# The **Surg-e-Screener HF** Tool:

# *Improving Heart Failure Recognition using Electronic Health Records*

## e-Learning Module


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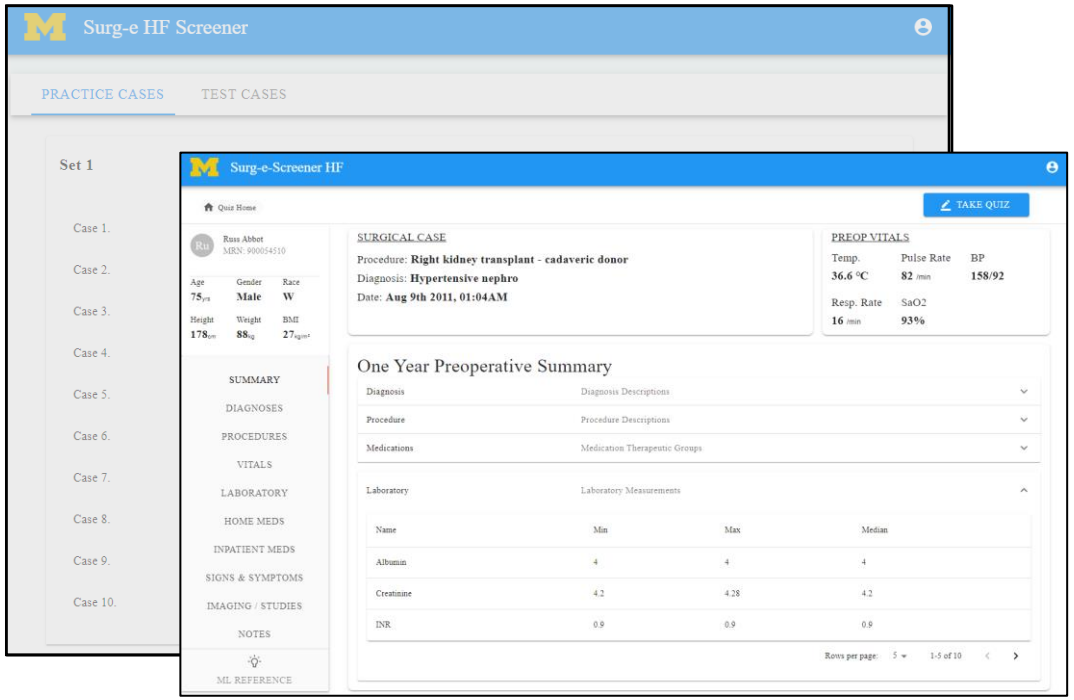
# The Problem

Treatments for **heart failure** (HF) proven to extend & improve quality of life are limited by clinicians' ability to diagnose the disease in **early stages**.

# The Problem

***Unrecognized or untreated*** heart failure is the single greatest risk factor for cardiovascular complications and mortality after **major surgery**.

