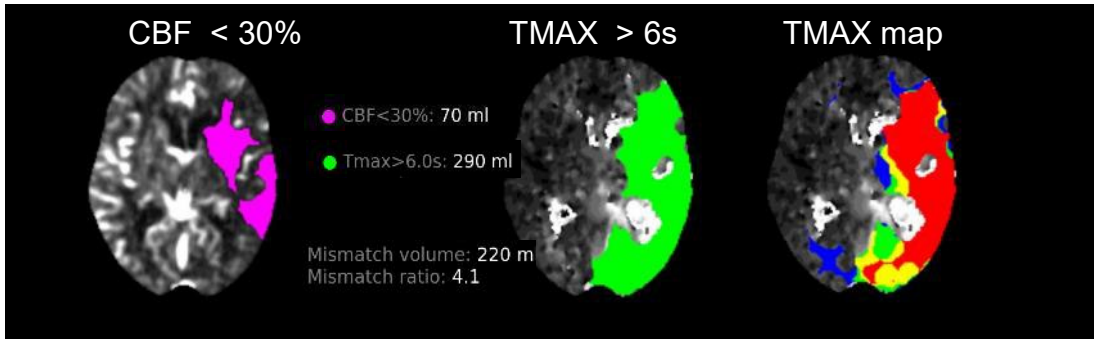
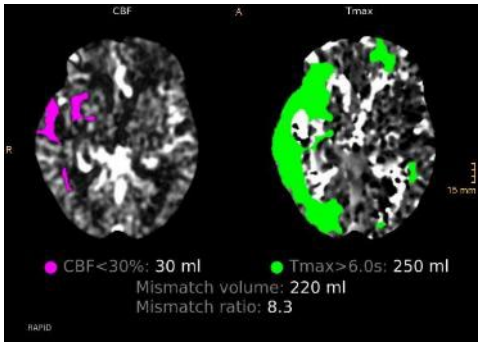
# Clinical Decision Making supported by AI and LLMs in Stroke

AI is already used in imaging of stroke patients…




Susanne Wegener

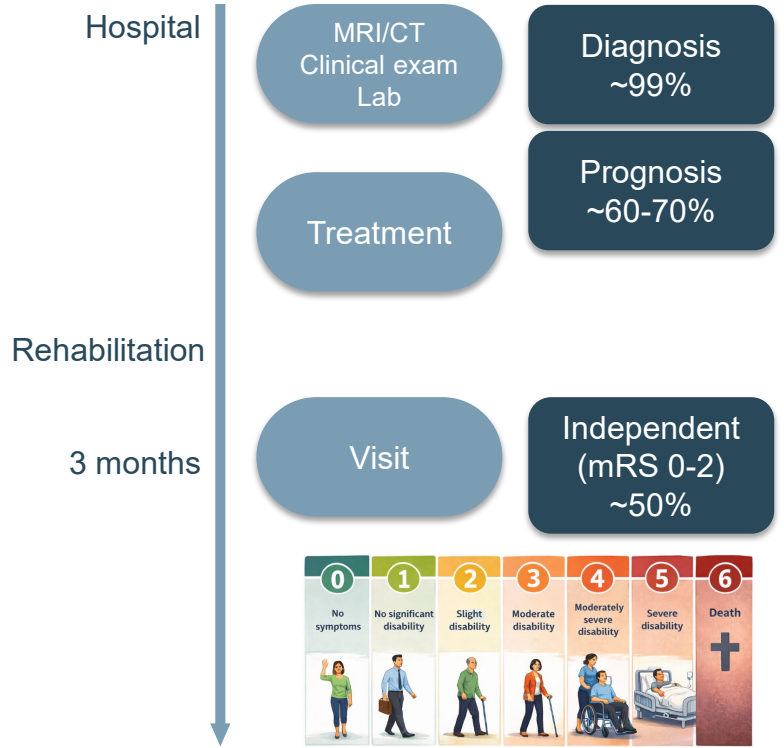
*Department of Neurology, University Hospital Zurich (USZ) and University of Zurich (UZH), Switzerland*

Lausanne Stroke Symposium, Sep 17 2026

# The gap in the system

## Current guidelines treat the average patient

- ❑ We know “what” has happened (**Diagnosis**)
- ❑ We can only guess what will happen (**Prognosis**)
- ❑ We need to play out “what if” scenarios to reach a **treatment decision**
- ❑ There is no objective estimate of the **individual treatment effect**



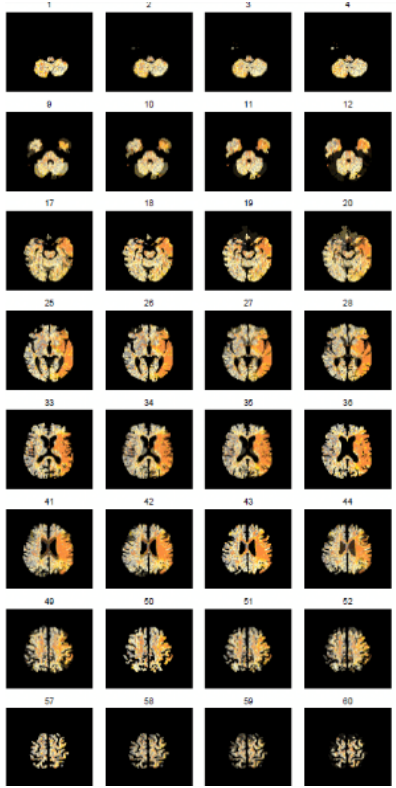
# How well do we currently predict outcomes in acute stroke patients ?

# Status Quo: Stroke Neurologists vs. Models predicting mRS 3 months (binary)

Clinical Data (LVO M1)

| | 2 |
|---|---|
| ID | 516341.00 |
| Age (y) | 54.00 |
| Sex (1: female) | 0.00 |
| Independent before stroke (1: yes) | 1.00 |
| NIHSS on admission | 15.00 |
| Oral anticoagulation (1: yes) | 0.00 |
| Statin therapy (1: yes) | 0.00 |
| Antihypertensive therapy (1: yes) | 1.00 |
| SBP (mmHg) | 158.00 |
| DBP (mmHg) | 91.00 |
| Glucose (mmol/L) | 7.10 |
| HbA1C (%) | 6.10 |
| LDL (mmol/L) | 1.15 |
| HDL (mmol/L) | 1.68 |
| TG (mmol/L) | 0.89 |
| CRP (mg/L) | 3.00 |
| INR | 1.00 |
| Atrial fibrillation (1: yes) | 0.00 |
| Diabetes (1: yes) | 1.00 |
| Hypertension (1: yes) | 1.00 |
| Hypercholesteraemia (1: yes) | 1.00 |
| Smoker (1: yes) | 1.00 |
| CHD (1: yes) | 1.00 |
| pAVK (1: yes) | 0.00 |
| Previous stroke or tia (yes) | 1.00 |
| Infarct side (1: left, 2: right) | 2.00 |
| Additional occlusions (yes) | 0.00 |
| Collateralization (0: good, 1: moderate, 2: poor) | 1.00 |
| Time onset to imaging (min) | 171.00 |

