digitalhealth

AI + DATA

Deep dive: AI in clinical imaging and diagnostics, progress so far

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Internal Medicine Doctor
University College
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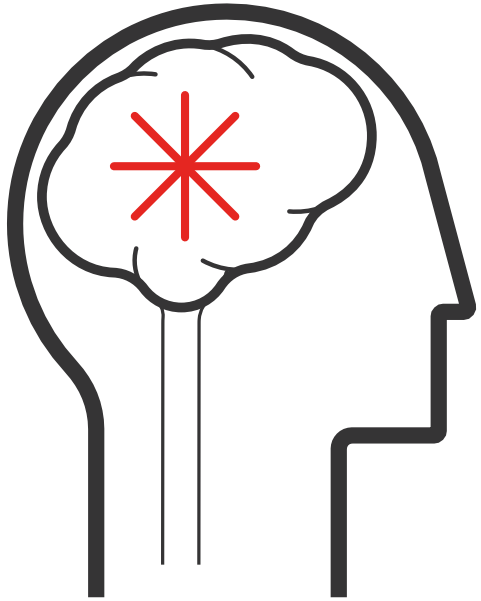
#AIDATA23

Digital Transformation of the Acute Stroke Pathway Using AI

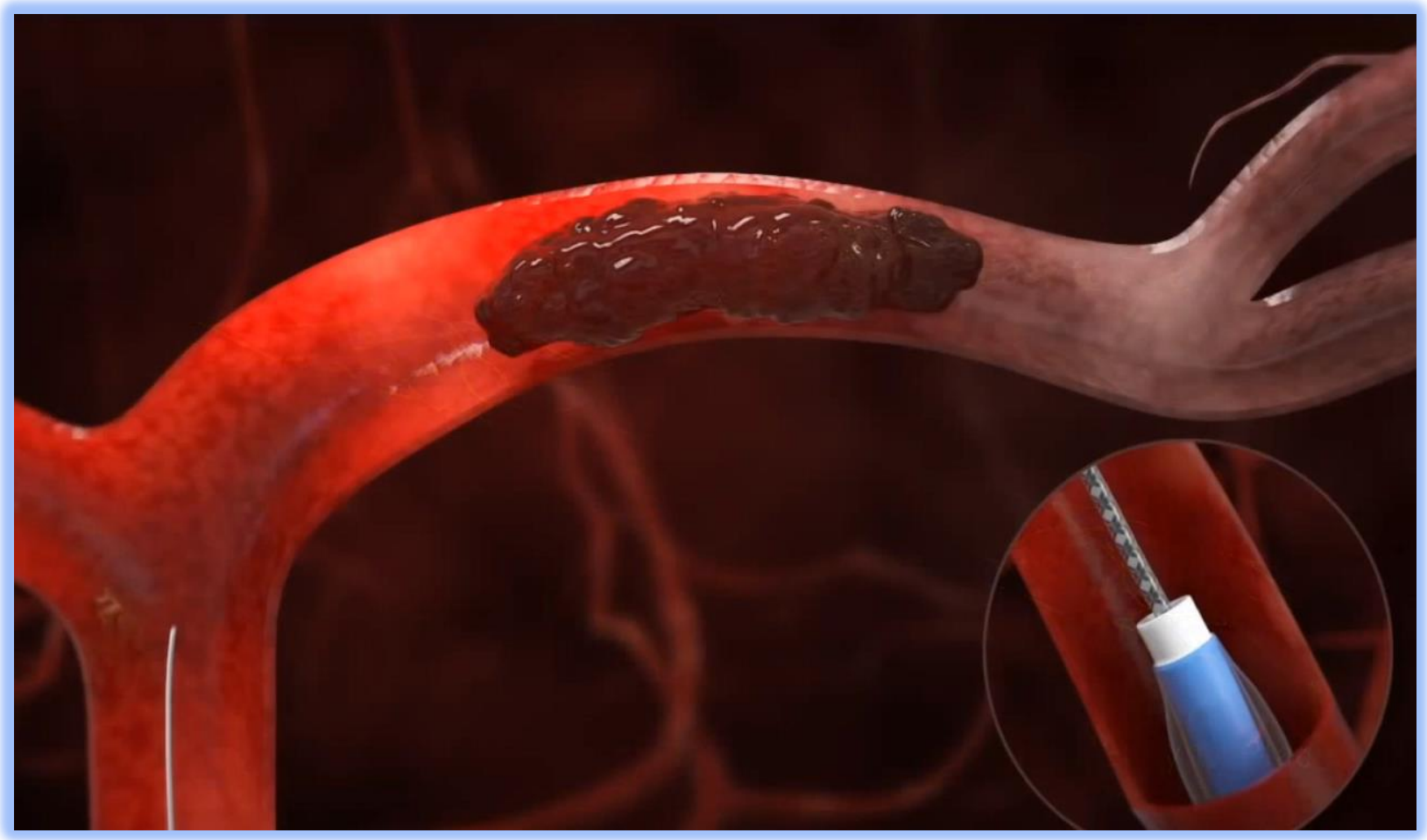
Dr Kiruba Nagaratnam
Consultant Stroke Physician & ISDN Clinical Lead for Stroke
The Royal Berkshire NHS Foundation Trust

The Burden of Stroke

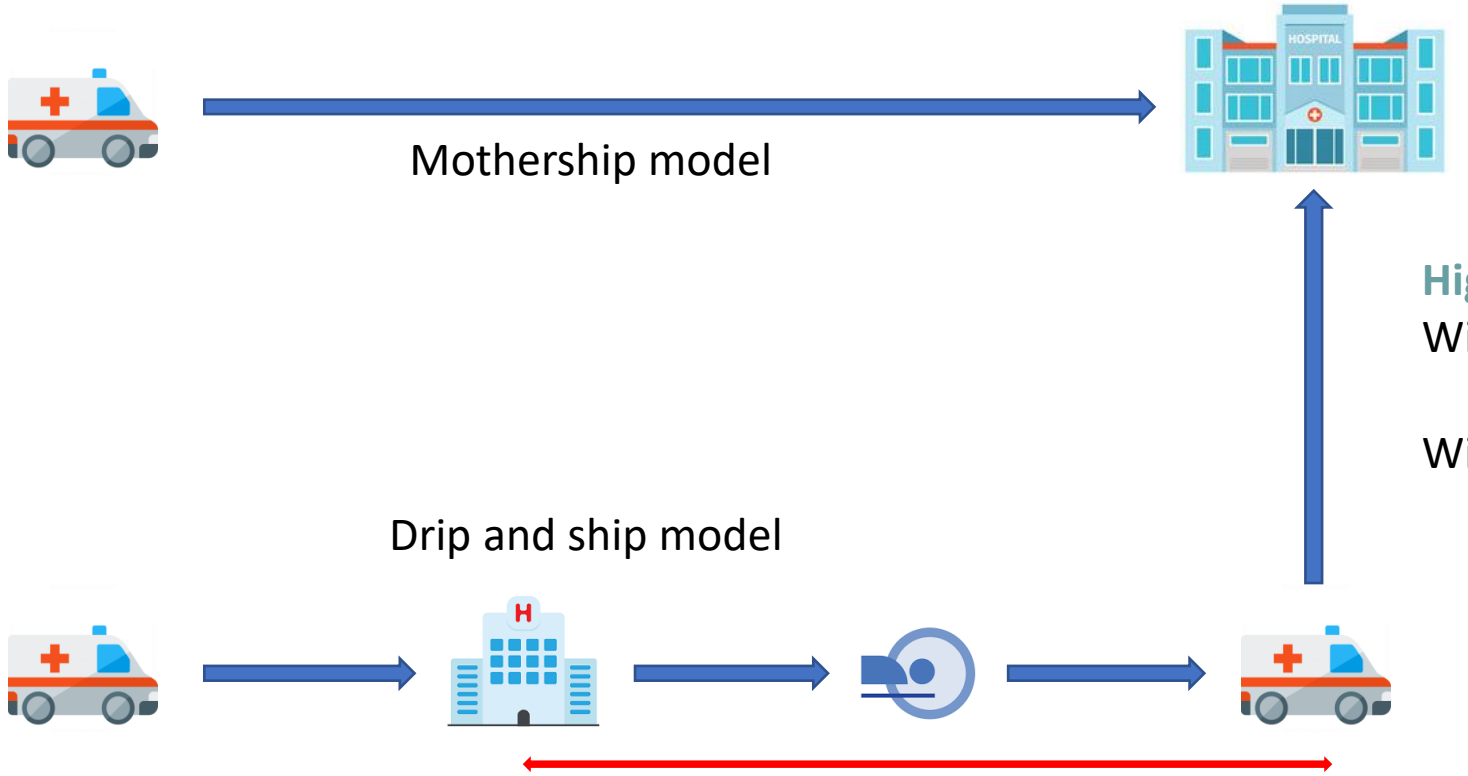


- **1 stroke every 5 minutes**
- **100,000 strokes per annum**
- **38,000 deaths per year**
- **Estimated to cost the NHS around £3billion per year**

Mechanical Thrombectomy



Mechanical Thrombectomy Pathway



Highly time sensitive

With every minute delay

2 million neurons are lost

With every 15minutes delay

One month of healthy life is lost

Mechanical Thrombectomy

Annual Thrombectomy
April 2021-March 2022

Thrombectomy total
2,262

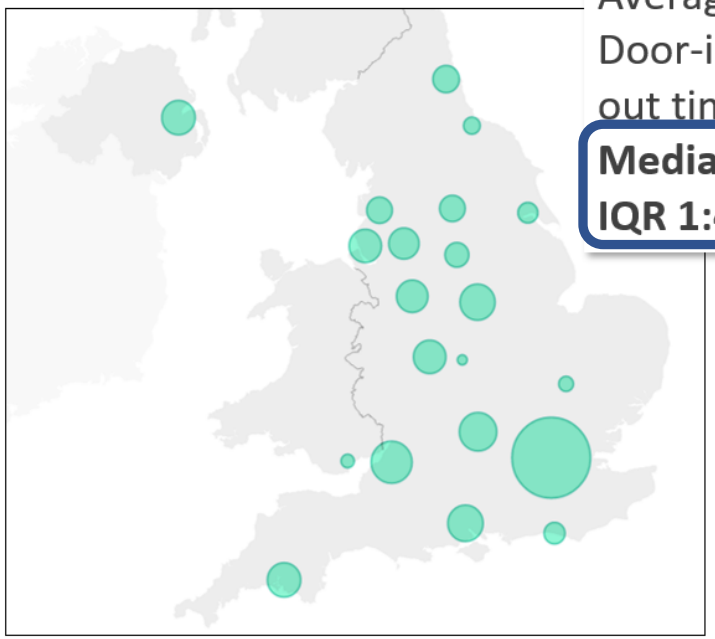
Proportion of all strokes treated
2.4%

Proportion transferred from ASC
54.7% (20-21: 48.8%)

