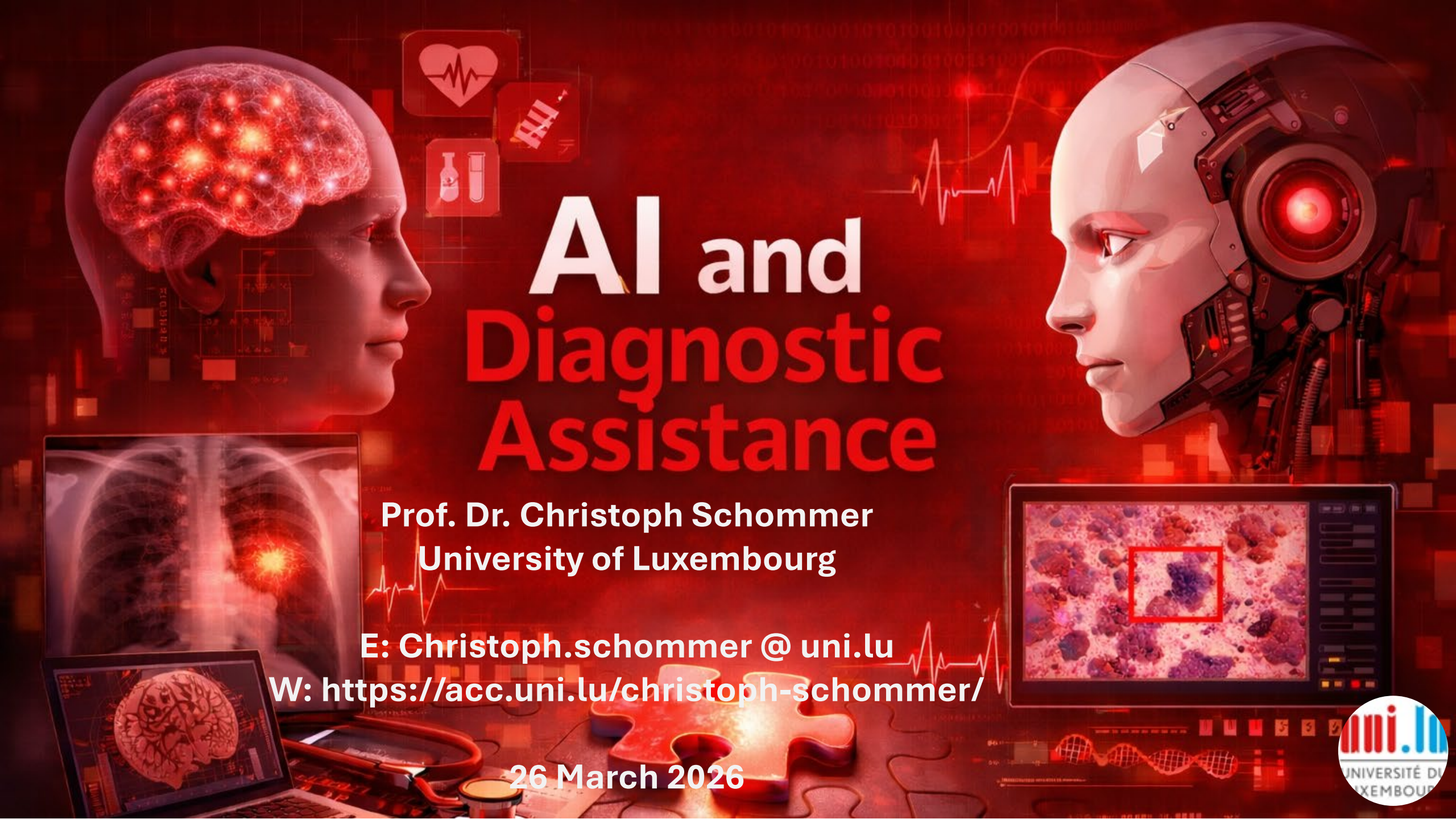

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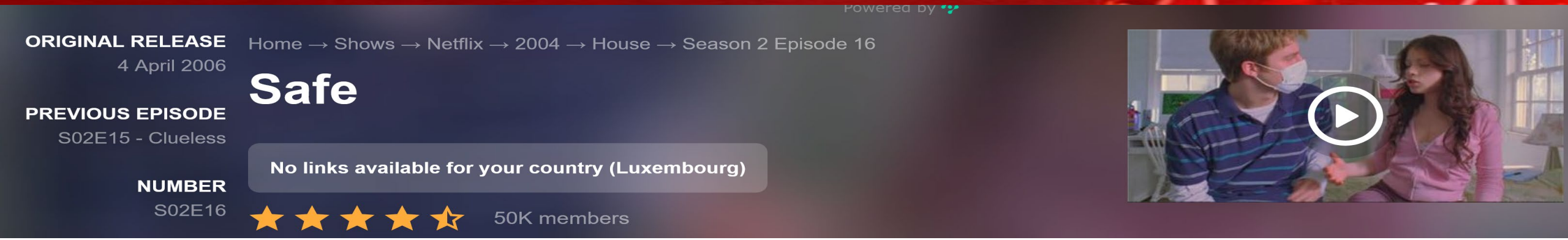
26 March 2026

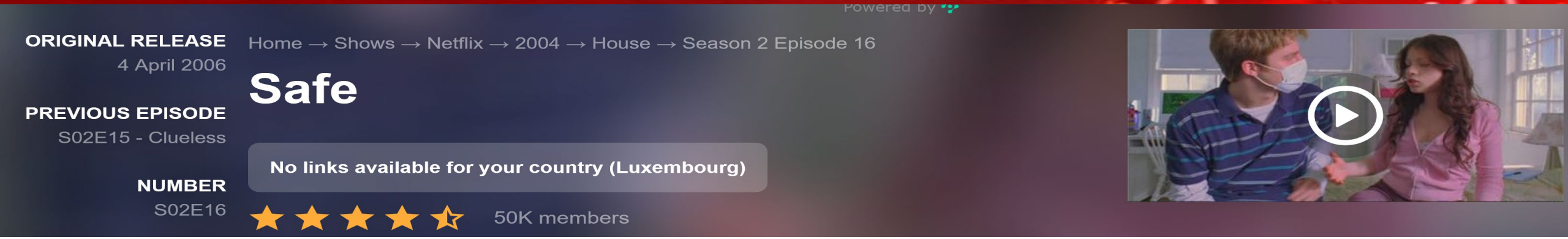
Making a diagnosis is like solving a puzzle – a hypothetical use case



- Melinda, a troubled teenager, who is **immuno-compromised due to the medication she must take after a heart transplant, suffers a severe allergic reaction and goes into shock when her boyfriend visits her**.