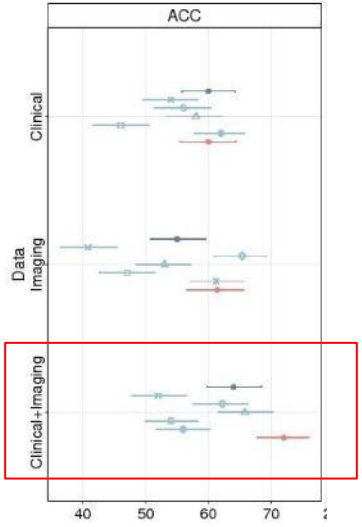
**Acute Stroke MRI**



Images: DWI, CBF, CBV, Tmax> 6s

*Thanks to Stroke Center Berne!*

**Task**: give a 3 months
mRS prognosis for this patient based on
a) Clinical b) Imaging c) Clinical + Imaging data.




We perform moderately well.
CNN is at least on par with neurologists with imaging data.

Herzog et al., *Stroke 2023*

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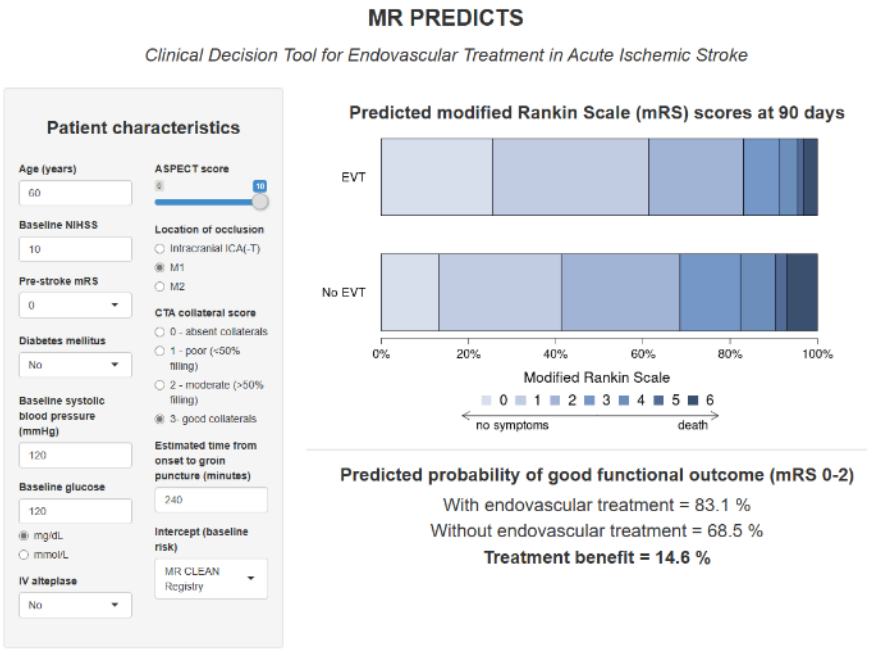
# The next step after the MRI data competition:

## New Data (CT), Randomized Data (MR CLEAN), New Models (Foundation Models) New comparators (MR PREDICTS)

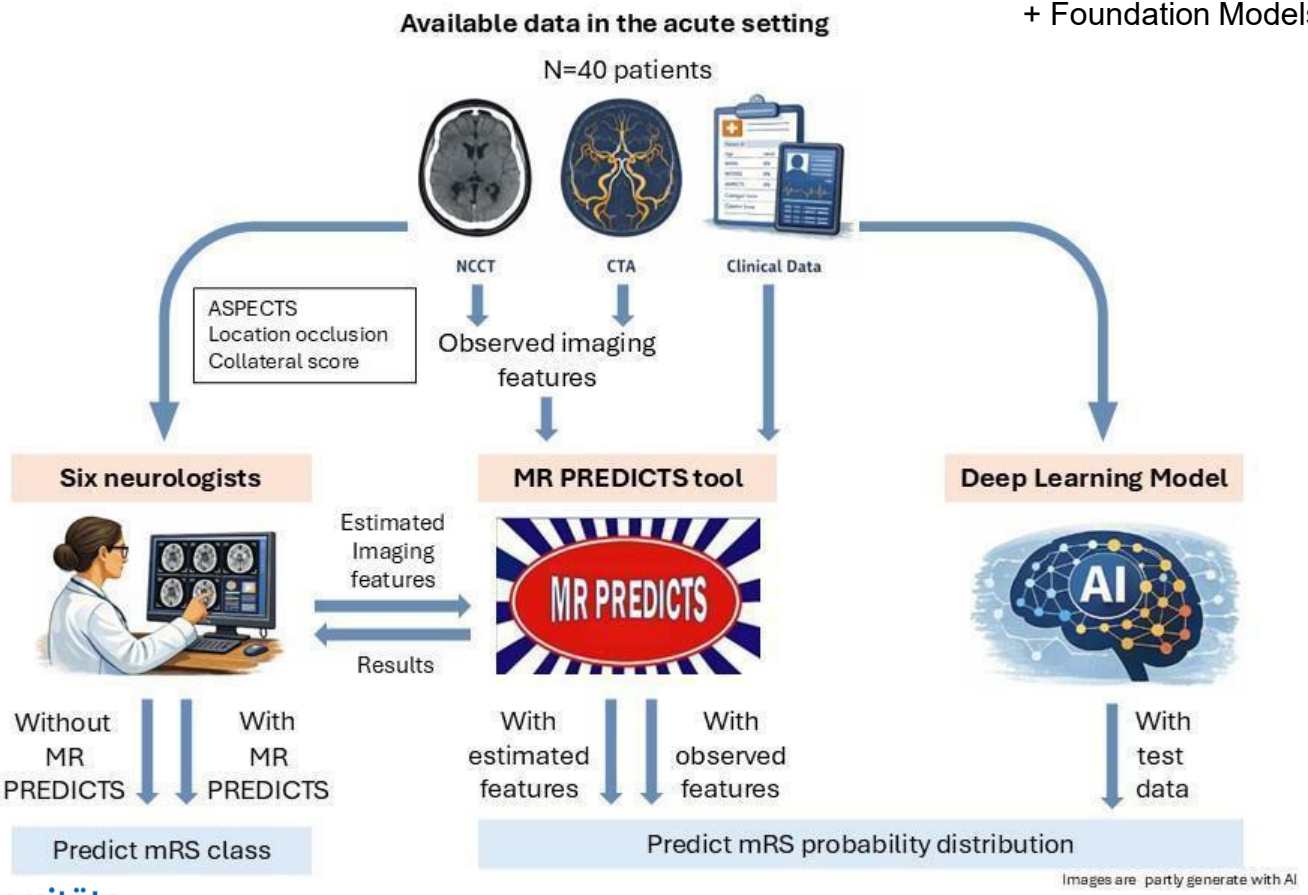




https://mdmtest.shinyapps.io/RRRR_2/

# Bringing in different imaging modalities (CT, CTA) + randomized data (MR CLEAN)

+ Foundation Models (instead of CNN)





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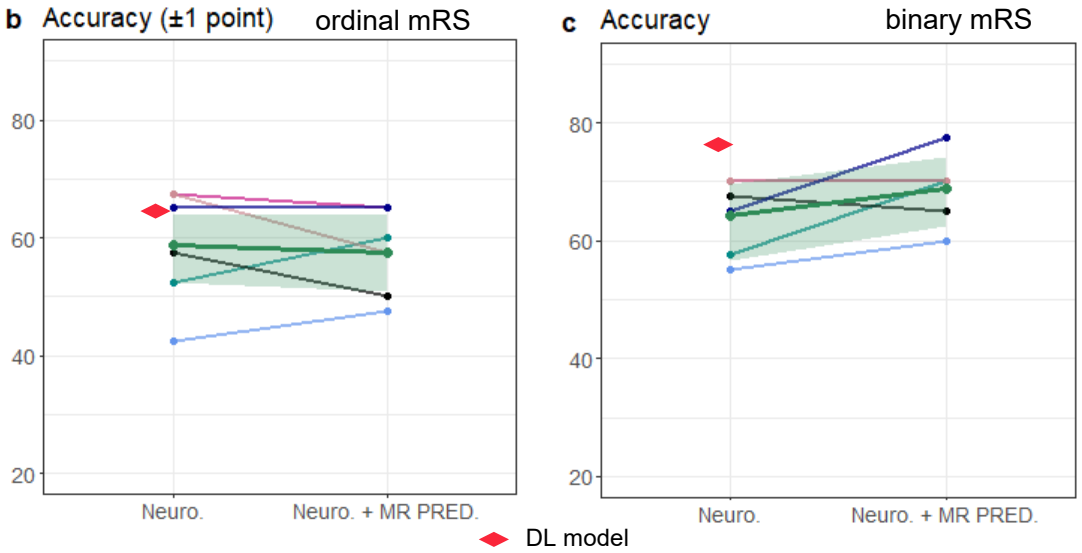
Herzog et al., *under Review 2026*

# Accuracy of Neurologists +/- support of MR PRED. vs. DL

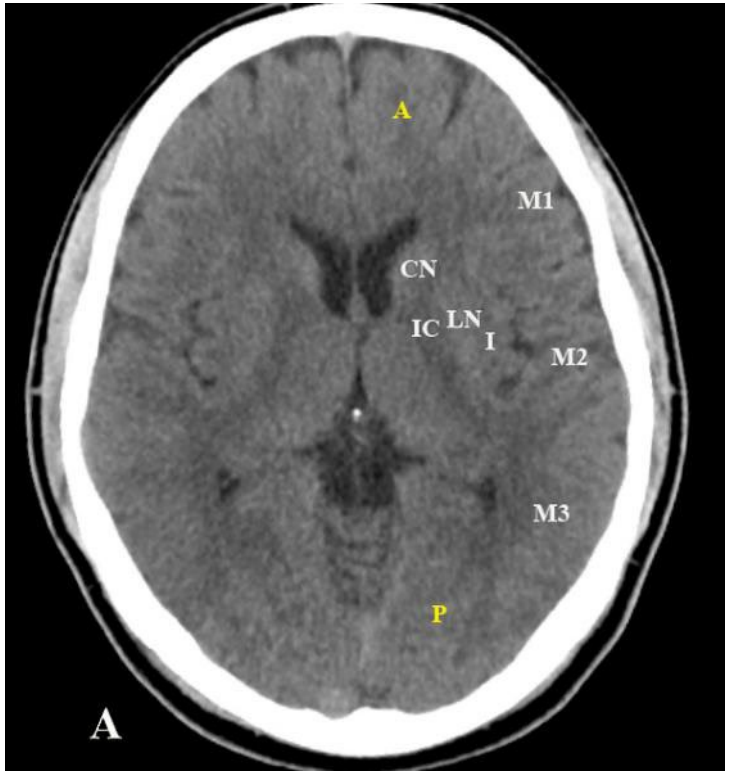



Not all raters improve with decision support tools.



Herzog et al., *under Review 2026*

# Imaging features are difficult to extract in clinical reality.




Accuracy for:

**Occlusion location**
65.8% (95% CI 59.2% to 71.7%)

**Collateral Score**
44.6% (95% CI 37.5% to 50.8%)

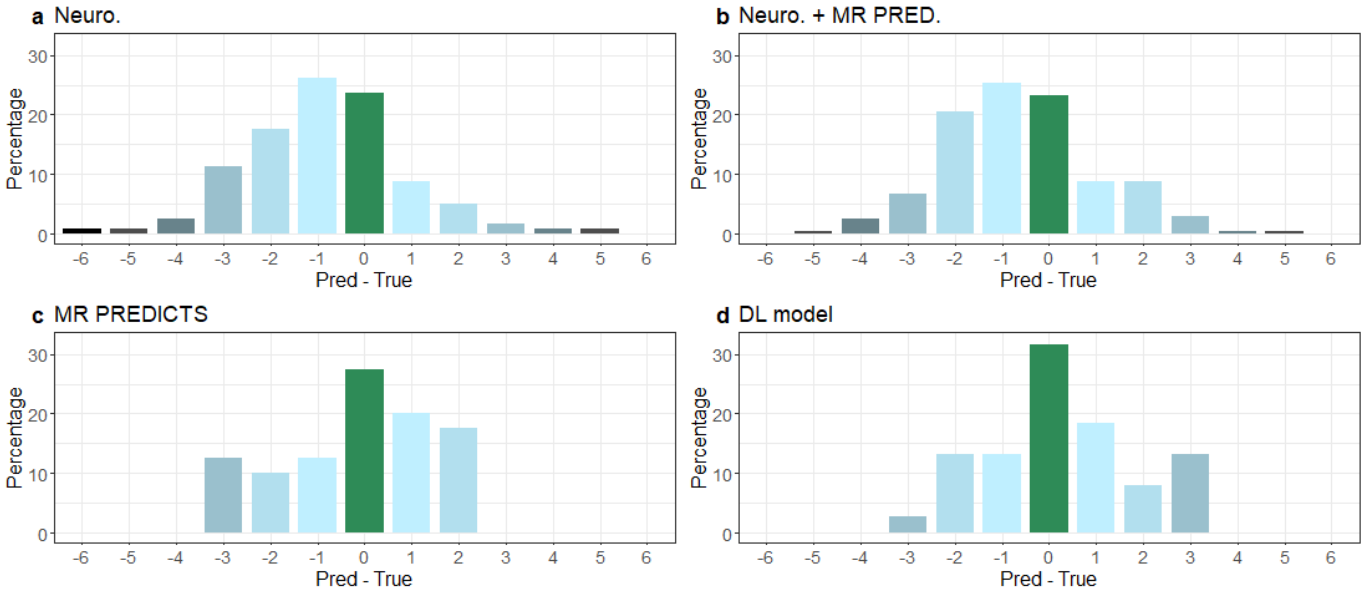
**ASPECTS Score** deviated by 3.4 points (95% CI 3.0 to 3.8)

Herzog et al., *under Review 2026*

Alberta stroke programme early CT score (ASPECTS) | Radiology Reference Article | Radiopaedia.org

# Prediction errors of Neurologists – and model

Optimism ⟷ Pessimism




Neurologists have an «optimism bias».



Herzog et al., *under Review 2026*

# Factors associated with prediction errors

| | Neuro. | Neuro. + MR PRED | |
|---|---|---|---|
| IAT = yes | -0.23 [-0.65–0.19] | -0.23 [-0.61–0.16] | Optimism Bias |
| IVT = yes | -0.35 [-1.05–0.35] | -0.16 [-0.81–0.48] | |
| Age | 0.01 [-0.01–0.03] | 0.01 [-0.01–0.03] | Pessimism Bias |
| Sex = male | 0.90 [0.45–1.35] | 0.76 [0.35–1.18] | |
| NIHSS on adm. | -0.01 [-0.05–0.04] | 0.04 [0–0.09] | |
| Hypertension | 0.77 [0.25–1.29] | 0.69 [0.21–1.16] | |
| Diabetes | 0.67 [-0.17–1.51] | 0.84 [0.07–1.62] | |
| SBP | -0.03 [-0.04–-0.02] | -0.03 [-0.04–-0.02] | |
| Glucose | -0.03 [-0.06–0] | -0.03 [-0.05–0] | |
| Time onset to door (min) | 0 [0–0] | 0 [0–0] | |

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Herzog et al., *under Review 2026*

# Summary: Neurologists, Scores and AI

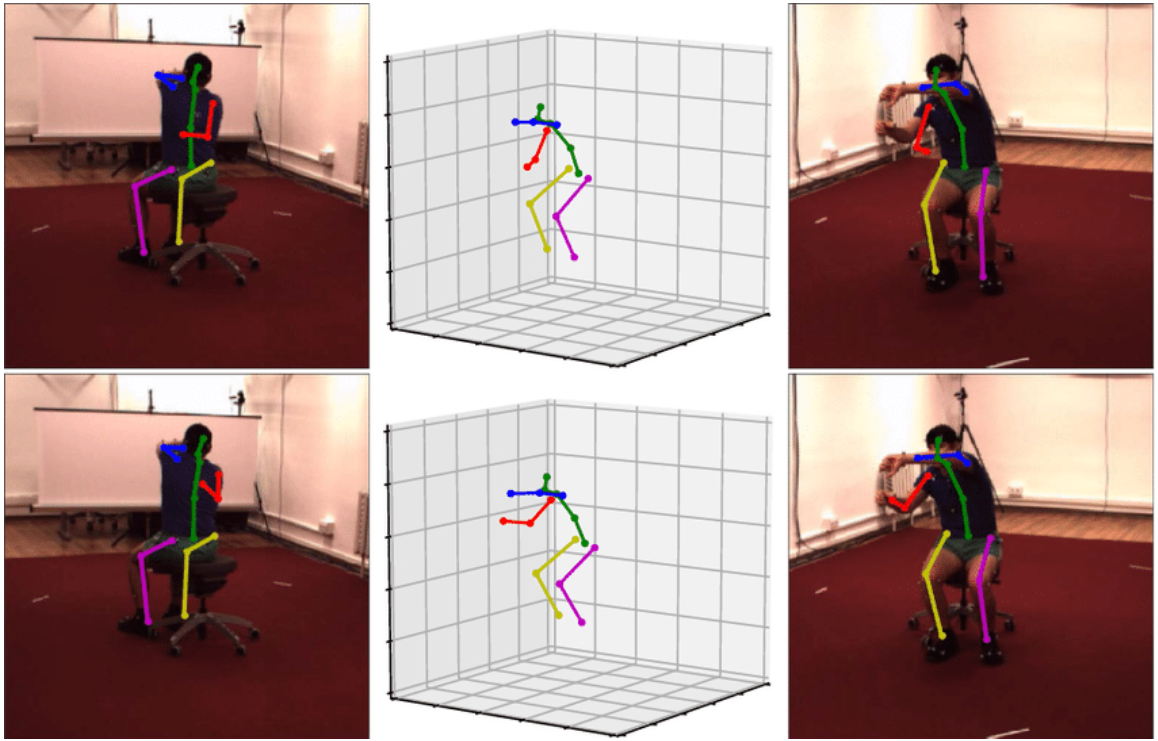
- We perform moderately well prognostifying 3month mRS (Acc 64.2%).
- On average, this improves slightly with use of MR PREDICS (Acc 68.8%).
- Not everyone benefits from score-assistance (less experienced benefit more).
- Neurologists have an optimism bias.
- Neurologists tend to overemphasize treatment- effect.
- Problem with scores that use imaging readouts: getting those right.

If all this can be improved using AI – models:
why is AI-derived prognosis only slightly better ?

# Challenging our standard outcome measures

mRS is not a good outcome measure. Death/ AEs between discharge and 3 months can be independent of stroke or of information contained in images.