Proportion admitted via CSC
45.3% (20-21: 51.2%)

Sentinel Stroke National Audit Programme (SSNAP)

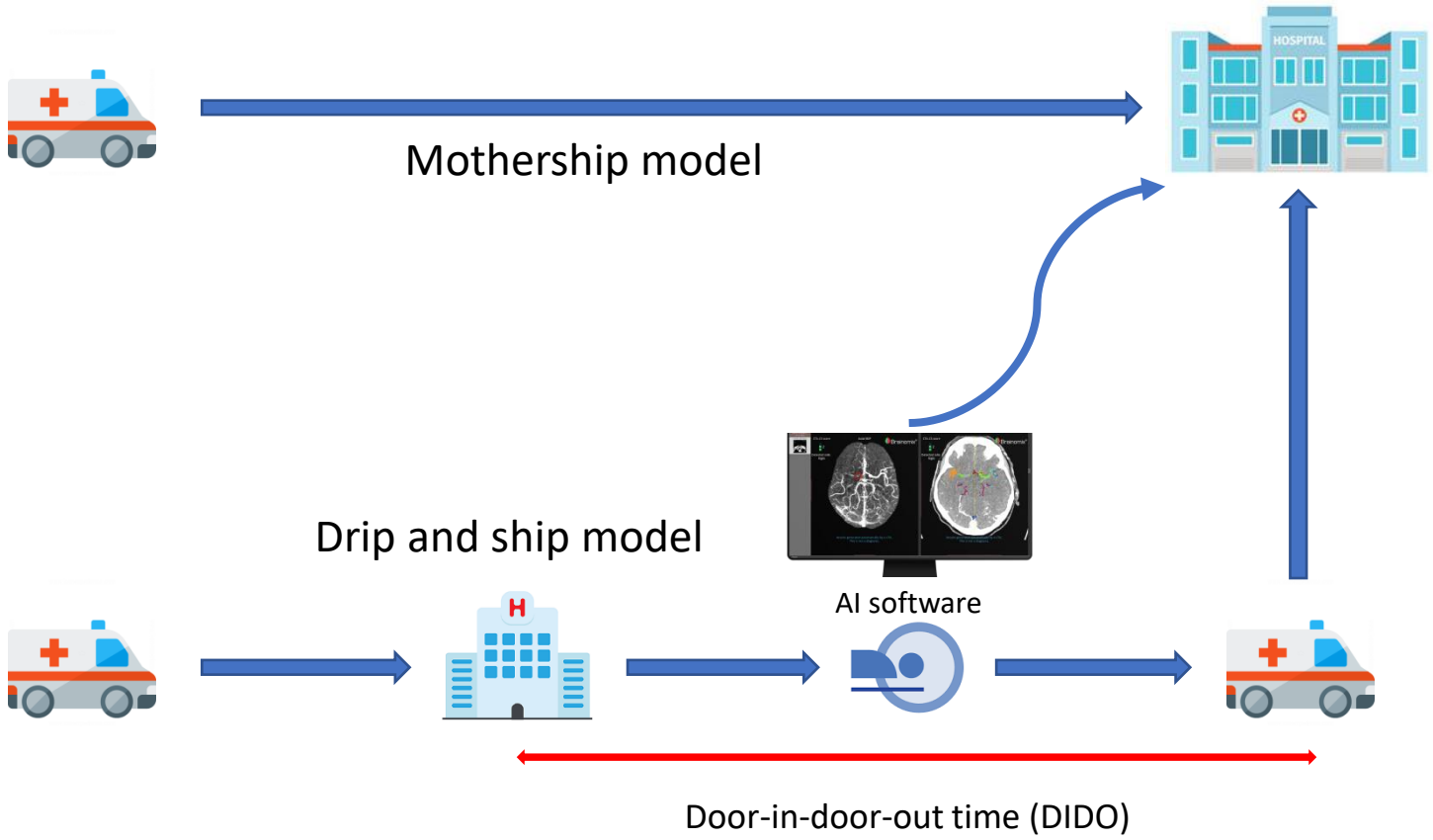
KING'S College LONDON



National Average Door-in-Door-out time:
Median 2:22
IQR 1:41-3:17

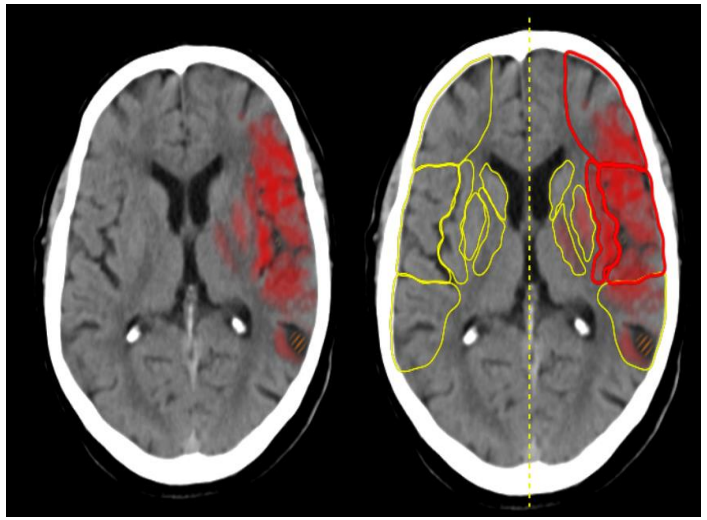
10% of stroke patients eligible

AI Enabled Mechanical Thrombectomy Pathway



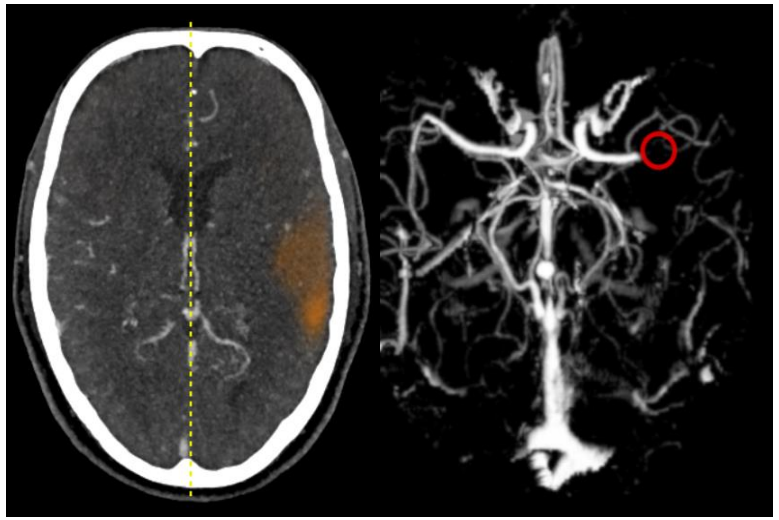
Instant Access and Faster Decision

Identifies early ischaemia



Assesses the non-contrast CT scan for **early signs of stroke**

Indicates occluded vessel



e-CTA identifies **large vessel occlusion**

Trebling of Better Functional Outcome for Patients

- Door-in-door-out time

  Reduced from 140 minutes to 79 minutes ($p < 0.01$)

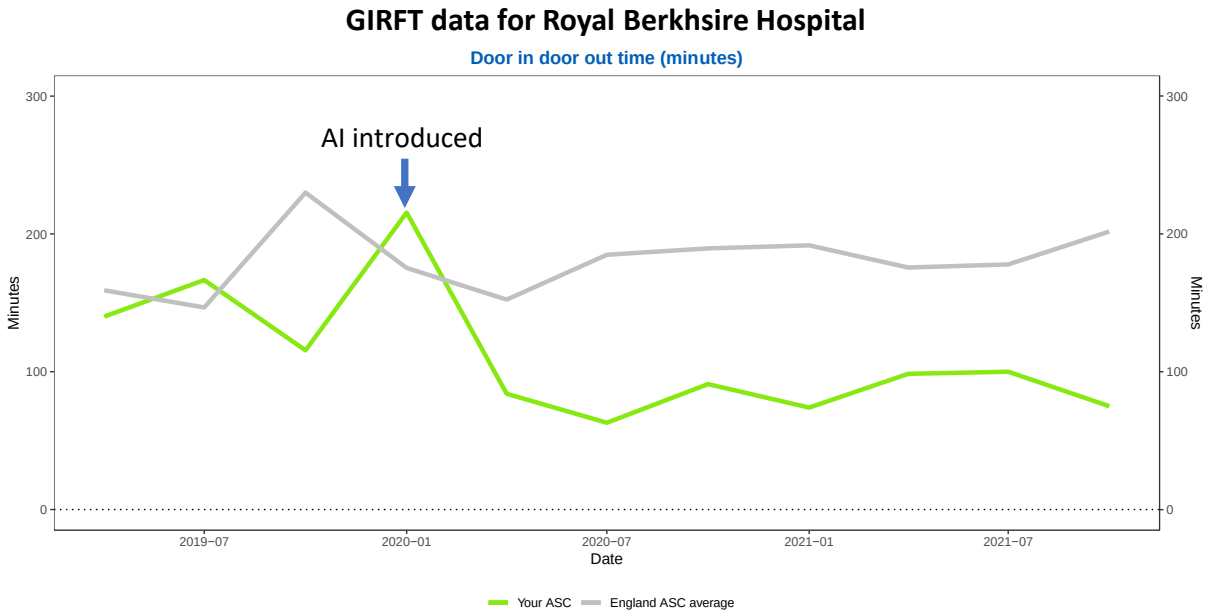
- Door-in to referral time

  Reduced from 70 minutes to 44 minutes ($p < 0.05$)