# The Solution: Surg-e-Screener HF

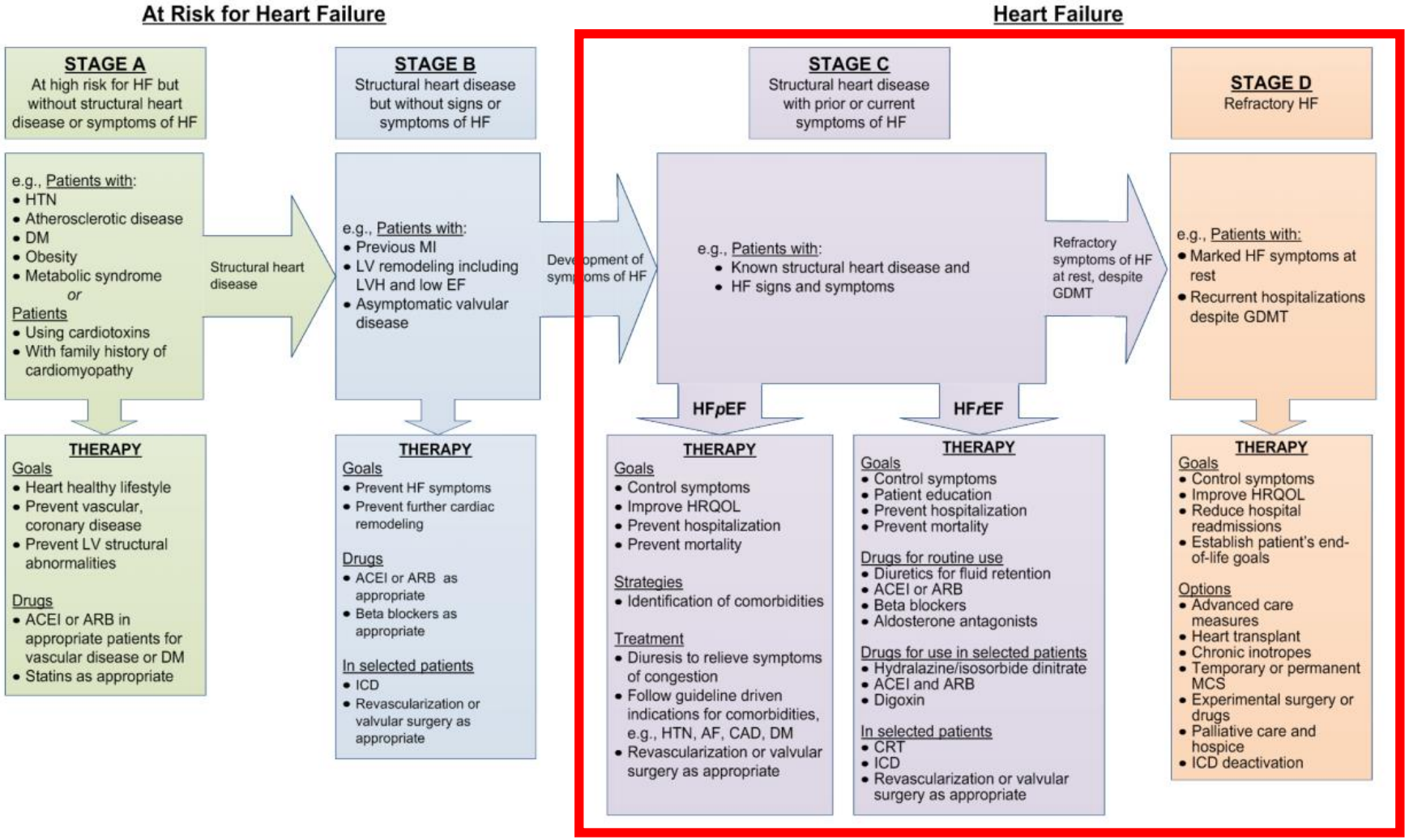



**Surg-e-Screener HF:**
*Automated screening & educational tool*

**Education & Training –**

- It is a quiz-based webapp to **improve HF recognition** with surgical cases in EHR
- It provides a report after completing quizzes to ***compare*** your clinical judgment to **a pane of HF experts**
- It is designed to **augment clinicians' ability** using EHR data and machine learning (ML) reference

# Chronic Heart Failure Definition for this Tool




For purposes of this tool, **Chronic HF** defined as:

- **Chronic**:
  Signs +/- symptoms or underlying pathophysiology persistent for ≥ 3 months (with onset defined as the *start* of this ≥ 3 month period)
- **HF**:
  ACCF/AHA Stage C or D (*prior* or current symptoms + structural heart disease)


Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology.* 2013;62(16):e147-239.

# Purpose of this study

To understand how EHR-based *heart failure (HF) recognition* can be improved as aided by the **Surg-e-Screener HF** tool.

# Case Review Process

## 1. Case Reviews

Assume you are *a preop physician* reviewing the patient's medical history prior to surgery in order to identify factors pertaining to presence/absence of HF

- Previous HF diagnoses (simplest way to detect, but occasionally inaccurate)
- Signs & symptoms, labs, studies/imaging, medications, clinical notes.

## 2. *Pre-test*: HF Recognition Quiz


For the first 10 cases, you use EHR data to decide if a patient had HF (chronic ACC/AHA Stage C or D) before the start of the surgery.

## 3. ML Reference

After completing the quiz, you have access to the ***Machine Learning (ML) reference,*** ML performance indicators and a list of risk factors ranked by an algorithm.