## The POSE Trial.



Alexander Mathis (EPFL),
Julian Deseö,

- on discharge
- at 3 months

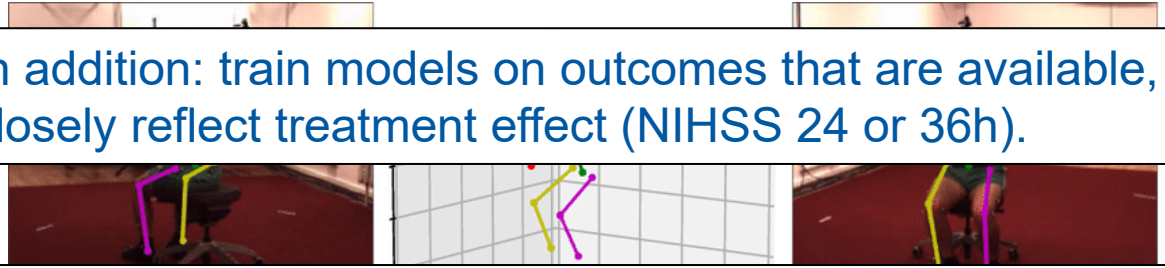
First experience with stroke patients + recovery trajectory,


# Challenging our standard outcome measures

mRS is not a good outcome measure. Death/ AEs between discharge and 3 months can be independent of stroke or of information contained in images.

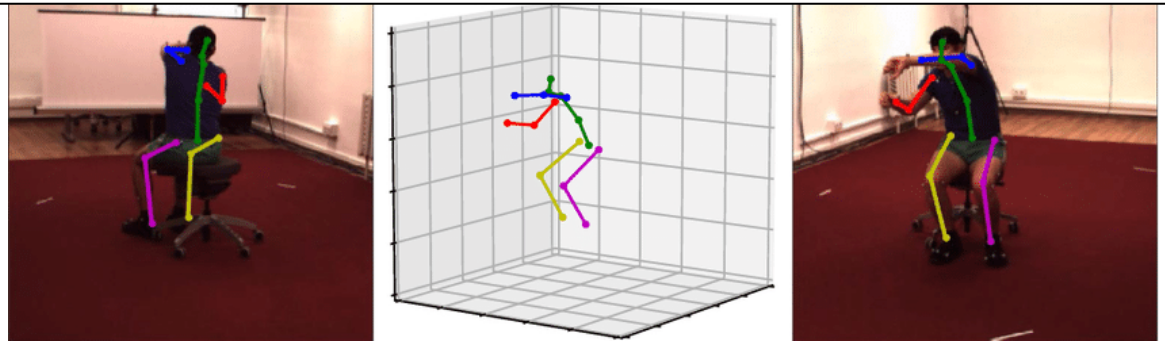
## The POSE Trial.

In addition: train models on outcomes that are available, and more closely reflect treatment effect (NIHSS 24 or 36h).



Alexander Mathis (EPFL),

Go back to clinical source data and understand which cases were predicted wrongly and why…



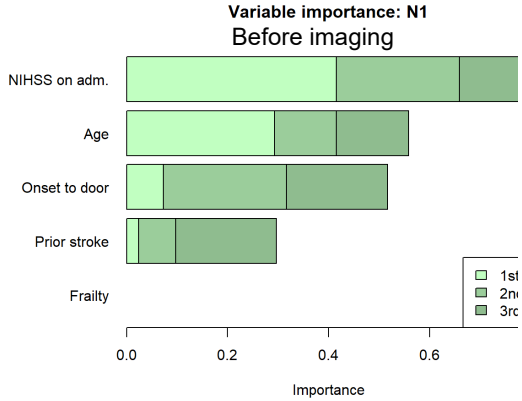
First experience with stroke patients + recovery trajectory,


# Bringing in new variables for prediction from a prospective observational trial

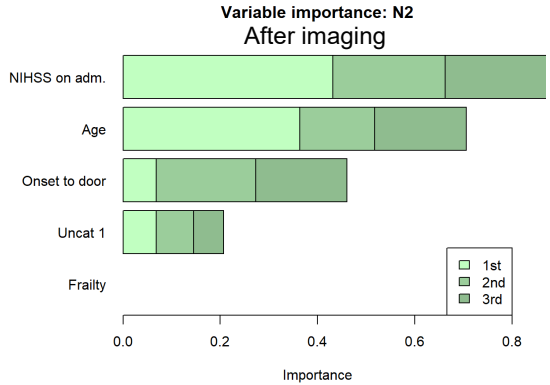
**Searching for other variables**: prospective Study: **STOP Stroke (recruiting)**

***STOP-stroke: STroke Outcome Prediction in the acute treatment setting***

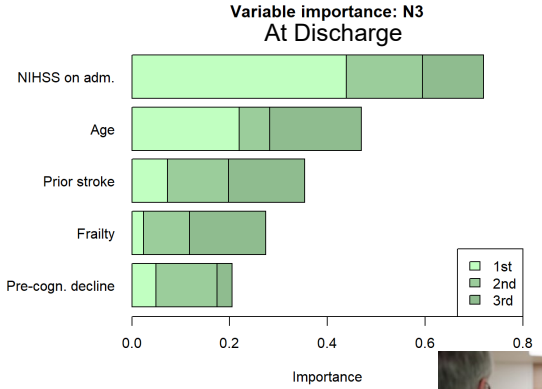
- prospective collection of clinical and imaging variables that clinicians consider important such as frailty, social support, previous living situation…other




ACC: 71.4%




ACC: 85.2%




ACC: 87%

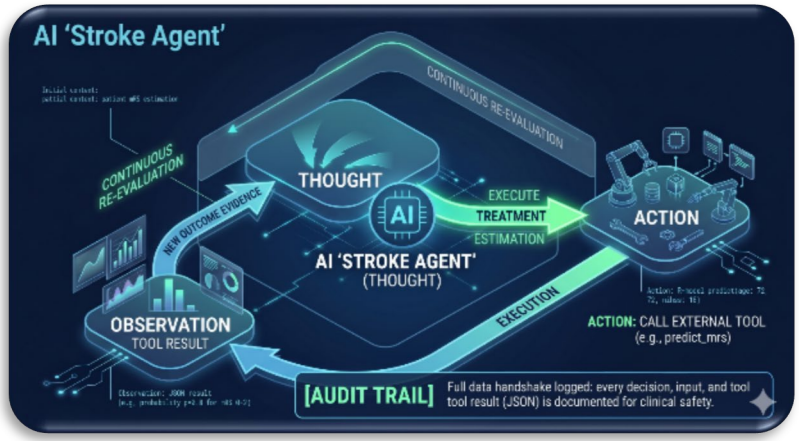

First 50 patients: accuracy is better than in retrospective trial design.
Which variables are particularly helpful? Ongoing.
We dont consider imaging variables very much.

