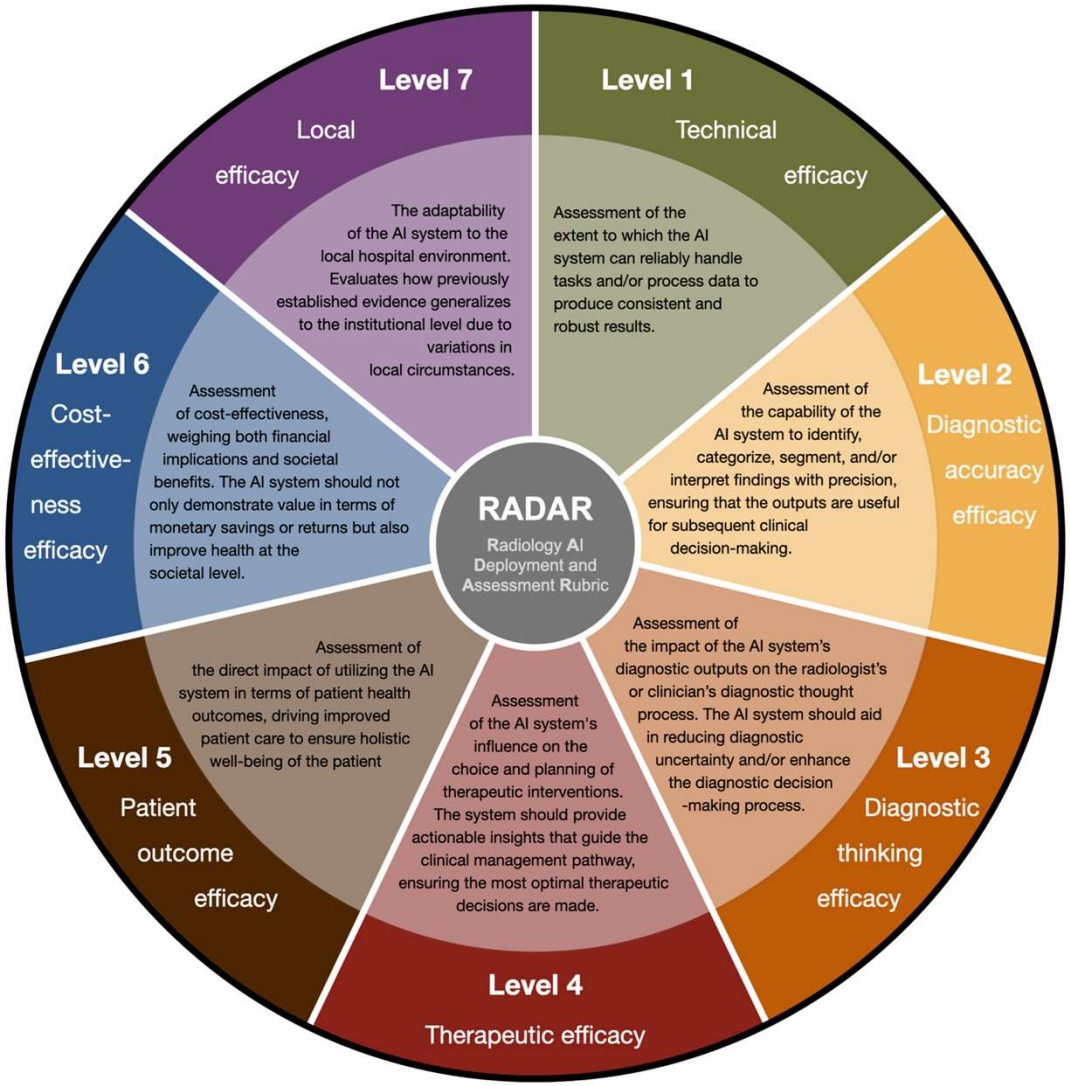
Opportunistic osteoporosis screening using chest CT with artificial intelligence

Jinrong Yang [# 1], Man Liao [# 2], Yaoling Wang [2], Leqing Chen [1], Linfeng He [2], Yingying Ji [1], Yao Xiao [1], Yichen Lu [3], Wenliang Fan [1], Zhuang Nie [1], Ruiyun Wang [2], Benling Qi [4], Fan Yang [5]

- Considerations regarding reimbursement for AI by insurer:

  - Not many real-world examples that have proven that AI is valuable, so that the use of AI is reimbursed
  - There is no reimbursement for PACS or for radiology information systems (RIS) or electronic health records (EHR), they are simply practice costs
  - The lack of reimbursement for AI may deter hospitals from purchasing the technology

https://radiologybusiness.com/topics/artificial-intelligence/what-roi-ai-adoption-radiology?utm_source=newsletter&utm_medium=rb_news



Boverhof et al; Radiology AI Deployment and Assessment Rubric (RADAR) for value-based AI in Radiology; accepted for publication in Insights into Imaging

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