- Patients achieving independence

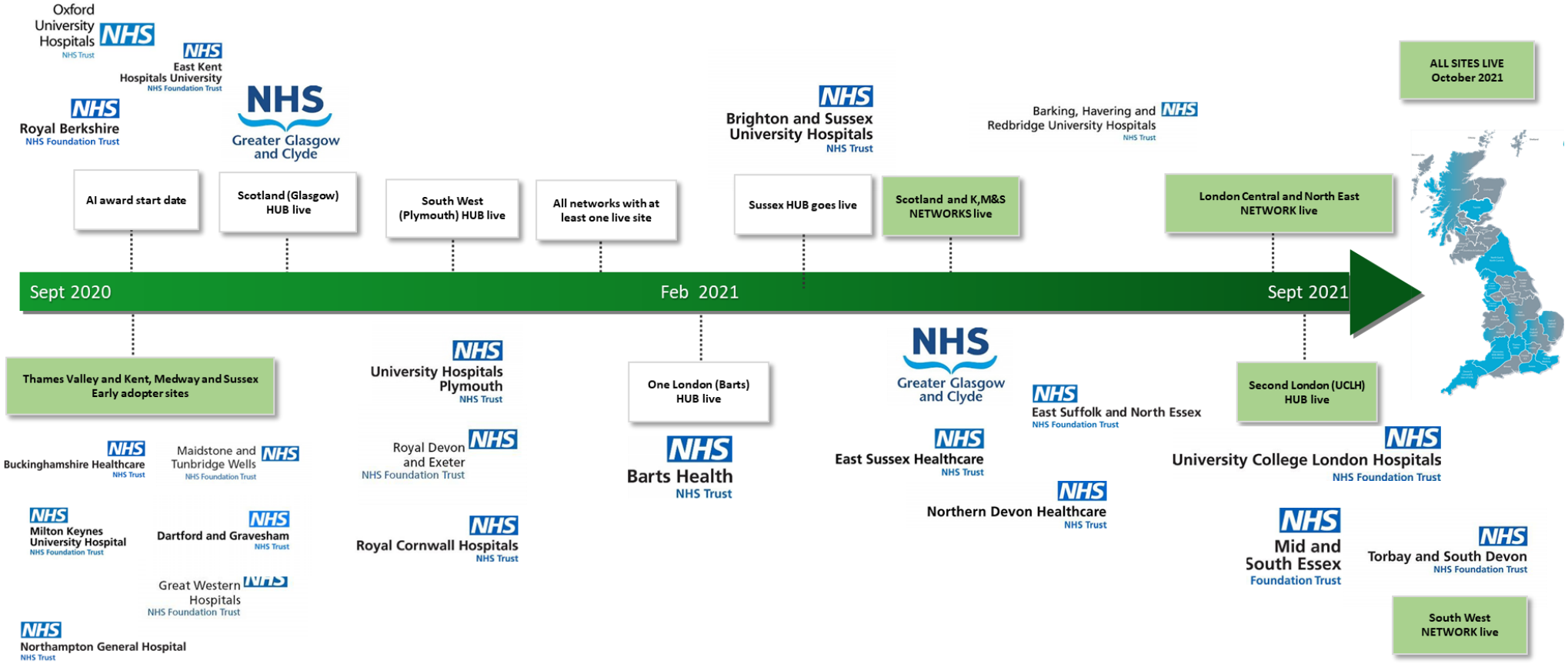
  Increased from **16% to 48%** ($p < 0.05$)

	Admission	Referred	Transferred
Before-AI	846	22	19
After-AI	785	25	21



NHS Impact: Blueprint for Adoption at Scale

The Artificial Intelligence in Health and Care Award

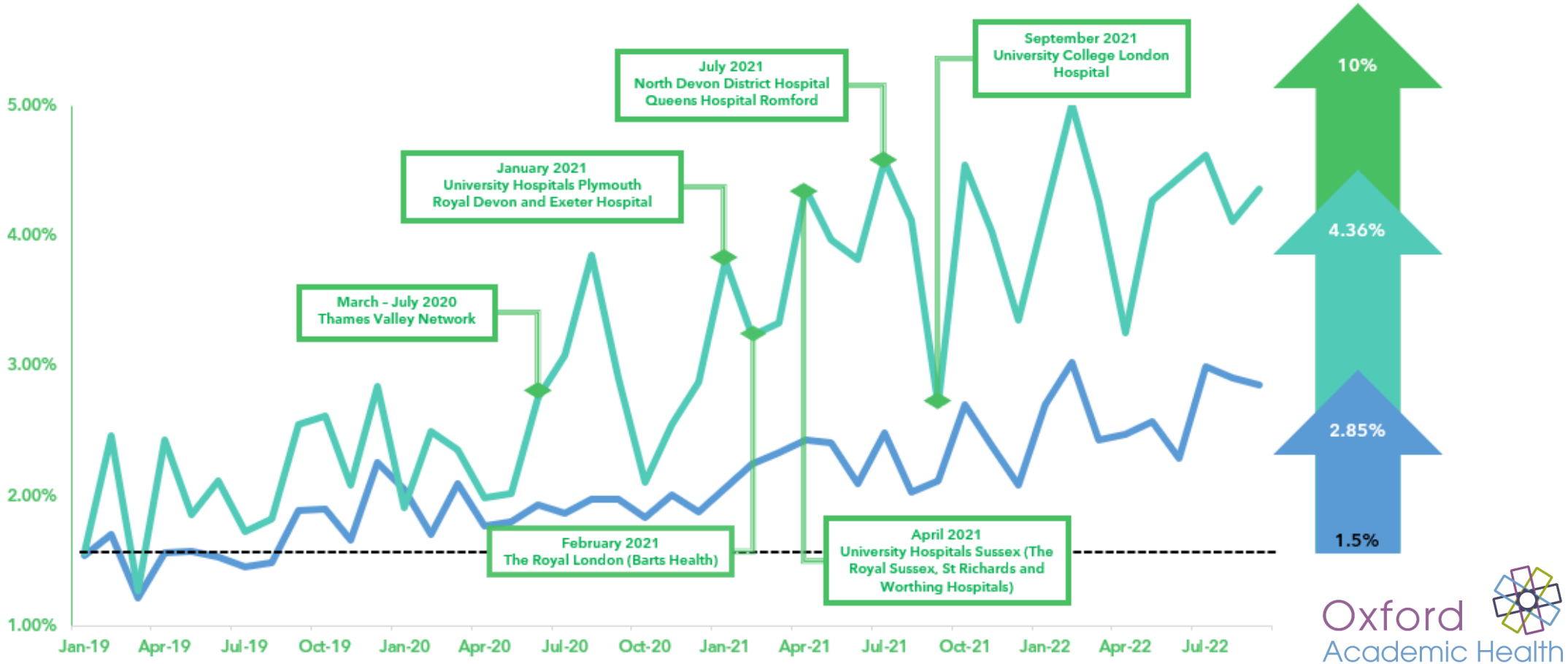


80+ NHS hospitals

11 ISDNs

+ 250,000 scans

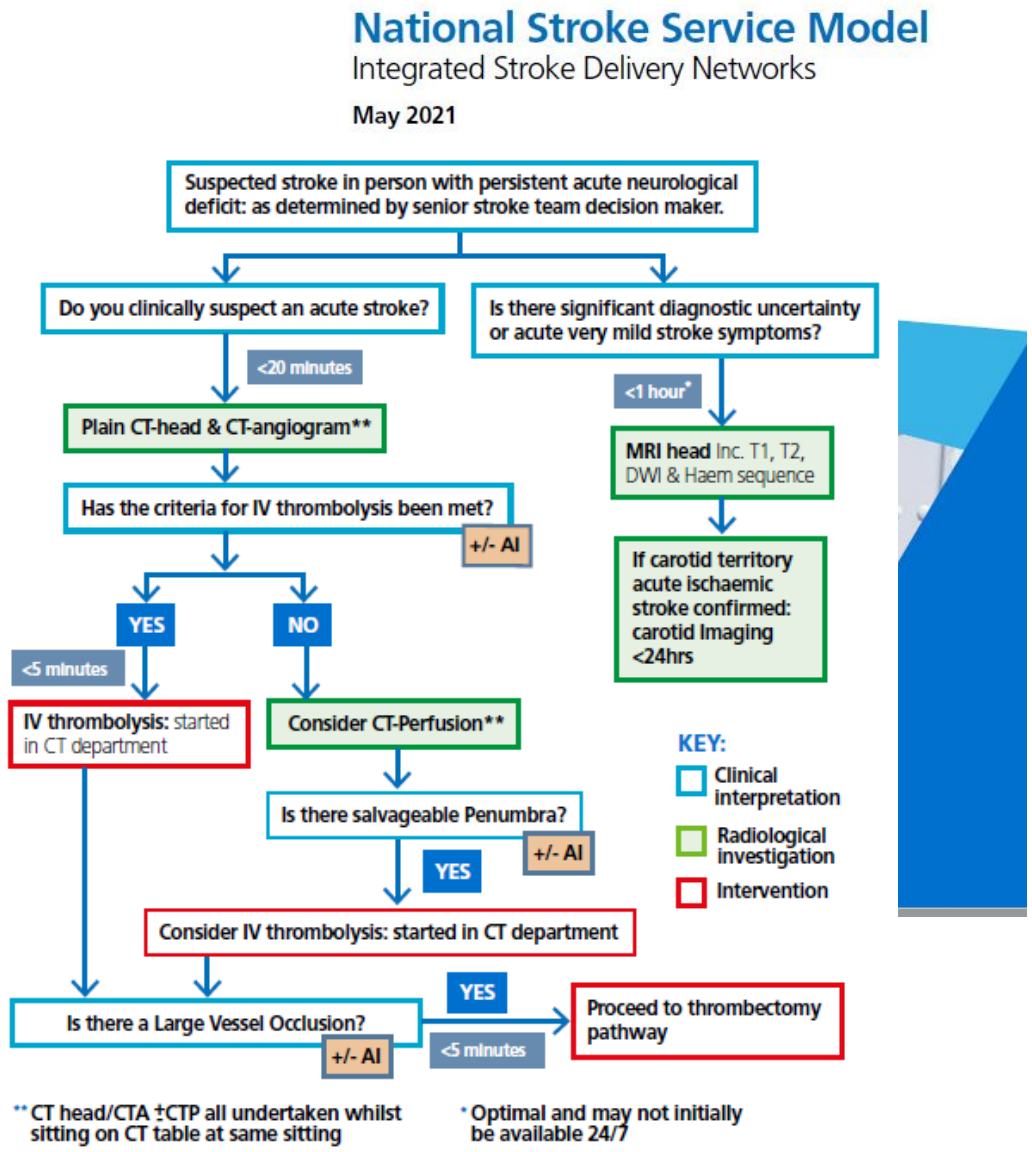
Real world evaluation of e-Stroke



Oxford
Academic Health
Science Network

Key Enablers

1. National Stroke Service Model
2. NHS Health and Care Awards
3. System leadership and networking



National Optimal Stroke Imaging pathway

Challenges

- Stakeholder scepticism
- Navigating Information Governance
- Funding

Future Direction

- **Sustain the gains** beyond the NHS AI award
- **Generate robust evidence** to support NICE appraisal
- **Working together** to advance the technology

Thank You!