- Melinda arrives at Princeton Plainsboro Hospital **with a high fever, severe headache and skin rash**. The doctors run the **usual tests, but nothing is conclusive**.

Making a diagnosis is like solving a puzzle – a hypothetical use case

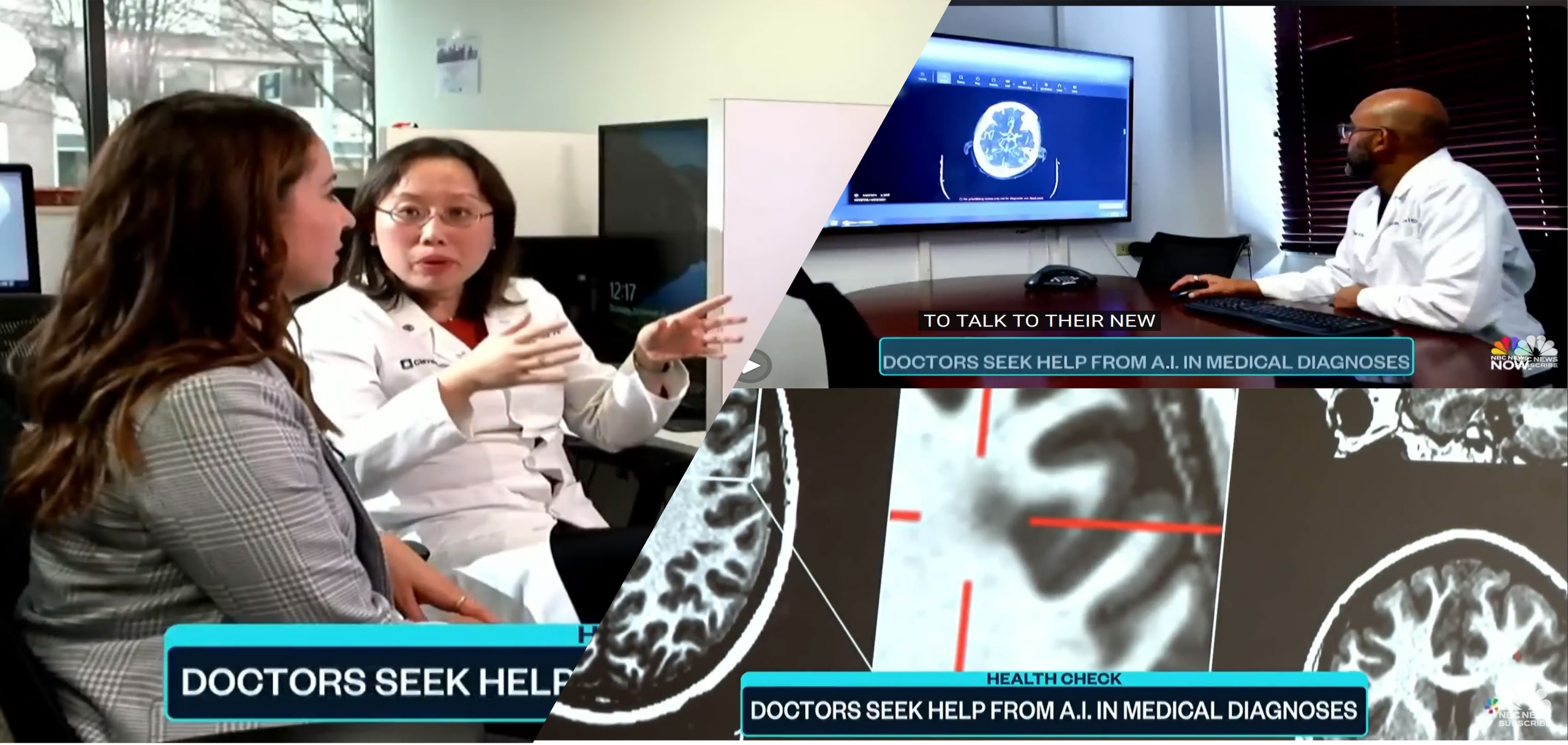


- The team **considers several ideas: meningitis, a viral infection and an autoimmune disease**.
- One treatment fails, others have side effects. The patient's condition worsens.
- Dr House considers **all the clues**: the patient's travel history, the lab results, rare combinations of symptoms - and finally he connects the dots.
- **<u>The correct diagnosis:</u> a rare form of tick-borne disease. Treatment is administered and the patient recovers.**

Making a diagnosis is like solving a puzzle

It is precisely this type of diagnostic puzzle that doctors have to solve day by day. Difficulties are:

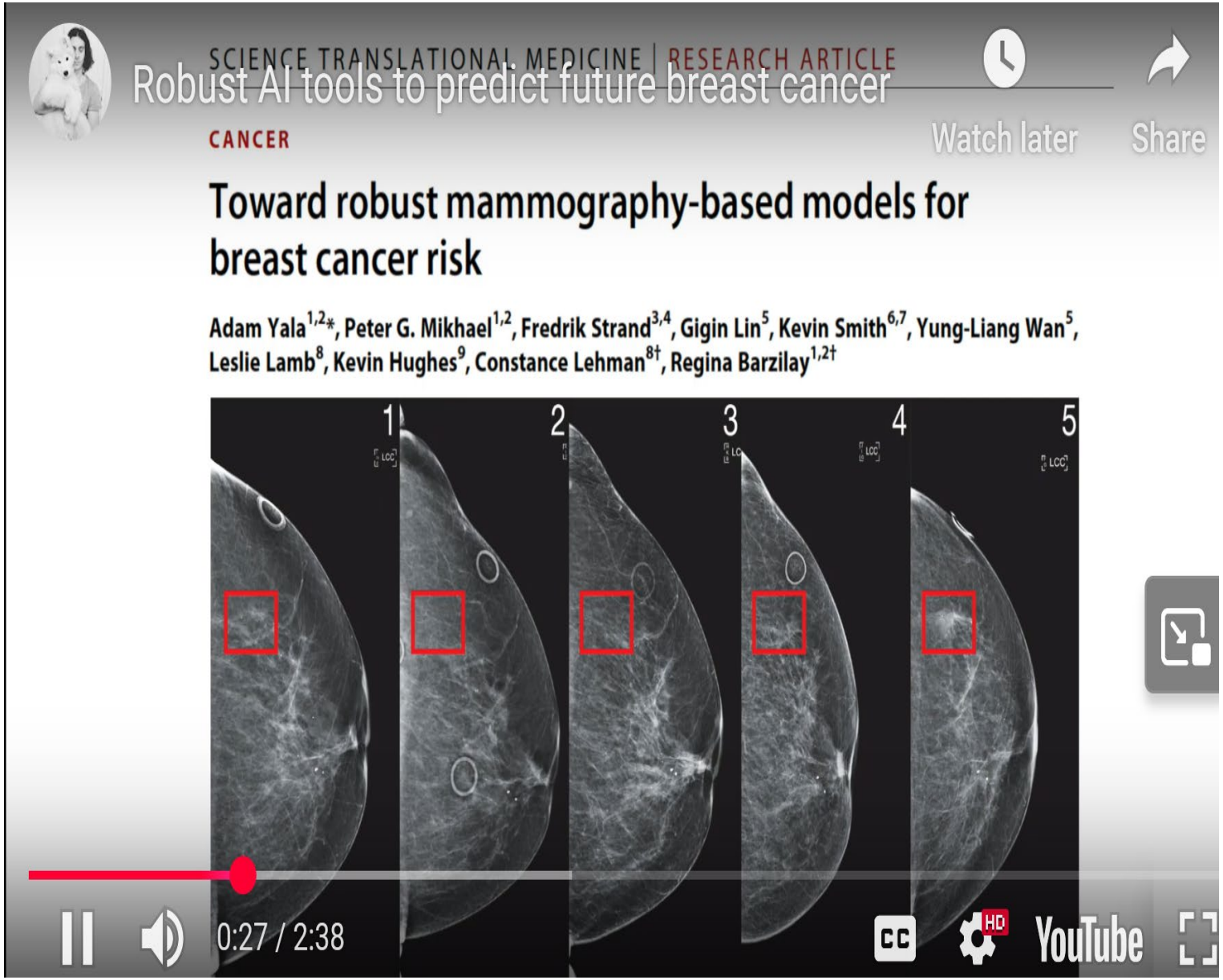
- **High time pressure** : decisions must often be made quickly
- **Huge volume of data** : images, lab tests, patient histories
- **Requires deep medical expertise** : knowledge of thousands of diseases
- **Needs creative reasoning** : forming and testing hypotheses
- **Tedious, repetitive work** : reviewing many similar cases; tests have to be repeated in order to avoid wrong test results.
- **Rare and unusual cases** : easy to overlook without experience
- **Increasing patient numbers**
- **Overloaded specialists** (for tests)
- **Complexity and heterogeneity of data** as well as correctness of the data: images, lab results, genomics.
- Often **insufficient/wrong information** from the patient.
- **Human fatigue** and **variability**
- **Constant learning** : medical knowledge evolves continuously



NBC news (2024): Some doctors **from the Cleveland Clinic collaborate through and utilize AI** to detect thre correct medical diagnosis. **Required : expertise, willingness, technical infrastructures. See: https://youtu.be/C5euaa4p4Pk**

A Deep learning system to predict cancer risk using just a patient's mammogram

https://www.csail.mit.edu/news/robust-ai-tools-predict-future-cancer



Large Language Models (LLMs)

What LLMs Can Do in Medicine

- **Interpret clinical text**: patient records, lab reports, and radiology notes.
- **Summarize information**: condense long histories into key points.
- **Answer diagnostic questions**: provide differential diagnosis suggestions.
- **Generate hypotheses**: help doctors consider rare or atypical conditions.
- **Assist with guidelines**: check treatments against medical protocols.

Large Language Models (LLMs)

How LLMs Support Diagnostics

- **Analyze unstructured data** (doctor's notes, patient descriptions) that traditional AI might struggle with.
- **Highlight patterns across patients in large datasets**.
- **Suggest next steps or tests** based on current symptoms and history.
- **Can be integrated** into clinical decision support systems..

Flat file display

```
....+....1....+....2....+....3....+....4....+....5....+...
  70.0   1   4 130.0 322.0   0   2 109.0   0   2.4   2   3   3   Y
  67.0   0   3 115.0 564.0   0   2 160.0   0   1.6   2   0   7   N
  57.0   1   2 124.0 261.0   0   0 141.0   0   0.3   1   0   7   Y
```