## 4. *Post-test*: HF Recognition Quiz


For the next 10 new cases, you use EHR data **AND** the ML reference to decide if the patient had HF (chronic ACC/AHA Stage C or D) before the start of the surgery.

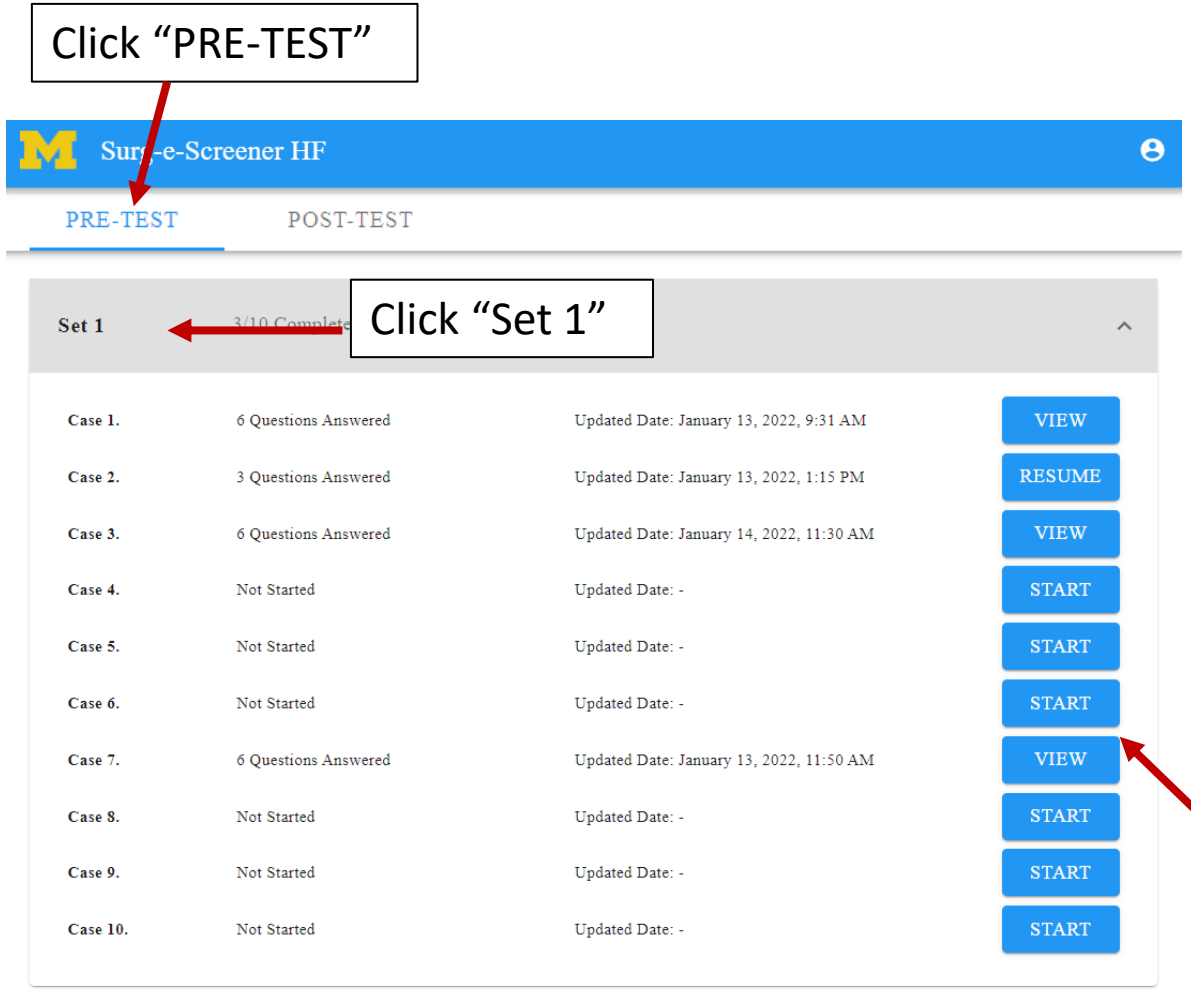
## 5. Expert Review Comparison

After completing 20 surgical cases, you can access a result report, comparing your HF decision to pre-determined answers and a short case summary by HF experts.