Royal Brompton and Harefield hospitals

NHS
Guy's and St Thomas'
NHS Foundation Trust

PCD-AID: Artificial Intelligence Diagnosis of Primary Ciliary Dyskinesia

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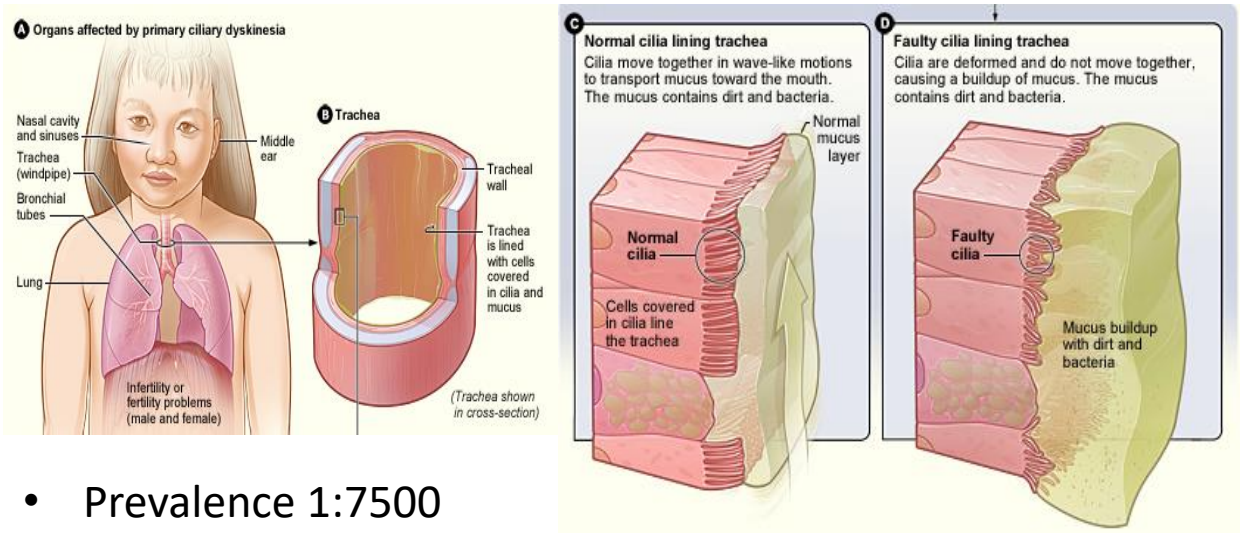
30-31 OCTOBER 2023
BUSINESS DESIGN CENTRE, LONDON
DIGITALHEALTHAIDATA.COM

Imperial College London
NHLI

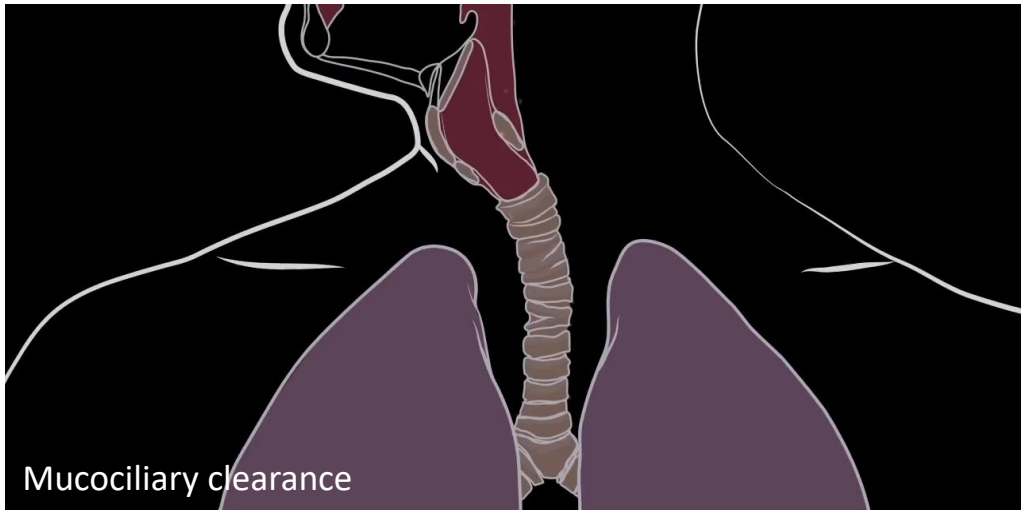
intel

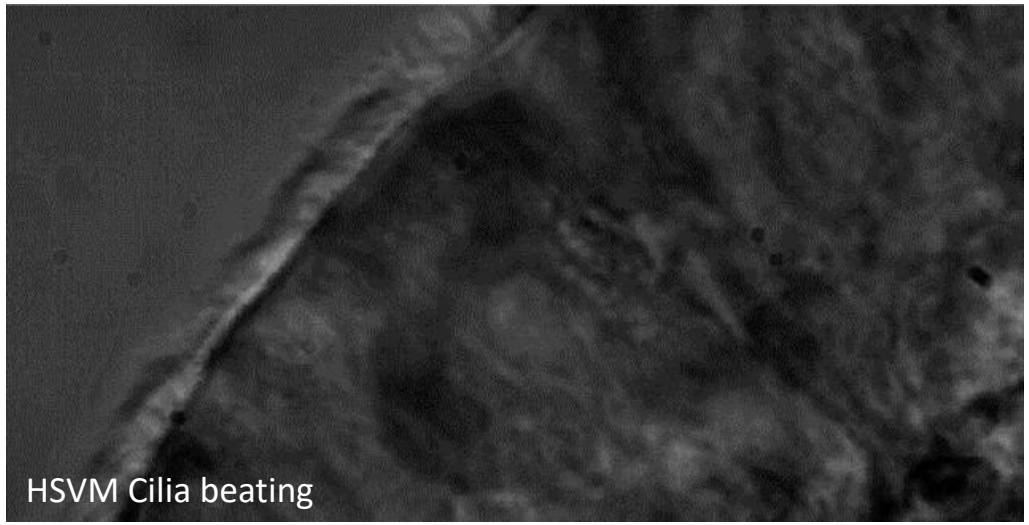
FUNDED BY
NIHR | National Institute for Health and Care Research

Primary ciliary dyskinesia (PCD)



- Prevalence 1:7500
- Multi-system disease
- Primarily autosomal recessive [rarely X-linked & AD]
- > 50 known PCD mutations
- 74% of cases can be confirmed using genetics
- Clinical spectrum of severity across a common phenotype:
  - oto-sinus disease, chronic suppurative lung disease and reduced fertility [motile cilia]
  - organ laterality defects in approximately 50% of patients [embryonic nodal cilia]





Cilia function and dynamics

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Diagnosis of PCD: microscopy techniques

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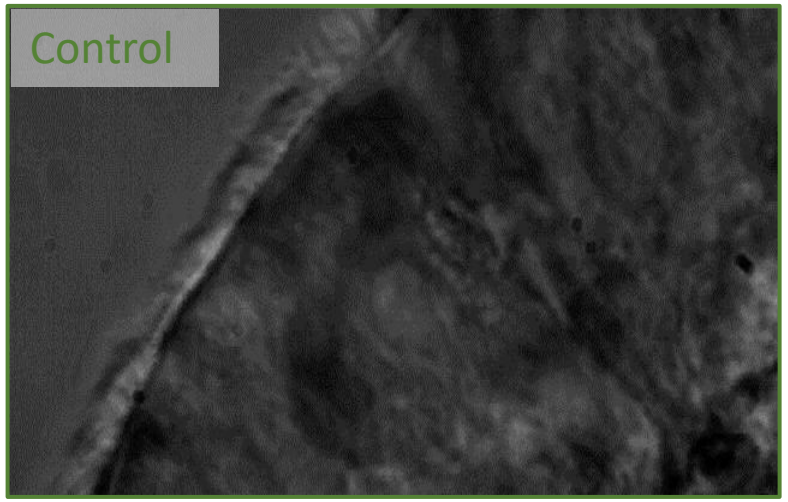
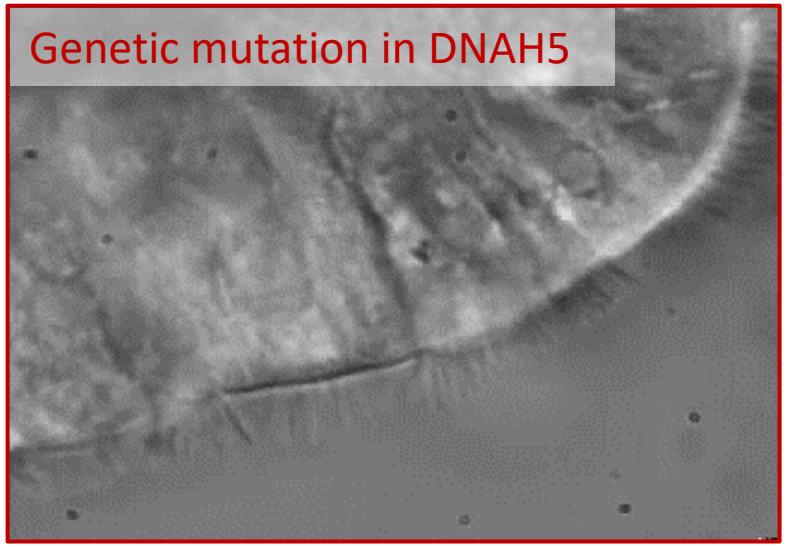
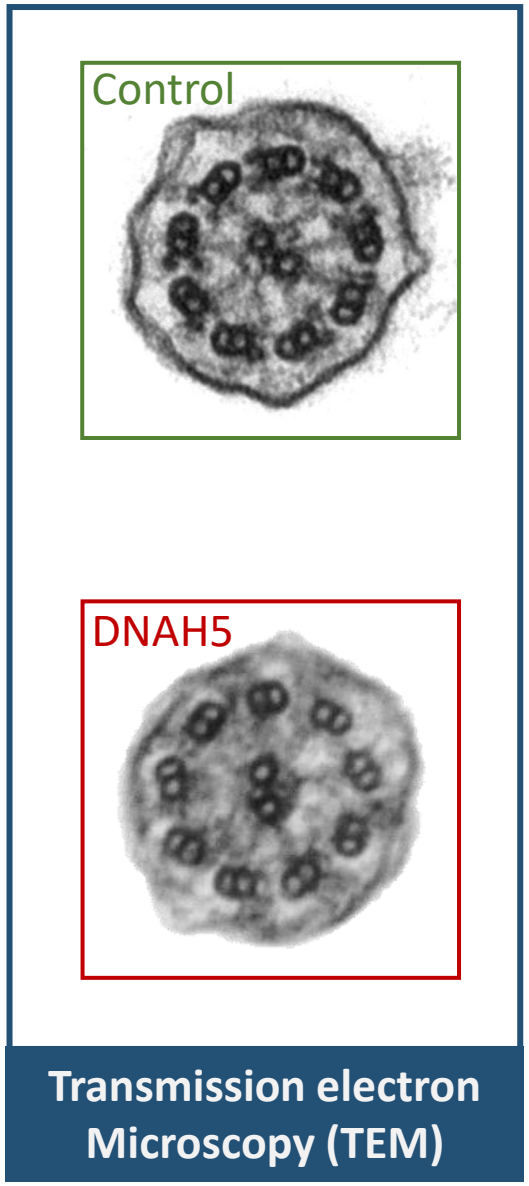
Loss of function