Selection

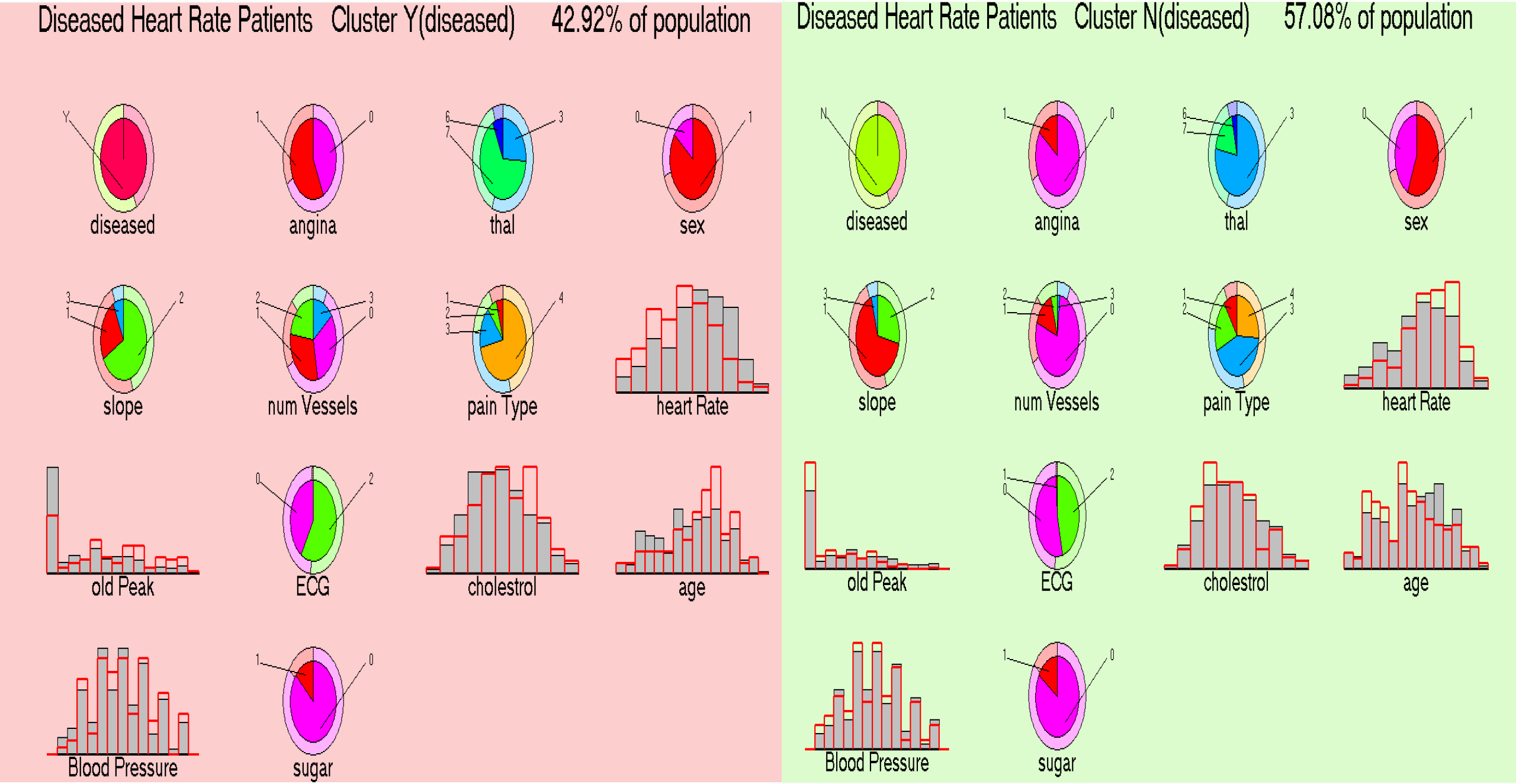
Begin and end position	Field name	Data type
		Categorical

Field parameters

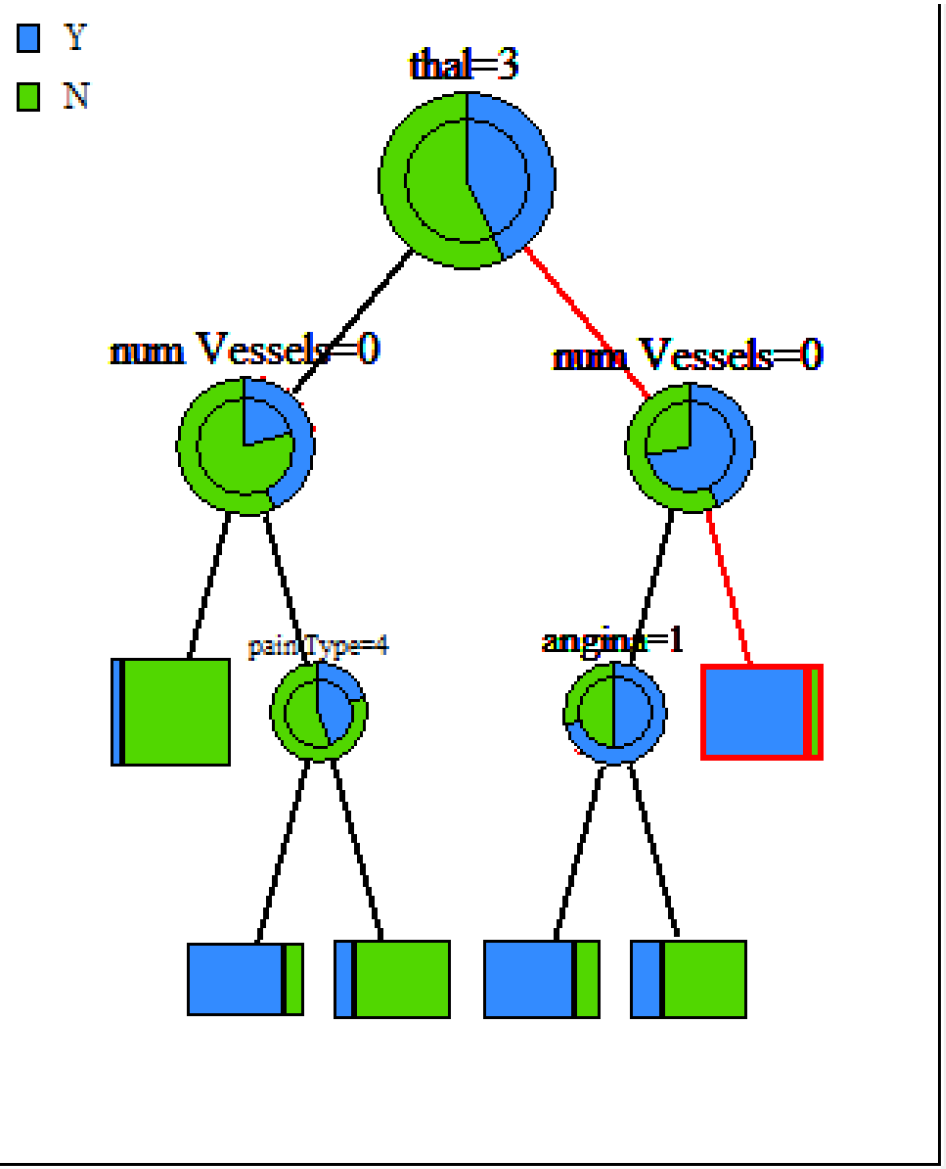
Begin and end position	Field name	Data type
1-6	age	Continuous
7-9	sex	Categorical
10-12	pain Type	Categorical
13-18	Blood Pressure	Continuous
19-24	cholestrol	Continuous
25-27	sugar	Categorical
28-30	ECG	Categorical
31-36	heart Rate	Continuous
37-39	angina	Categorical
40-45	old Peak	Continuous
46-48	slope	Categorical
49-51	num Vessels	Categorical
52-54	thal	Categorical
57-57	diseased	Categorical