# How to use the tool:

Step-by-step Guide

# Step 1. Case Reviews



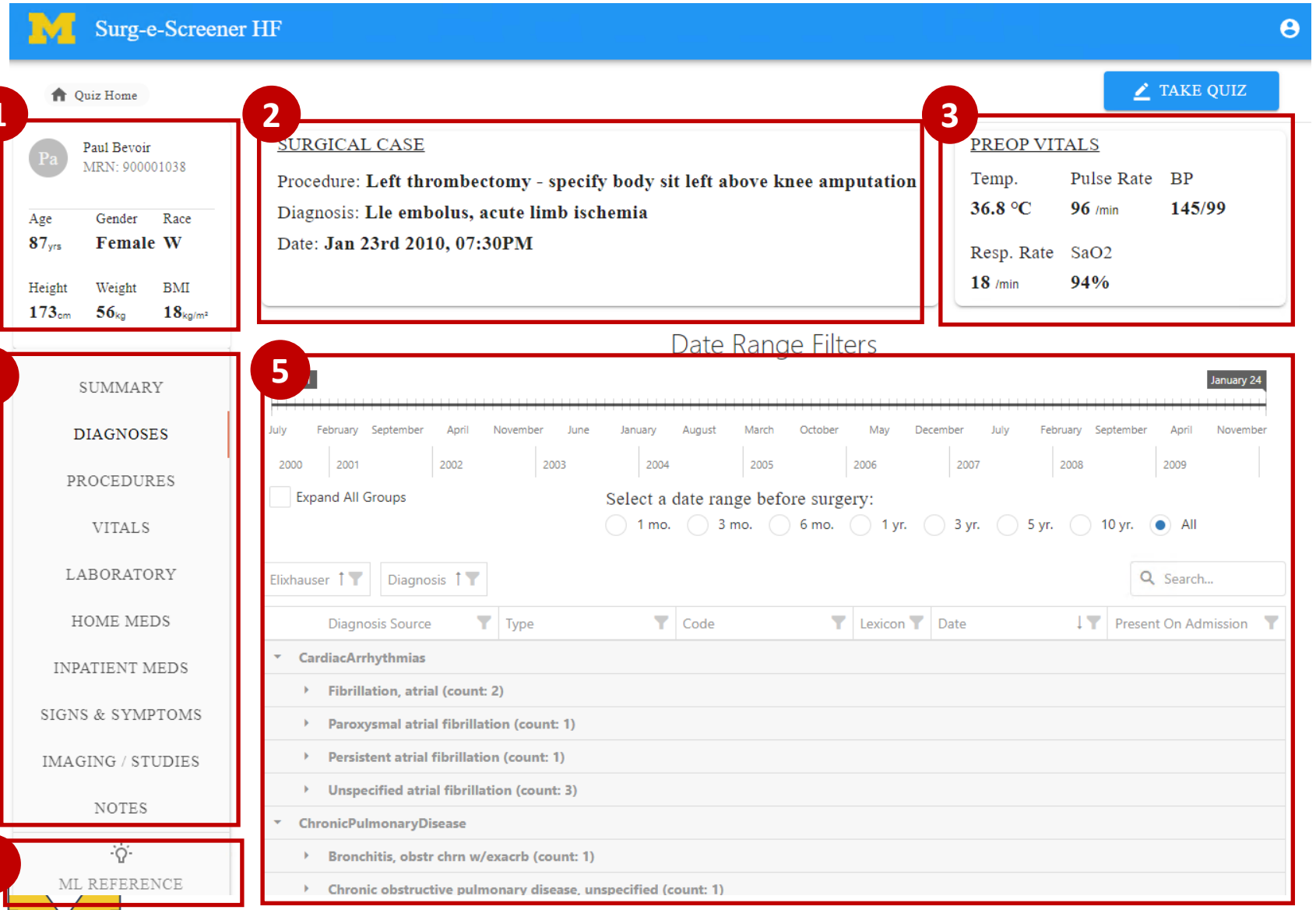

## Check your assigned cases

- 10 surgical cases are assigned to ***Pre-Test*** and 10 surgical cases are in ***Post-Test***.
- Click ***Pre-Test*** to review 10 surgical cases.
- Click the ***Start*** button to begin your case review. The button indicates your status.