STOP-STROKE
STROKE OUTCOME PREDICTION IN THE ACUTE TREATMENT SETTING

# Our vision: The STROKE AGENT

Digital AI support for neurologists

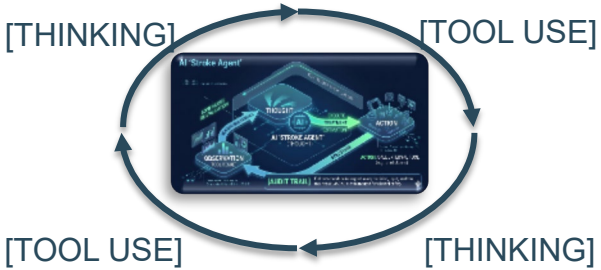
- **Multimodal integration:** Fuses imaging and clinical information
- **Predictive models:** Uses validated statistical/AI models for prognoses and treatment recommendations
- **Interactive:** Natural dialogue with neurologists
- **Transparent:** Rationale for the prognoses and decisions
- **Guideline-compliant:** Integration of clinical guidelines



# Interactive user interface (LLM)

## Collaboration between human and machine


- **Simplicity:** Queries via text / voice
- **Real-time:** Uses validated statistical/AI models for prognoses and treatment recommendations
- **Focus:** Reduces cognitive load for the physician by listing guidelines and relevant patient data




Implementation Science

**Doctor:** "What is the 90-day mRS for my patient: NIHSS 12?"

**Doctor:** "80 years."

**Doctor:** "Should I treat the patient?"

????

**Doctor:** "Are there any Contra-indications visible in the patient record?"

**AI:** "For the prediction, I also need the age."

**AI:** "The estimated mRS-distribution is: mRS 0=15.5%, mRS 1=17.4%, …"

**AI:** "The probability of a good outcome (mRS 0-2) with treatment is 60% vs. 45% without treatment."

**AI:** "…"

# AUDIT TRAIL

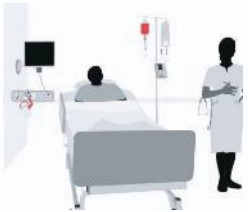
## Safety & Trust

- **No black box:** Every reasoning step of the AI is logged in the background
- **Legal certainty:** Complete record for clinical audits
- **Traceability:** Which data/inputs lead to which recommendation, and why.

*{ "tool": "predict_mRS", "input": {"age": 60, "nihss": 12}, "output": "success", "signature": "verified" }*

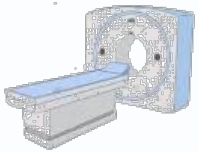
# Models supporting treatment decisions in acute stroke and for secondary prevention

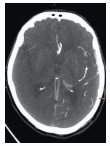
**Stroke Patient admission**



Patient history
Third party history

Clinical assessment





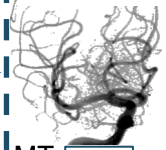
Neuroimaging

Blood

ECG

USZ Stroke Agent

**Acute Tx**



MT +/-

IVT

Stroke Unit (no IVT/MT)

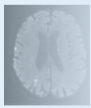
*Shorter Tx-Times*

USZ Stroke Agent

*Proper Preventive Tx*

\+

Clot



Pose estimation

**Prev.Tx**

?

**Outcome**

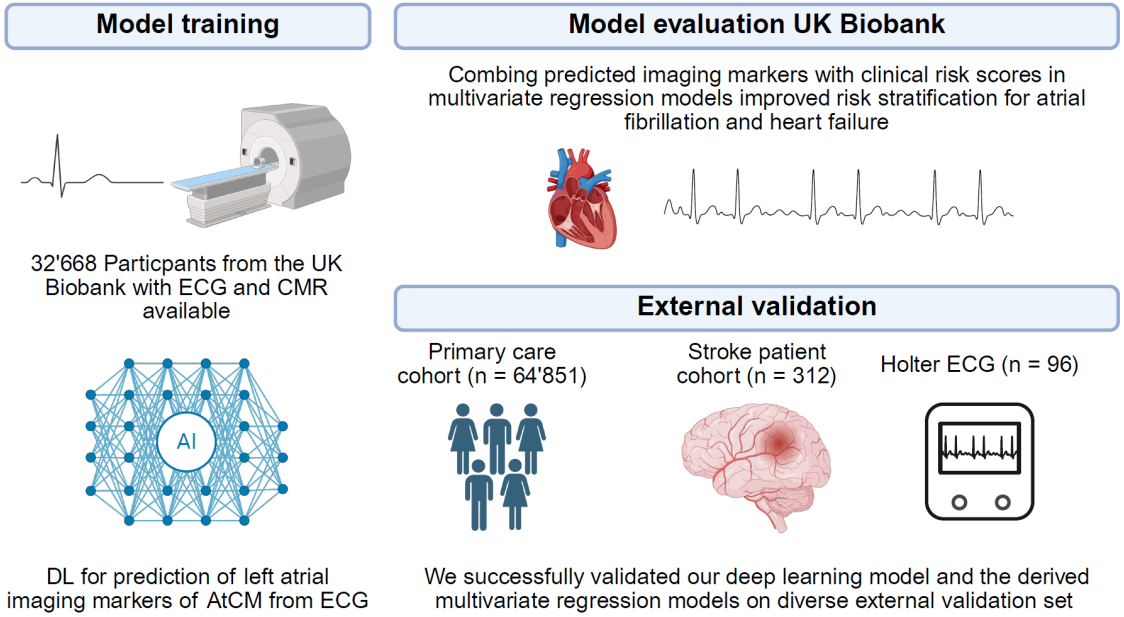
**Best possible individual Recovery**
**+**
**Prevention of Stroke Recurrence**

Acute Stroke (< 12h)

Hospital (1-7 d)

3 months visit

# AI and imaging for secondary prevention (example: screen for atrial cardiopathy)




**CMR**: Cardiac magnetic resonance, **DL**: deep learning, **ECG**: electrocardiogram

## Deep learning enables diagnosis of atrial cardiomyopathy from routine 12-lead electrocardiogram


a) Deseö et al., *Stroke 2026*
b) Deseö et al., *under Review* 2026

medRxiv 2025.12.18.25342359

Prospective Trial: anticoagulation in ESUS based on ECG model (+ combined with other data)?