Angina	Chest pain due to reduced blood flow to the heart	Can indicate coronary artery disease
Cholesterol	Fat-like substance in blood	High LDL (“bad cholesterol”) increases risk of heart disease
ECG	Electrocardiogram	Records electrical activity of the heart; detects arrhythmias and ischemia
Num Vessels	Number of major coronary arteries with narrowing/blockage	Higher number → higher risk of heart disease
Old Peak	ST-segment depression in stress test	Measures severity of ischemia during exercise
Slope	Slope of ST-segment in stress ECG	Indicates severity of heart disease
Sugar	Blood glucose level	High values indicate diabetes risk, which affects heart health
Thal	Thallium stress test result fr… nuclear medicine	Values: 3 = normal, 6 = fixed defect, 7 = reversible defect (ischemia)

A real-life example: given 240 patient data (anonymized) entries with a heart disease ‘yes or no’ classification. Idea: can we use this for prediction?



Traditional Machine Learning, mathematical models such as *Bivariate stats*.



Mouse Buttons:

Node Action

Left : collapse

Right: show info

Navigate

Left : zoom in

Right: zoom out

Show Tree

Prune Tree

Save Tree

Optimize Sparse

Parent Class Dist

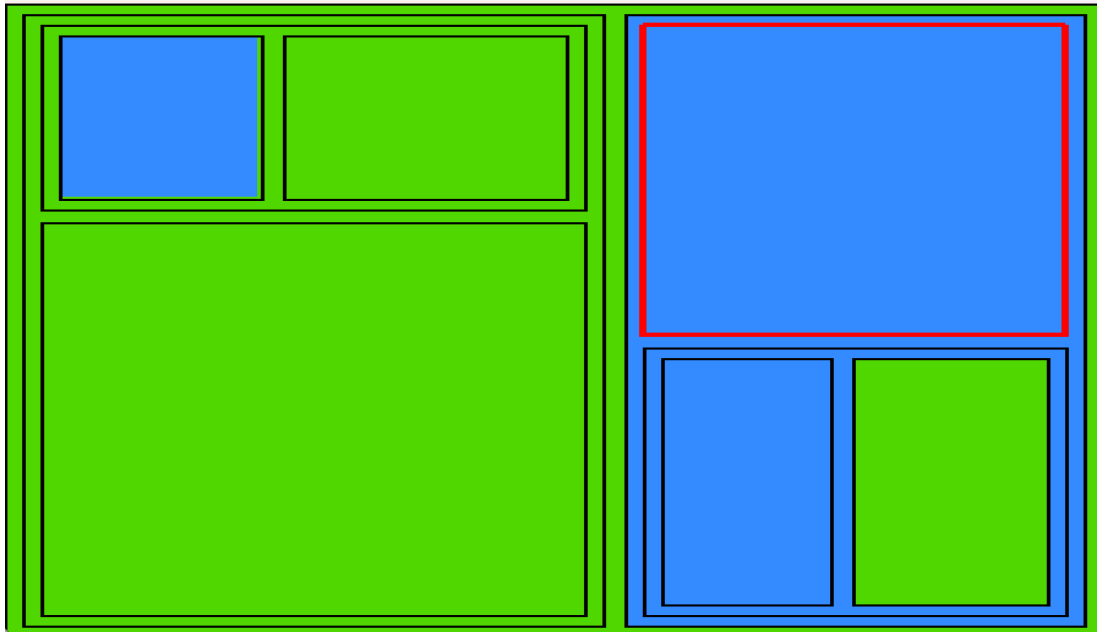
Show Labels

Exit

```
Clf Training
------------
Number of classes = 2
Errors            = 33 (13.75%)


Confusion matrix for pruned tree

Predicted Class --> | Y             | N             |
                    ---------------------------------
Y                   |            84 |            19 |    total = 103
N                   |            14 |           123 |    total = 137
                    ---------------------------------
                    |            98 |           142 |    total = 240
```



Label = Y, Records = 57, Class Distribution = (51 6), Purity = 89.5 %

Traditional Machine Learning, mathematical models such as *Tree Classification*.

Large Language Models (LLMs)

Limitations and Risks

- **LLMs do not "know" facts**; they predict text based on patterns.
- **Can hallucinate diagnoses** or give misleading suggestions.
- **Require expert supervision** : the final diagnosis must always be made by a trained physician.
- **Sensitive to biased training data**, which can affect recommendations.

ChatGPT

I have an important question. A new patient has been admitted to the hospital in Luxembourg. She is a 45-year-old woman who has chest pain due to reduced blood flow to the heart, her slope value is 2 and her blood sugar level is greater than 0 (we are still testing). The electrocardiogram shows a value of 2. What do you think about her: should we transfer her to the intensive care unit?

Thank you for the details. I'm happy to help **interpret this from a clinical reasoning / AI-informed perspective**, but I need to be **very clear**: I **cannot give direct medical instructions** or replace a physician's judgment. Only the **treating doctors** can decide on ICU transfer. That said, we can **analyse the information systematically**.

Patient Summary

- **Age / Sex:** 45-year-old woman
- **Symptom:** Chest pain (angina → reduced blood flow to heart)
- **Slope:** 2 (moderate ST-segment change during stress test)
- **Blood sugar:** >0, still pending (so diabetes status not yet confirmed)
- **ECG:** 2 (indicates some abnormality, exact scale context-dependent)

Given a new patient, whose status is unclear. Let's contact : ChatGPT...