### Status of your progress:

| | |
|---|---|
| **START** | No questions completed. |
| **RESUME** | Partially answered questions, not yet completed. |
| **VIEW** | Completed questions. You can *only* view the case. |

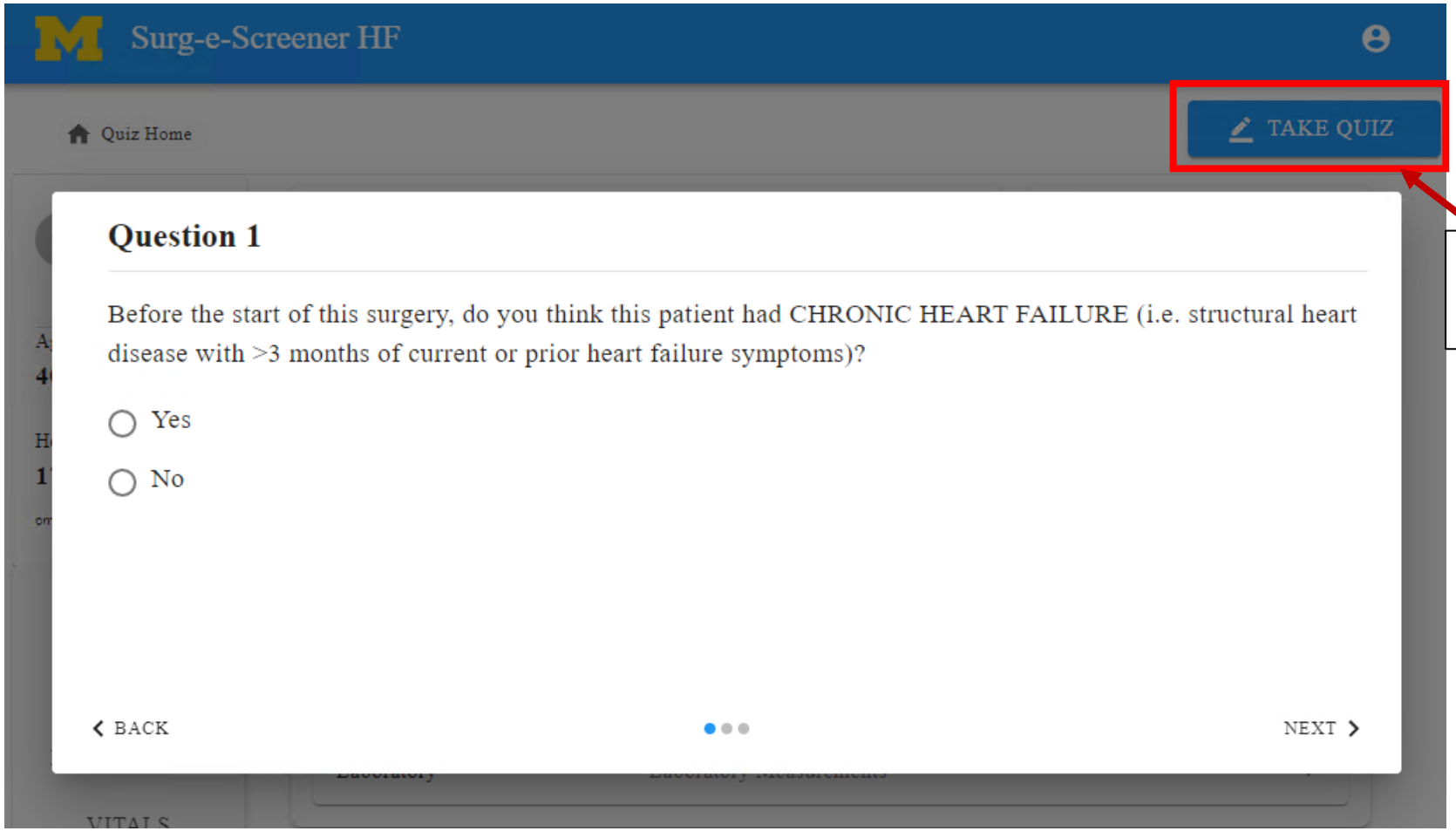
# Step 1. Case Reviews: Dashboard




## Key components

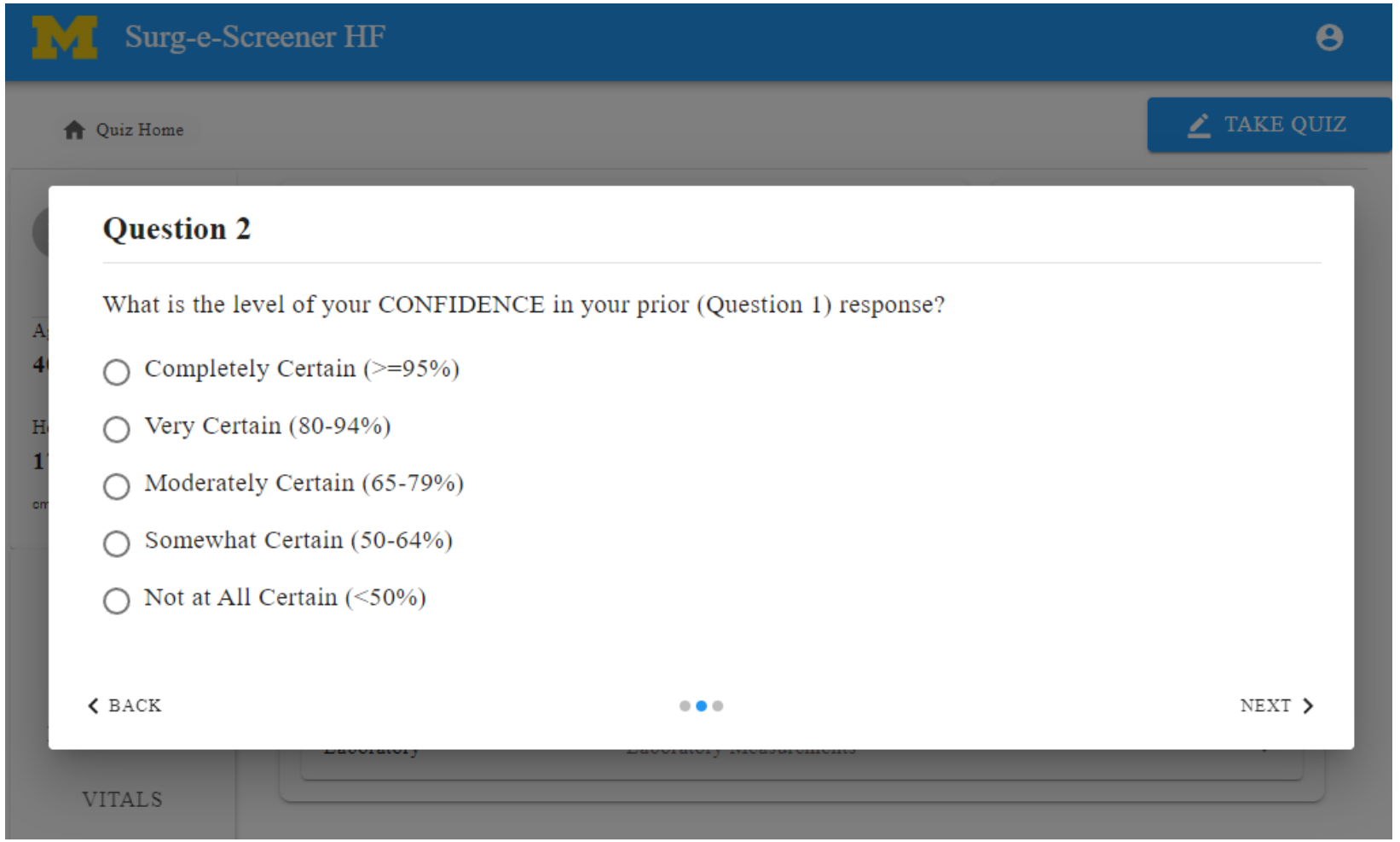
1. Demographics
2. Surgical Case
3. Preoperative Vitals
4. Subject Domains
5. Date Filter & EHR data
6. ML reference