# Where are we going with our models ?

- Better endpoints (instead of only 3 mRS)
- More images (the MAGIC consortium)
- Agentic AI

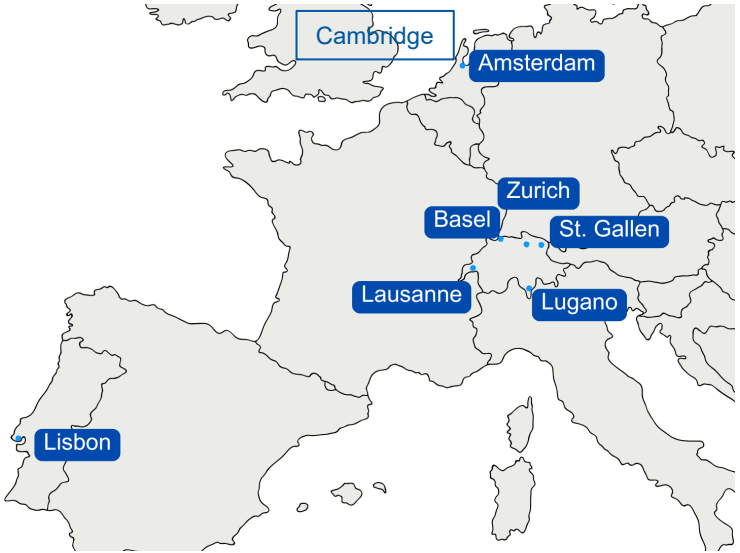
Test models in prospective clinical trials.

Task 1) Speed up Tx decisions with «Stroke Agent»

Task 2) Predict atrial fibrillation as source of stroke before it is found (for earlier Tx)

Task 3) Predict those at risk of reperfusion failure for maximum benefit of of new therapeutic agents (+ incorporate blood biomarkers)

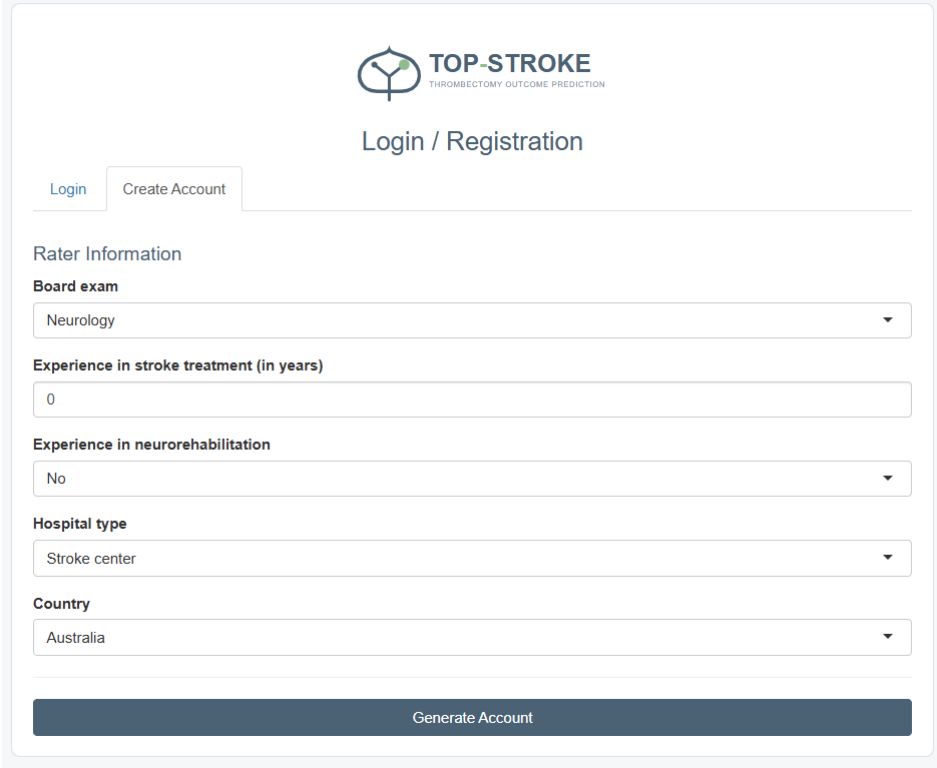
MAGIC: Currently n= approx. 2000 stroke data sets.

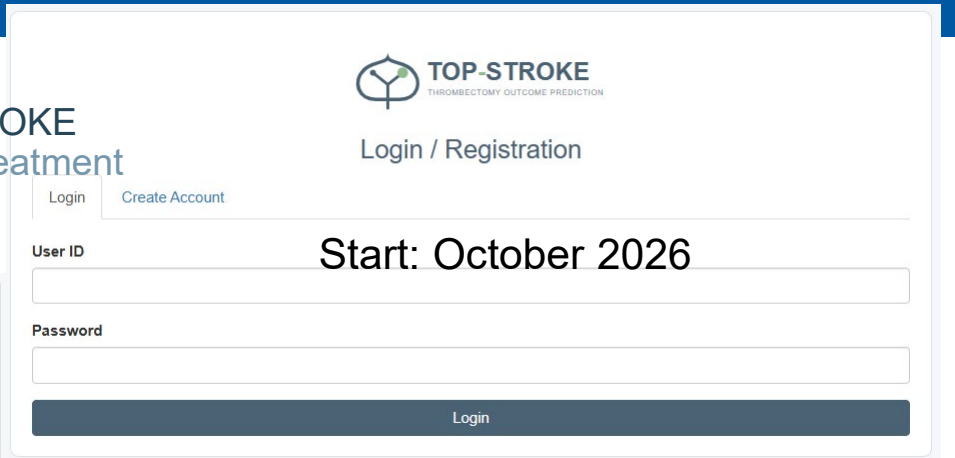



Hakim Baazaoui

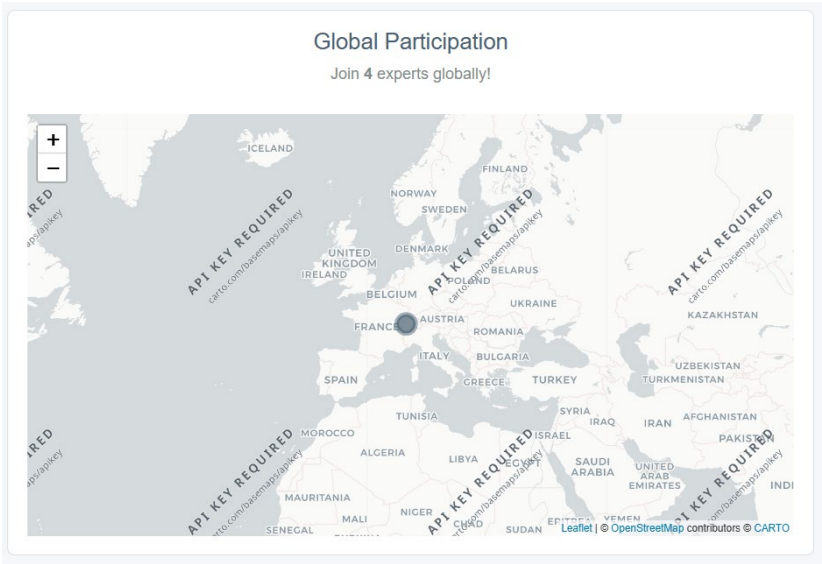
MAGIC: Baazaoui et al., *Frontiers Neuroinformatics* 2024