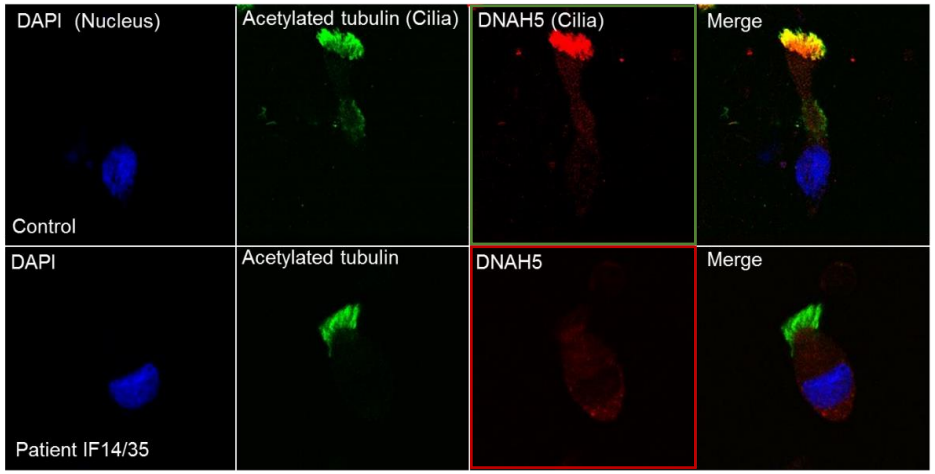
High speed video microscopy (HSVM)

Structural defect



Transmission electron Microscopy (TEM)

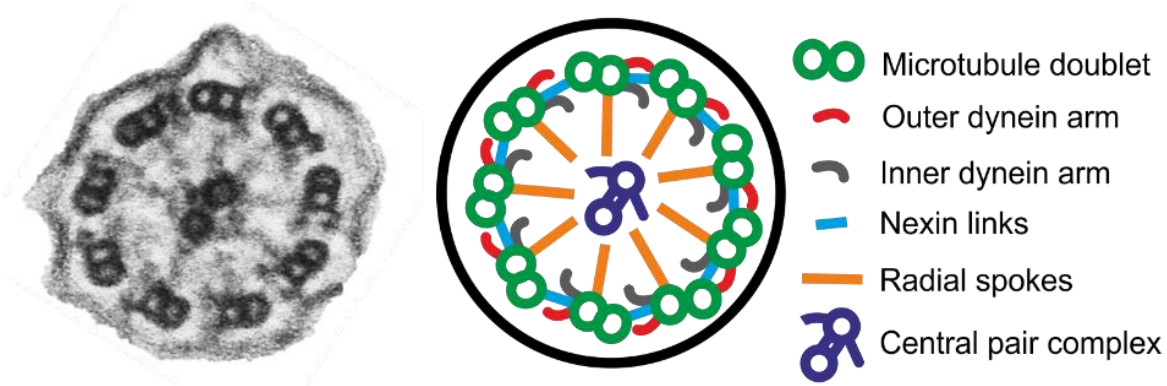
Control



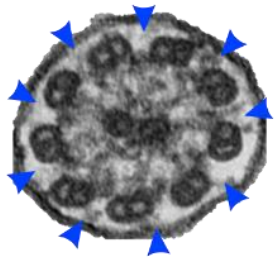
DNAH5

Immunofluorescence Microscopy (IF)

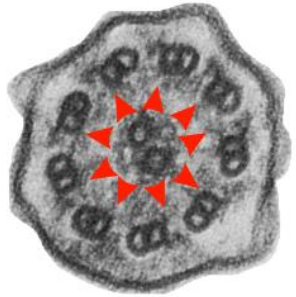
Diagnosis of PCD by TEM – ultrastructure defects



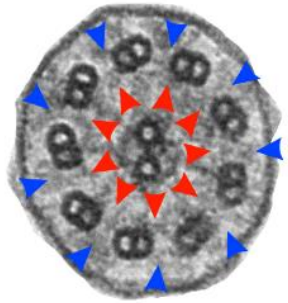
Cilium components



Absent outer dynein arms

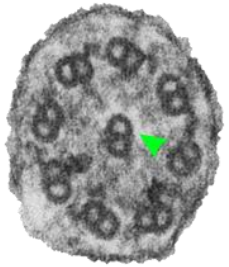


Absent inner dynein arms



Absent of both dynein arms

Disorganization defect

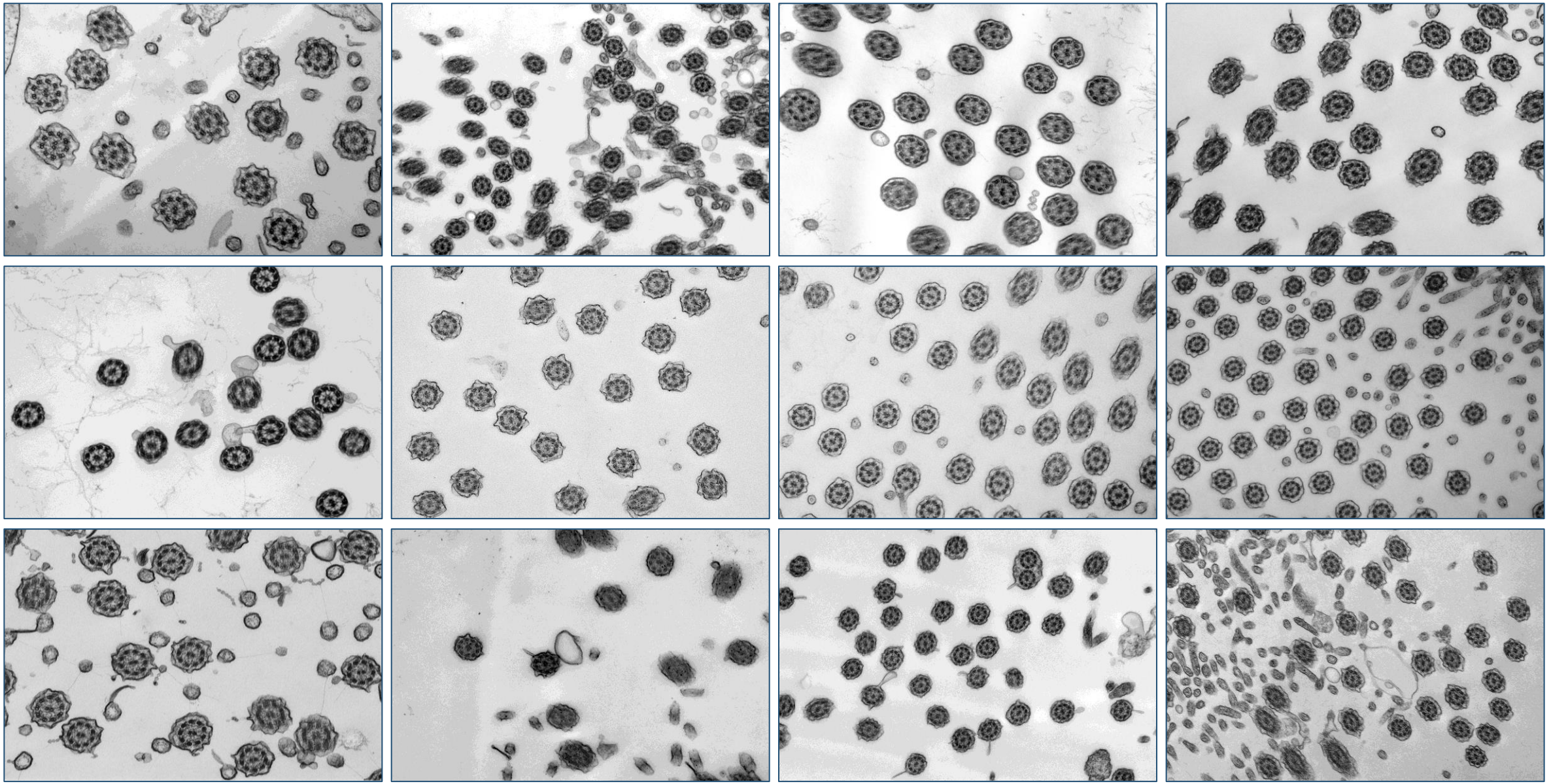


Central pair complex defect

Absent central pair

Structural defects associated with PCD

Diagnosis of PCD by TEM – requires expertise and time



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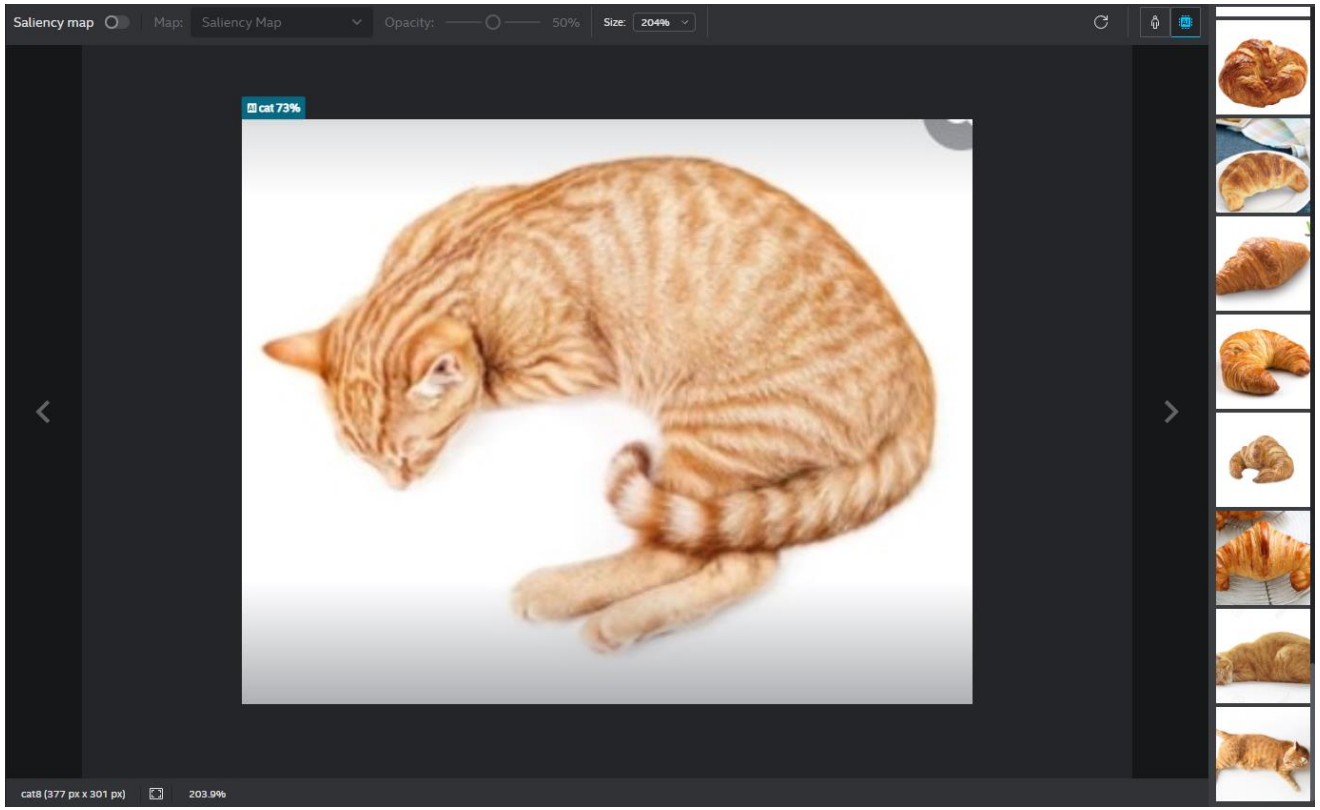
Machine learning computer vision