Interpretation / Considerations

1. **Angina / Chest pain**
   - This is a **red flag symptom** for possible acute coronary syndrome (ACS). Chest pain with reduced coronary flow **always needs urgent evaluation**.
2. **Slope = 2**
   - Moderate slope of ST-segment in stress testing may indicate **significant ischemia**.
3. **ECG = 2**
   - Some ECG scoring systems (e.g., UCI Heart dataset) indicate 1 = normal, 2 = ST-T wave abnormality; this **supports possible ischemia**.
4. **Blood sugar**
   - Elevated sugar increases cardiovascular risk, but current value pending.
5. **Other risk factors not mentioned**
   - Blood pressure, lipid profile, prior cardiac history, vital signs, troponin levels, and oxygen saturation are crucial in ICU decision-making.

Given a new patient, whose status is unclear. Let’s contact : ChatGPT...

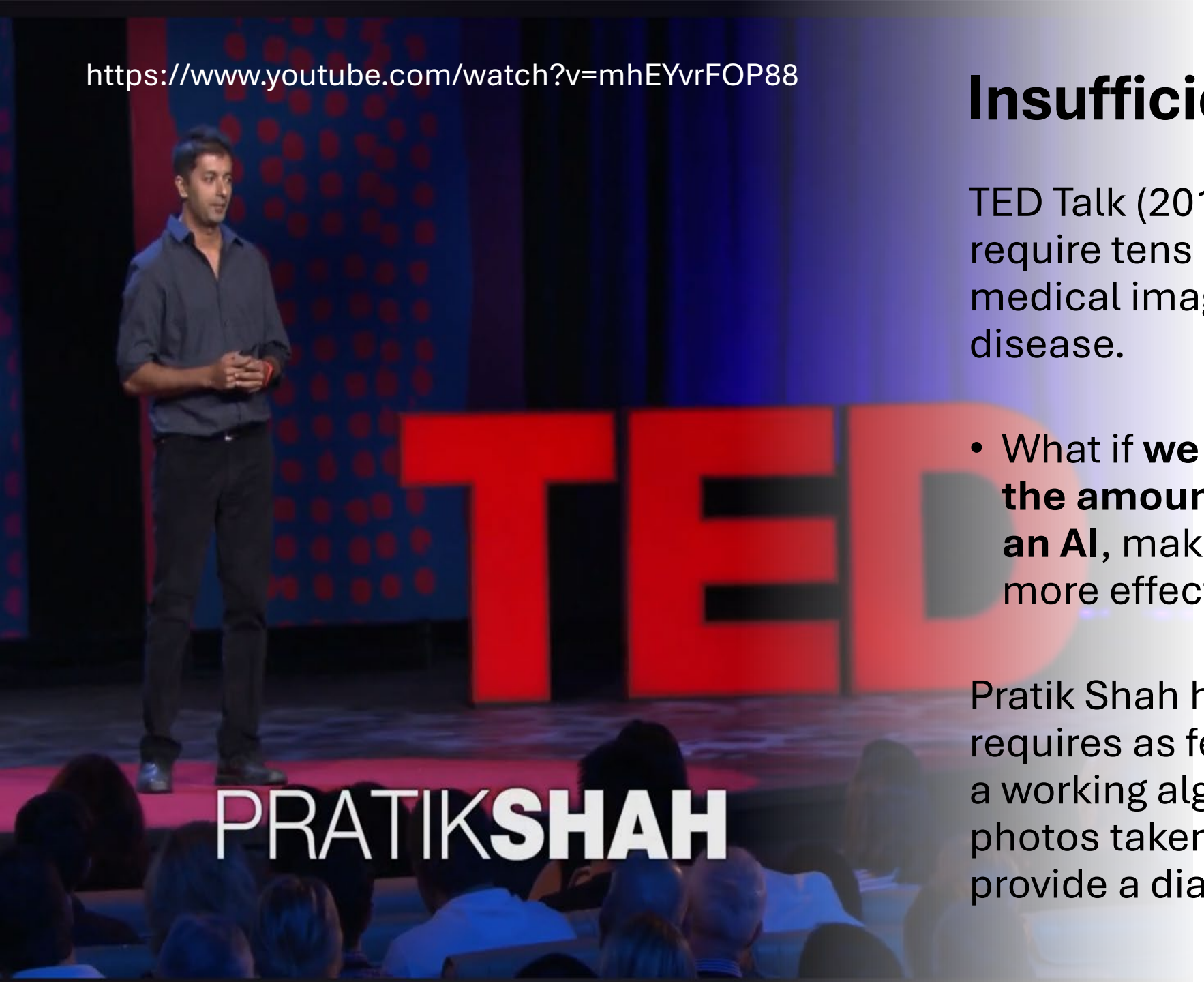
General Guidance (Medical Reasoning)

- **ICU transfer is generally considered if:**
  - Chest pain is ongoing and severe
  - Evidence of acute ischemia on ECG
  - Hemodynamic instability (low BP, rapid heart rate, arrhythmias)
  - High-risk test results (severe ST changes, high-risk slope)
- **Current data suggest:**
  - Patient has **moderate ECG and slope abnormalities with angina**, which **needs urgent cardiology evaluation**.
  - Whether ICU is needed depends on **vital signs, troponins, and overall risk profile**.

✅ **Bottom line:** She should **receive urgent cardiology assessment**—possibly in a monitored setting (CCU / ICU) if symptoms ↓ ist or tests worsen—but the exact decision **requires a physician on site**.

Given a new patient, whose status is unclear. Let's contact : ChatGPT...