# The Zurich TOP-STROKE study
# Thrombectomy Outcome Prediction in ischemic STROKE
## A public rating study to improve our understanding of treatment decision-making in LVO Stroke



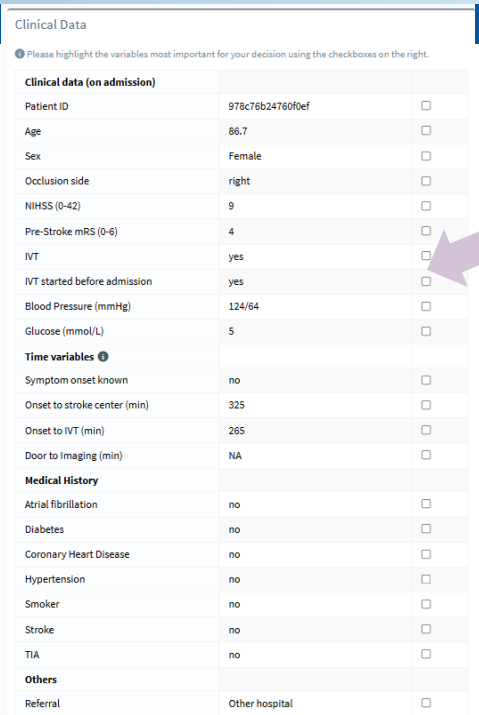




Start: October 2026



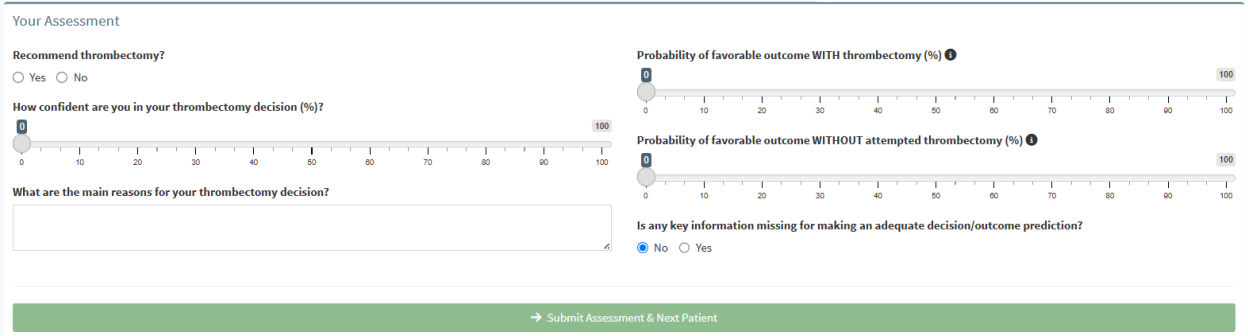
Interactive DICOM viewer
For NCCT, CTA and CTP
(TMAX, CBF)


Clinical variables



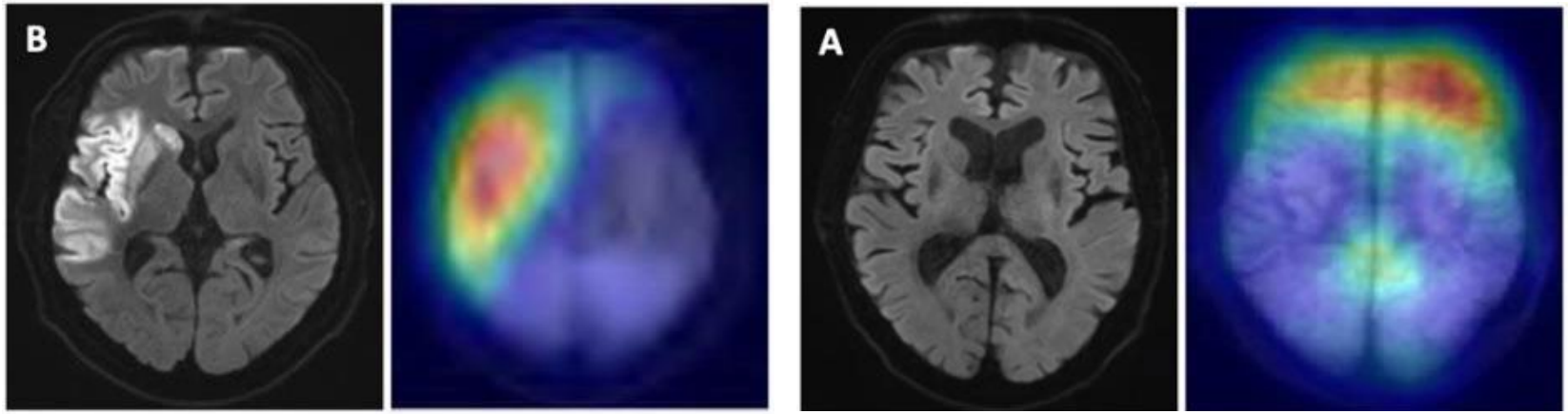

Treatment recommendation

Understanding decision

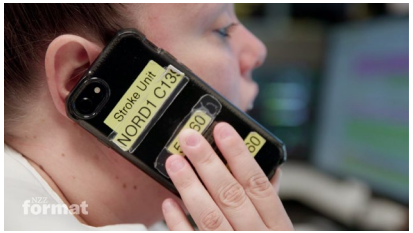


# Thank you!

## What is important in these images - for the specific outcome prediction mRS 3 months?




Build Trust: Validate – Show Features – Show uncertainties – Test prospectively.

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University of Zurich[UZH]

FNSNF Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung

ZNZ Zentrum für Neurowissenschaften Zürich

Schweizerische Herzstiftung

NOVARTIS | The Novartis Foundation