Machine learning offers an opportunity to improve diagnostic accuracy, reduce time to analyse samples, minimise the subjective element and significantly reduce costs.

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Intel® Geti™ Model: Deep Learning Model Details

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intel. GeTi™

Object Detection

Model Architecture: Adaptive Training Sample Selection

Automatically adjusts positive and negative training samples based on the statistical characteristics of the object.

Backbone: MobileNet-V2

Ref: Zhang et. al., https://arxiv.org/pdf/1912.02424
Sandler et. al., https://arxiv.org/abs/1801.04381

Image Classification

Model Architecture: EfficientNet-V2

Training aware NAS search, adjusted depth-wise convolutions across layers.

Backbone: EfficientNet

Ref: Tan et. al., https://arxiv.org/pdf/2104.00298

Intel® Geti™ Model: Detection

digitalhealth AI + DATA

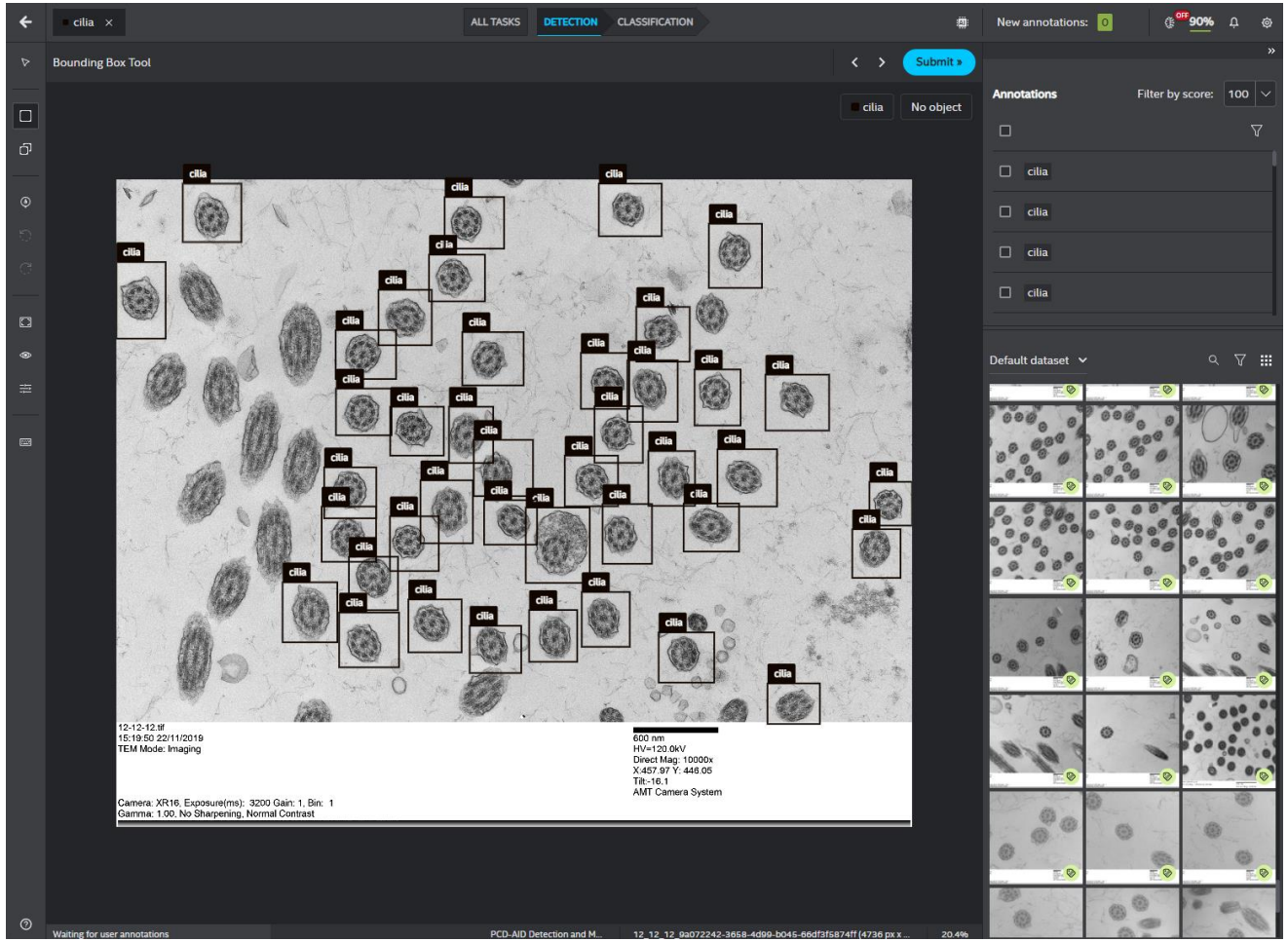
Detection of well-orientated cilia

⇩

Extract cilia (cropping)

intel. GeTi™

Training: 22,078 cilia



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Intel® Geti™ Model: Primary Classification

digitalhealth AI + DATA

Detection of well-orientated cilia

⇩

Extract cilia (cropping)

⇩

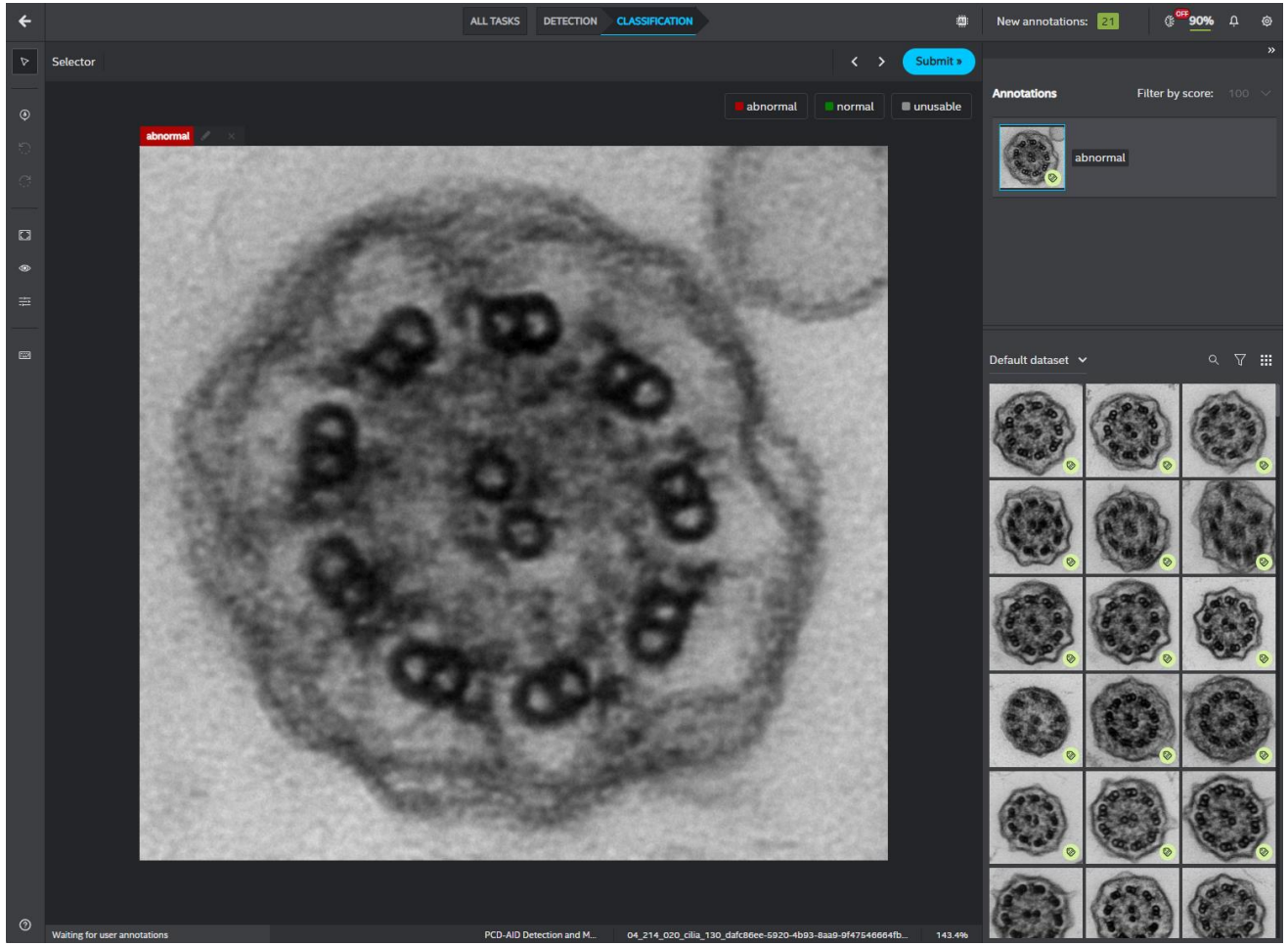
Primary Classification of cilia

⇩ ⇩ ⇩

Segregate ‘normal’ cilia	Segregate ‘abnormal’ cilia	Segregate ‘unusable’ cilia

intel. GeTi™

Training: 9,190 cilia



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Intel® Geti™ Model: Defects Classification