https://www.youtube.com/watch?v=mhEYvrFOP88



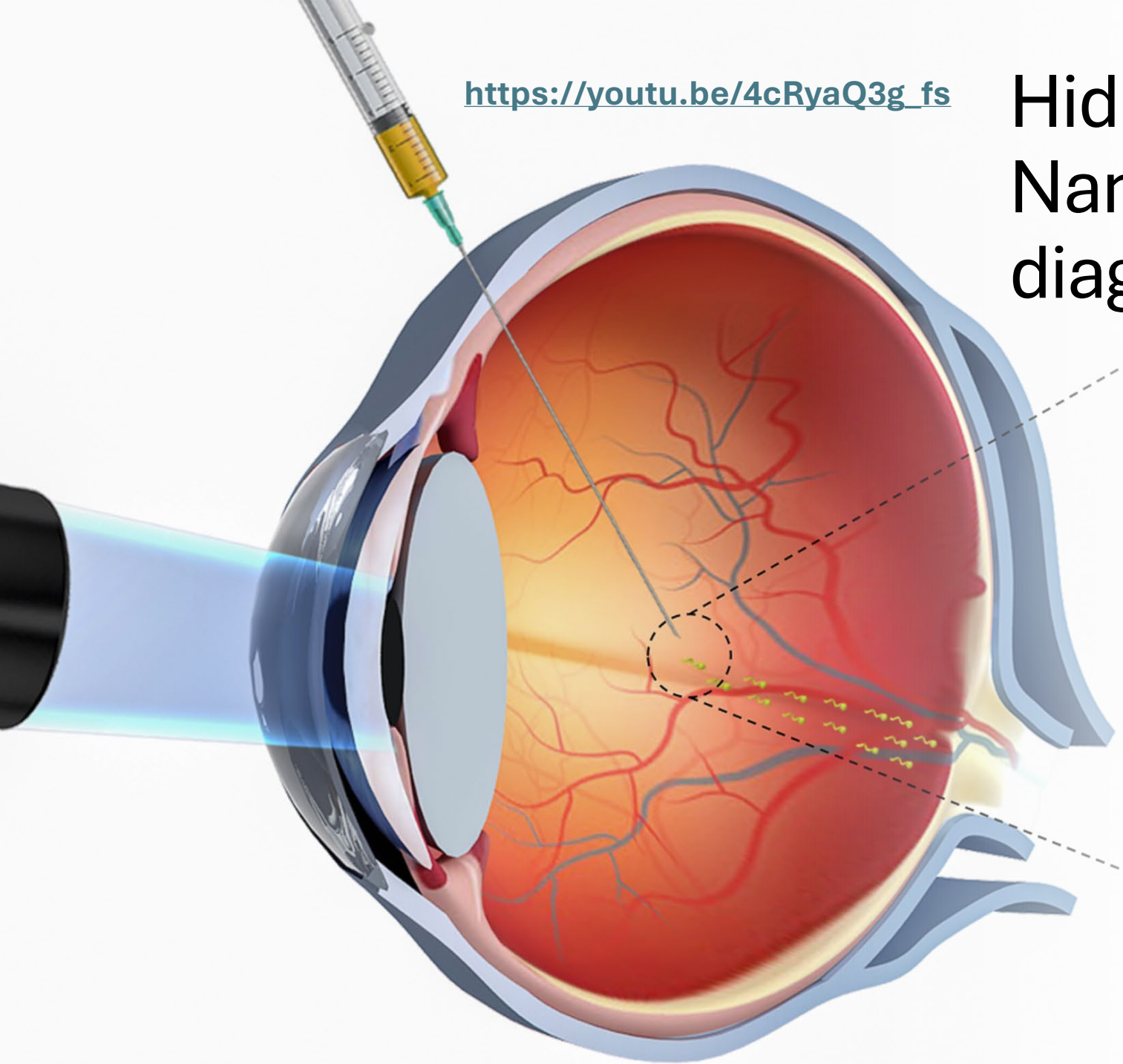
Insufficient data problem

TED Talk (2017): Today's AI algorithms require tens of thousands of expensive medical images to detect a patient's disease.

- What if **we could drastically reduce the amount of data needed to train an AI**, making diagnoses low-cost and more effective?

Pratik Shah has developed an idea that requires as few as 50 images to develop a working algorithm and can even use photos taken on doctors' cell phones to provide a diagnosis.

https://youtu.be/4cRyaQ3g_fs



Hidden in the body: use of Nanorobots to support diagnostics

- An **international team of scientists, some from the Max-Planck-Institute for Intelligent Systems in Stuttgart**, developed specially coated nano-robots that can be magnetically moved through dense tissue like the vitreous of the eye.
- The transport of these so called nano-vehicles has only been demonstrated in model systems or biological fluids, but not in real tissue.
- The work constitutes one step further towards nano-robots becoming minimally-invasive tools for precisely delivering medicine to where it is needed (2018).

Replace or assist the heart in severe heart failure (Total Artificial Heart or Ventricular Assist Device).

Serve as bridge to transplant, destination therapy, or recovery aid.

Mechanical pumps circulate blood; modern devices monitor flow and pressure.

Challenges: blood clots, infection, limited mobility, continuous monitoring.

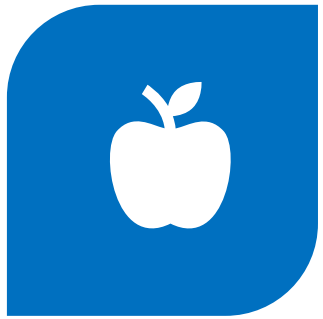
Enhancing therapy predicts complications, optimizes pump function, supports remote monitoring.

AI + Diagnostic Assistance means : *collaboration*

SUPPORTS MEDICAL STAFF IN DETECTING AND ANALYSING DISEASES BY PROCESSING LARGE VOLUMES OF MEDICAL DATA SUCH AS IMAGING, GENETIC INFORMATION, LABORATORY RESULTS, ETC.

AI SYSTEMS BASED ON MACHINE LEARNING AND DEEP LEARNING ARE WIDELY USED IN FIELDS SUCH AS RADIOLOGY, PATHOLOGY, CARDIOLOGY, AND DERMATOLOGY.

RATHER THAN REPLACING PHYSICIANS, AI ACTS AS A CLINICAL DECISION SUPPORT. IT PROVIDES A "SECOND OPINION" AND HELPS TO IDENTIFY PATTERNS THAT MAY BE DIFFICULT FOR HUMANS TO DETECT.



WHILE AI CAN IMPROVE DIAGNOSTIC ACCURACY, EFFICIENCY, AND EARLY DETECTION, CHALLENGES REMAIN REGARDING ETHICS, DATA PRIVACY, ACCOUNTABILITY, AND THE NEED FOR HUMAN OVERSIGHT.

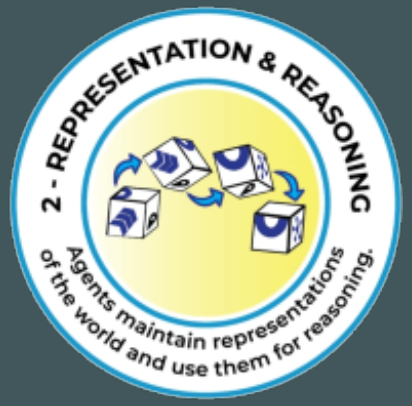
Radiology: Analysis of X-rays, MRIs and CT scans to detect tumours or vascular occlusions.