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intel. GeTi™

Detection of well-orientated cilia

⇩

Extract cilia (cropping)

⇩

Primary Classification of cilia

⇩

Segregate ‘normal’ cilia

Segregate ‘abnormal’ cilia

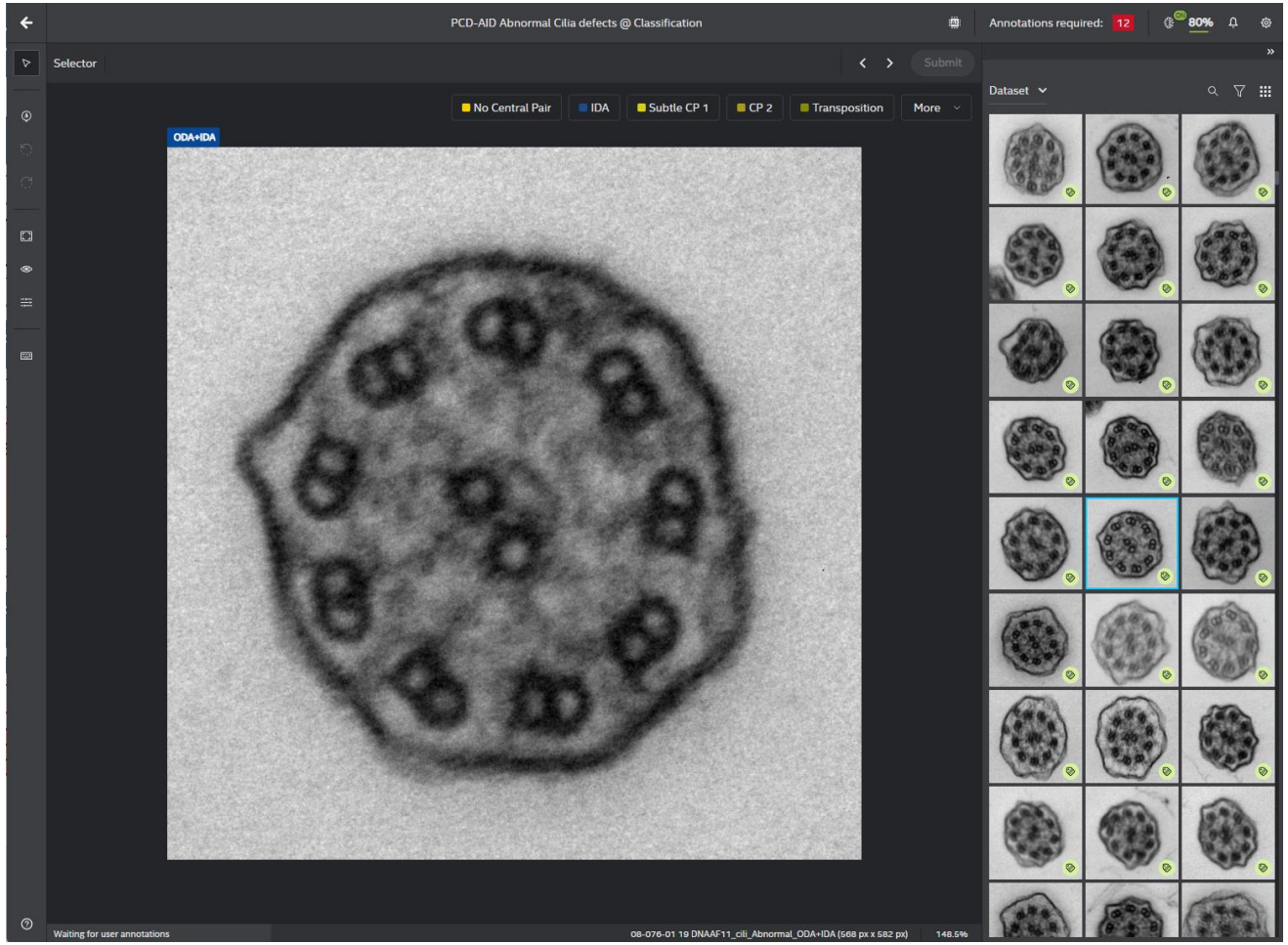
Segregate ‘unusable’ cilia

⇩

Classification of cilia structural defect

⇩

Segregate Cilia Defect



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Intel® Geti™ Model: Defects Classification

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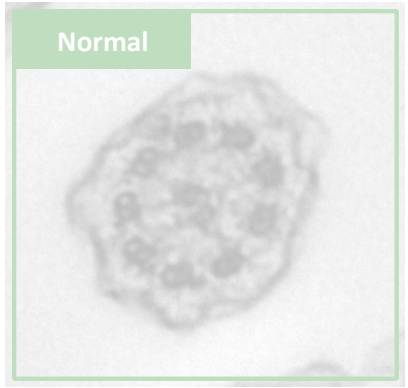

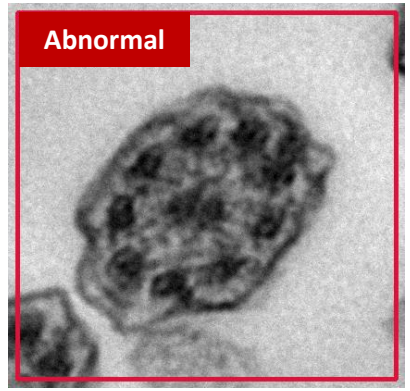

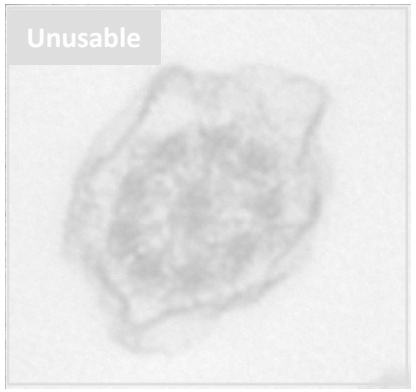

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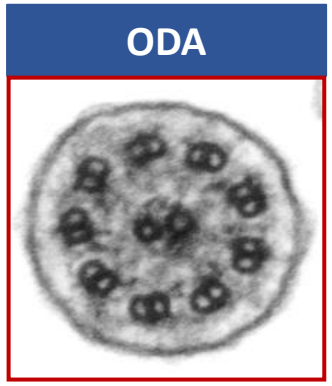
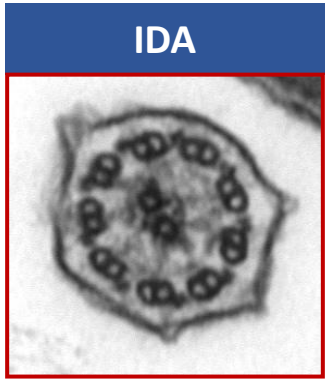
Training: 4,061 cilia

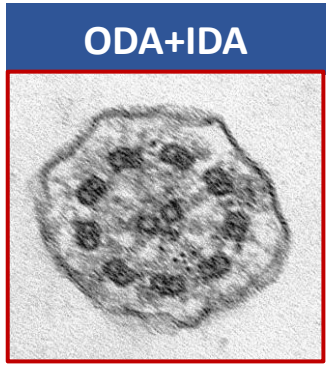
intel. GeTi™



Absent Outer Dynein Arms

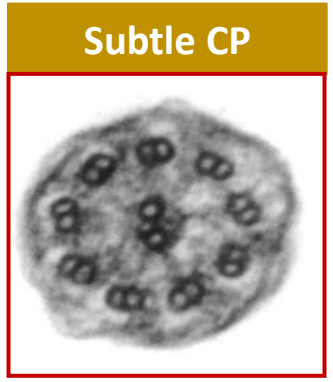


Absent Inner Dynein Arms



Absent of both dynein arms

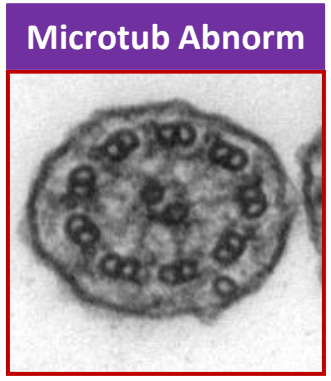
Absent central pair



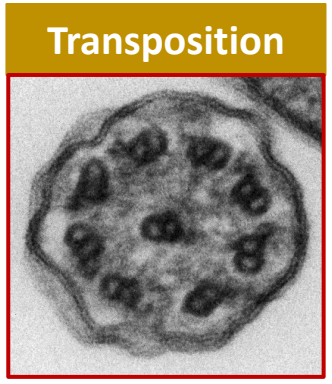
Subtle CP complex defect

Disorganisation defect

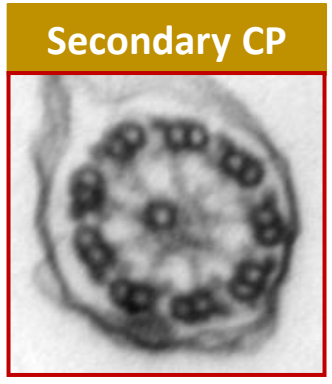
Secondary disorganisation defect



Microtubules abnormalities



Transposed doublet



Missing one of the central pair

PCD-AID: Artificial Intelligence Diagnosis of PCD

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After satisfactory training & testing, the model can be **deployed** (Geti-SDK OpenVINO™ Toolkit in Python 3.8) and used for the **Artificial Intelligence Diagnosis** of patients using the PCD International consensus algorithm.