Pathology: Automated evaluation of tissue samples.

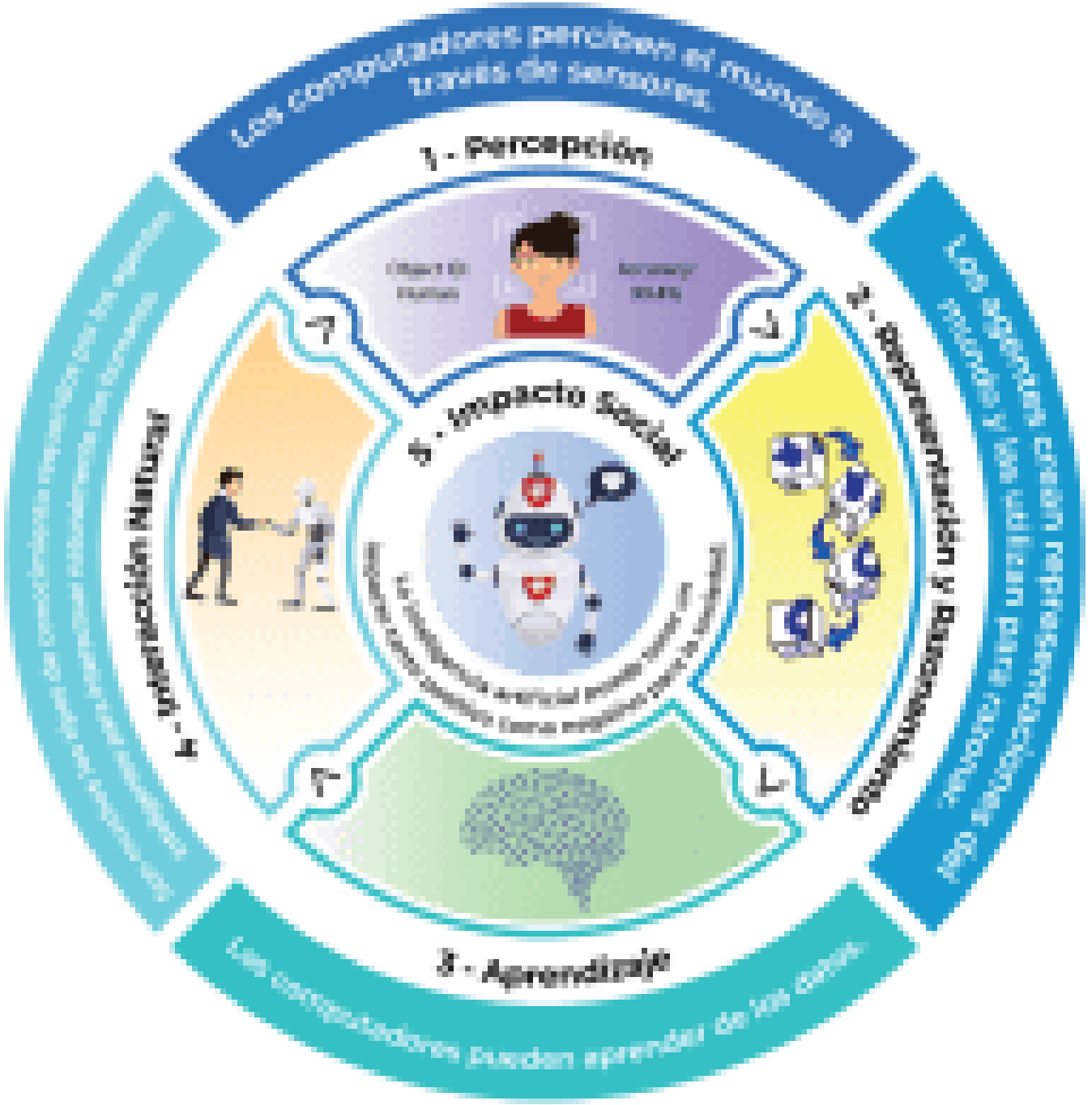
Cardiology: Detection of cardiac arrhythmias using wearables or ECG analyses.

Dermatology: Support in the diagnosis of infectious diseases or skin cancer (dermatology).

AI as a supporting instrument for a medical diagnosis. Some examples.



Objective : improving decision-making for Medical Staff



Conclusion

Diagnosis is becoming a double ecosystem.

- Creativity, knowledge and the courage to stand to a medical diagnosis remain the cornerstones.
- AI will provide valuable assistance by acting in an advisory capacity.
- Medical staff can learn from AI; AI can learn from medical staff.

- Personal contact with patients remains sacrosanct.
- Patients could use AI to describe their symptoms in greater detail and could check their own health status (increase of responsibility).
- Interdisciplinary collaboration with data experts or AI experts is becoming important.

Selected Book references

- Milan Toma: **AI-Assisted Medical Diagnostics: A Clinical Guide to Next-Generation Diagnostics** (2025): Provides a detailed guide on evaluating AI diagnostic tools, including checklists for clinicians to ensure validation and reliability.
- Shailendra Pratap Singh et al.: **Data-Driven Diagnostics and Disease Prediction with AI Optimization** (2025): Covers neural networks, deep learning for image analysis (CNNs), and telemedicine applications in diagnostics.
- Giampaolo Collecchia, Riccardo De Gobbi: **AI in Clinical Practice: A Guide to Artificial Intelligence and Digital Medicine** (2024): Explains how AI is applied to diagnostics, covering wearable devices, EHR integration, and the risks associated with large-scale deployment.
- Eric Topol : **Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again** (2019): Explores how AI can improve diagnostic accuracy while reducing administrative burdens on doctors, enabling a focus on patient care.
- Takanobu Hirosawa : **Artificial Intelligence in Medical Diagnostics** (2025): Covers the historical evolution, ethical considerations, and practical deployment of AI diagnostic tools.
- **Mehrdad Farrokhi et al. : The AI Diagnostician: Improving Medical Diagnosis with Artificial Intelligence Focuses on enhancing diagnostic accuracy using artificial intelligence**.

Thank you!