EUROPEAN RESPIRATORY *journal*

FLAGSHIP SCIENTIFIC JOURNAL OF ERS

International consensus guideline for reporting transmission electron microscopy results in the diagnosis of Primary Ciliary Dyskinesia (BEAT PCD TEM Criteria)

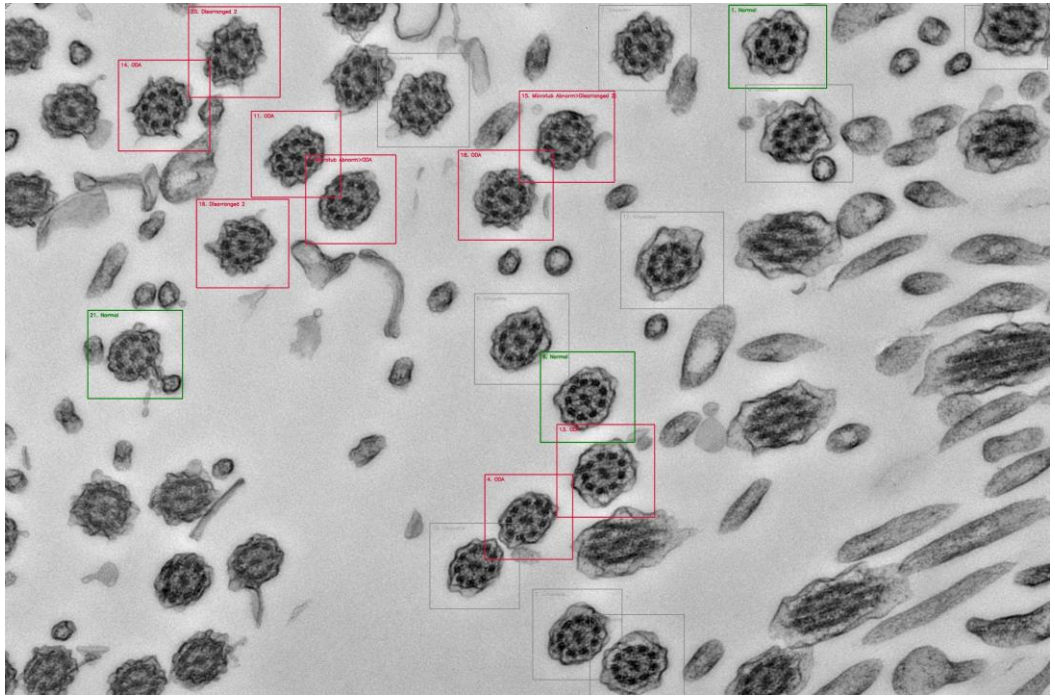
Amelia Shoemark, Mieke Boon, Christoph Brochhausen, Zuzanna Bukowy-Bieryllo, Maria Margherita De Santi, Patricia Goggin, Paul Griffin, Richard G. Hegele, Robert A. Hirst, Margaret W. Leigh, Alison Lupton, Karen MacKenney, Heymut Omran, Jean-Claude Pache, Andreia Pinto, Finn P. Reinholt, Josep Schroeder, Panayotis Yiallouros, Estelle Escudier

Please cite this article as: Shoemark A, Boon M, Brochhausen C, *et al*. International consensus guideline for reporting transmission electron microscopy results in the diagnosis of Primary Ciliary Dyskinesia (BEAT PCD TEM Criteria). *Eur Respir J* 2020; in press (https://doi.org/10.1183/13993003.00725-2019).

An **automatically generated report** includes:

- Number of cilia detected (normal, abnormal & unusable)
- Percentage of abnormal cilia
- List of defects classified

Annotated cropped cilia images



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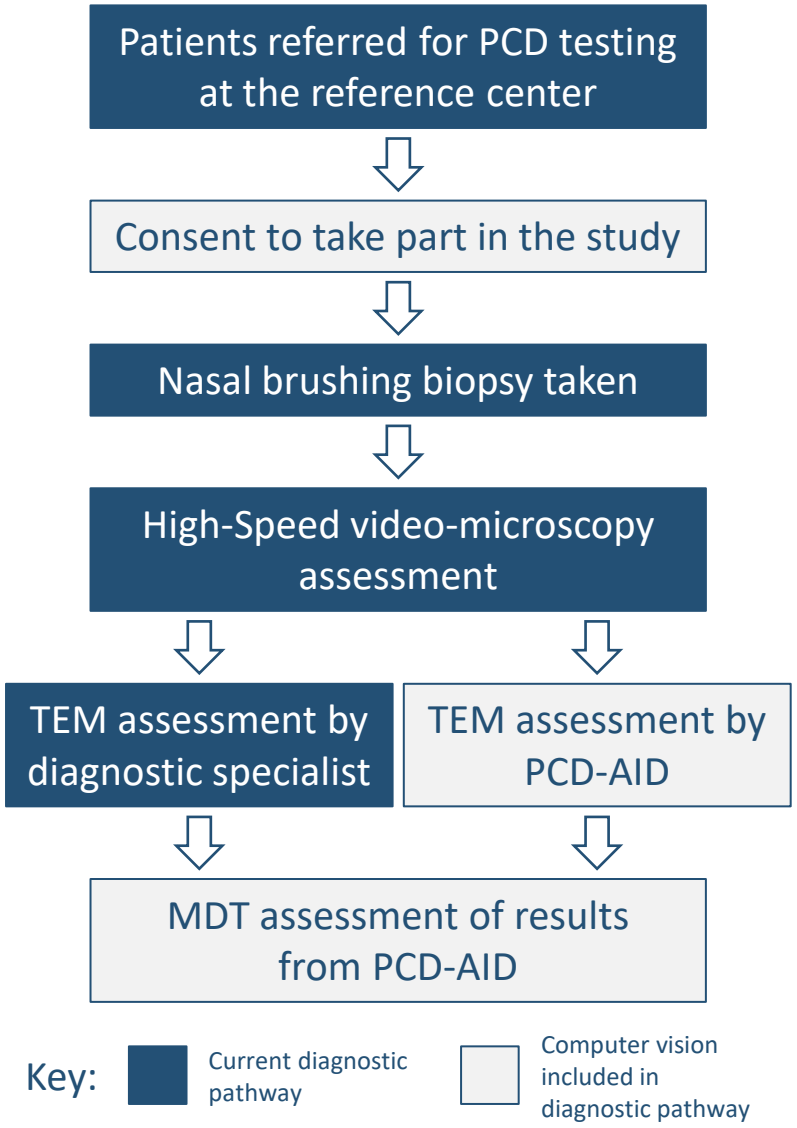
PCD-AID: Validation



178 patients included at PCD diagnostic referral

PCD-AID result	MDT specialists diagnostic: PCD Likely	PCD Unlikely	Non-PCD	Inconclusive	Total
PCD Likely	13	1	1	0	15
PCD Unlikely	0	4	14	0	18
Non-PCD	1	2	134	0	137
Inconclusive	0	0	2	6	8
Total	14	7	151	6	178

	Specialists	PCD-AID
Sensitivity	0.89	0.87
Specificity	0.83	0.88

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PCD-AID successfully recognizes PCD-related cilia defects

- Alternative to manual diagnosis
- PCD-AID assesses TEM images in under 30 seconds per patient

Implementing **computer vision artificial intelligence** in **the diagnostic pathway** can improved **diagnosis of PCD**, **reduce cost** by saving expert time and **bring the diagnosis to center lacking expertise**.

Next steps:

Deployment of PCD-AID to additional centers to test the model on images from different sources (first within the UK).

Intel® Geti™ & other diagnosis tests

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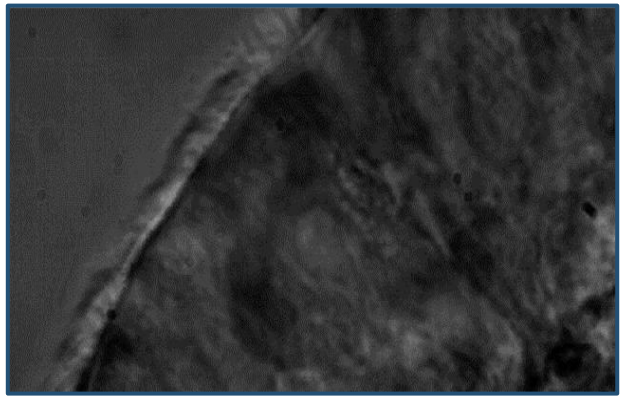
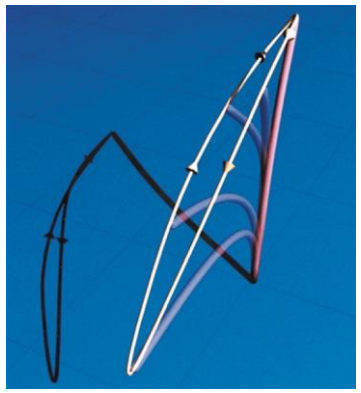
High speed video microscopy (HSVM)

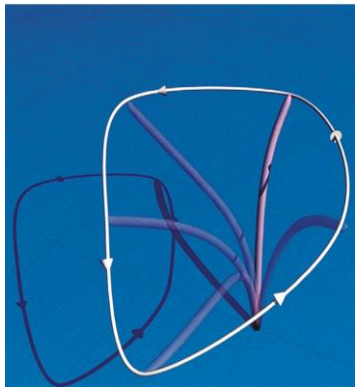




Normal pattern

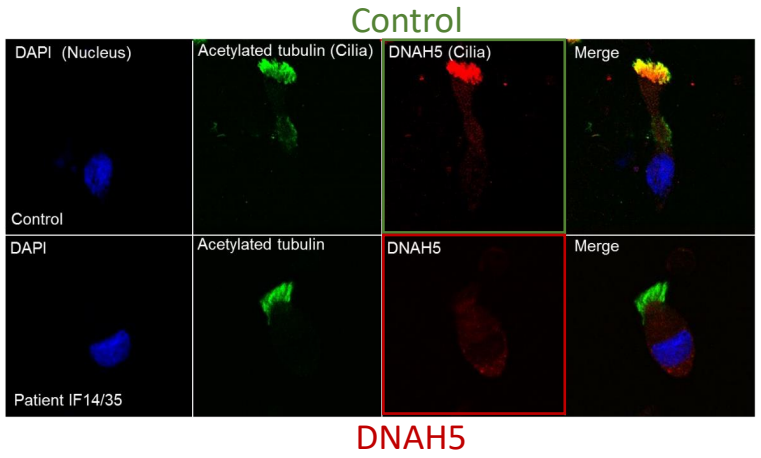
Reduced beat amplitude

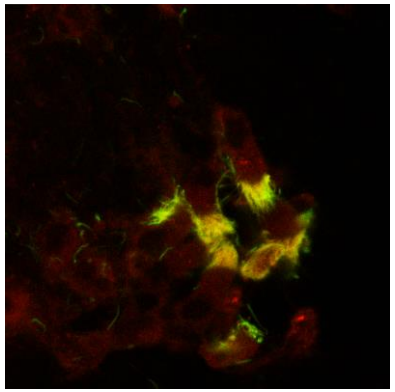
(Virtually) Immotile

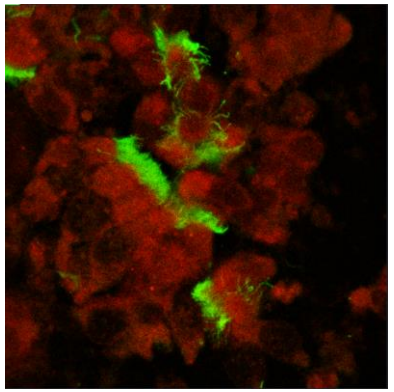


Circular/wavy motion

Immunofluorescence Microscopy (IF)







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