# Step 2. *Pre-test*: HF Recognition Quiz

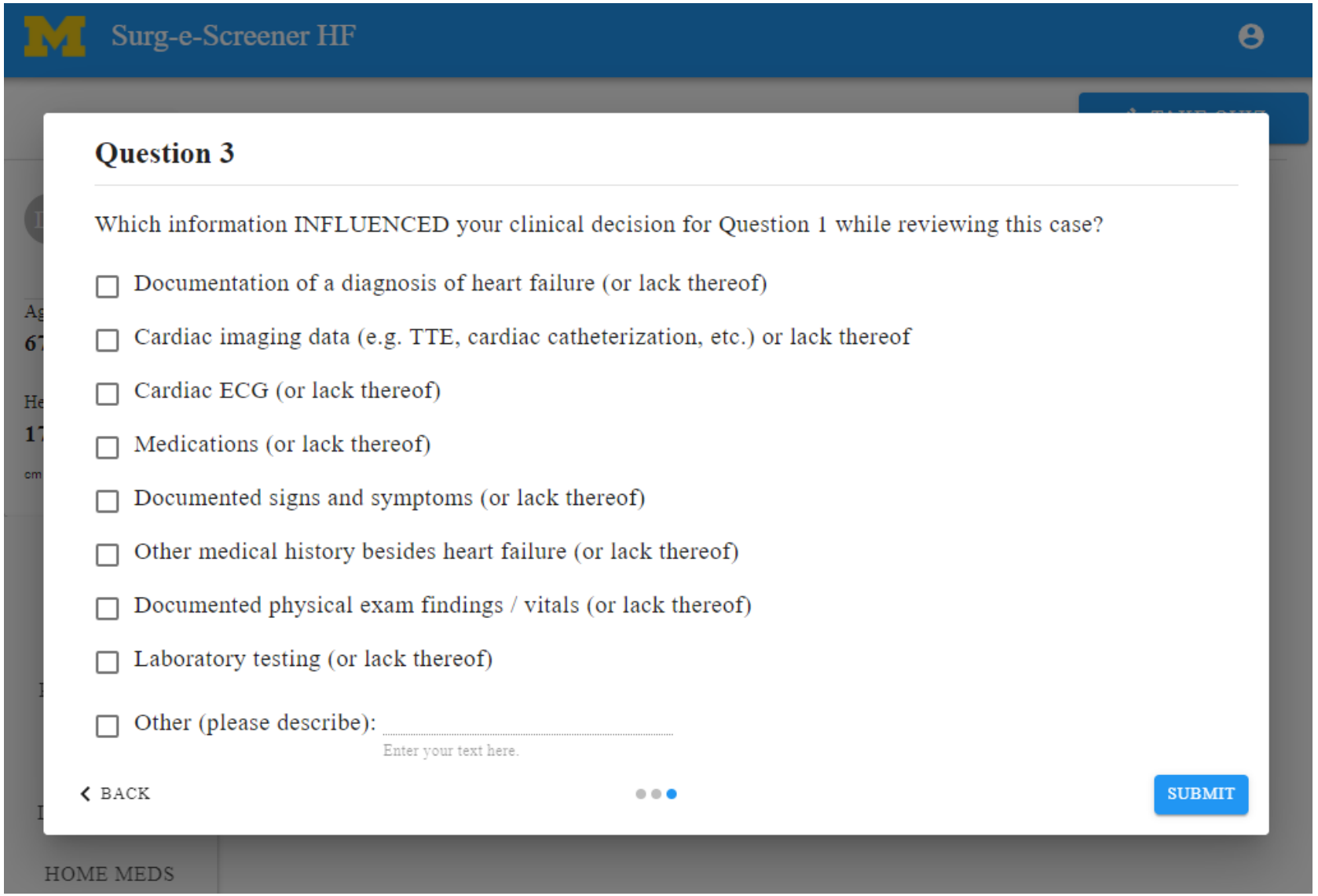



Click “Take Quiz” to answer your decision

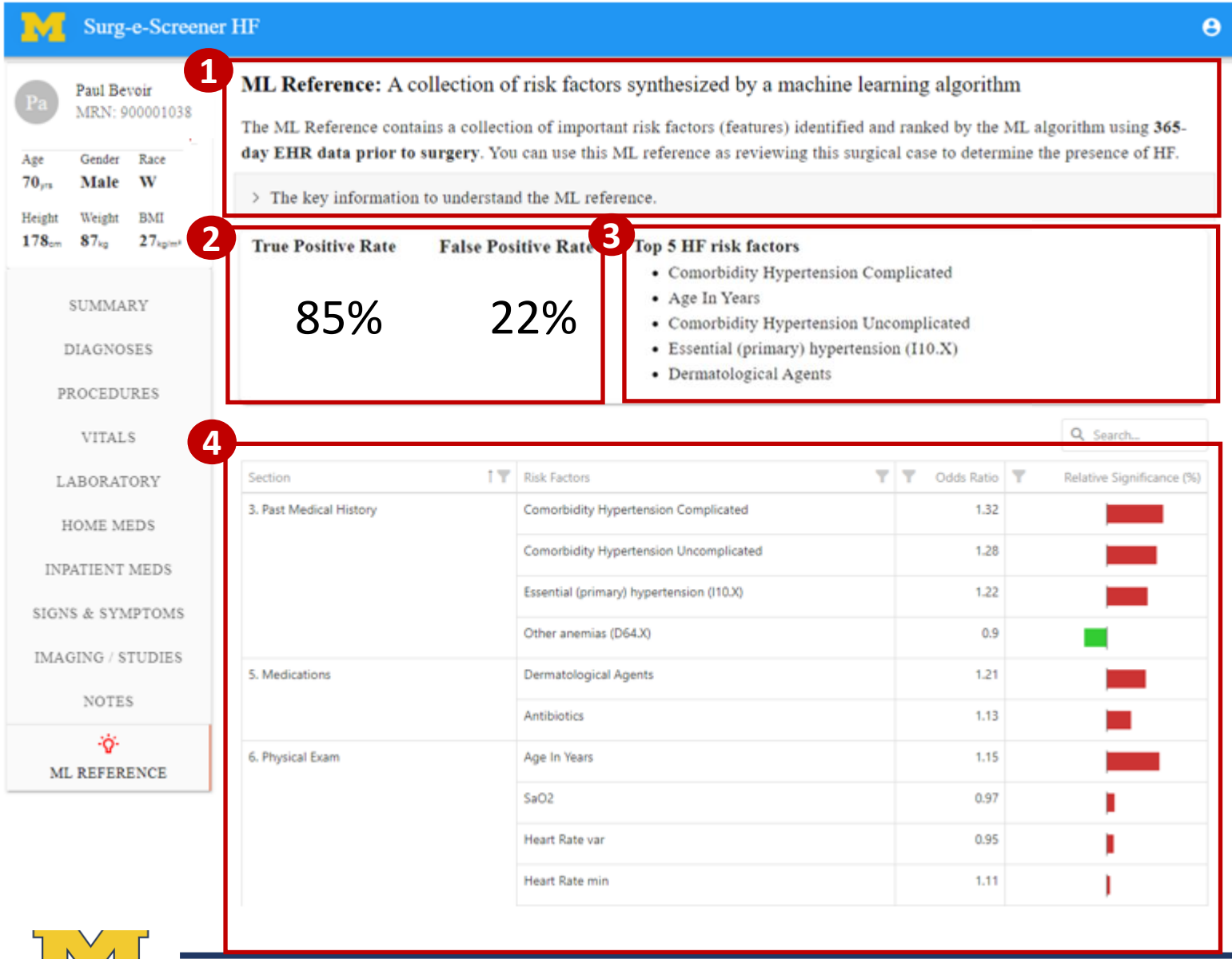
# Step 2. *Pre-test*: HF Recognition Quiz



# Step 2. *Pre-test*: HF Recognition Quiz



# Step 3. Machine Learning (ML) Reference




## Key components

1. The ML Reference description
2. TPR and FPR
3. Top 5 HF risk factors
4. Risk factors calculated and ranked by ML algorithms

# Using the Machine Learning (ML) Reference

**Key HF features are identified and ranked in each category**

**Odds Ratio**

- **OR = 1:** No Effect
- **OR > 1:** Higher Odds to HF
- **OR < 1**: Lower Odds to HF

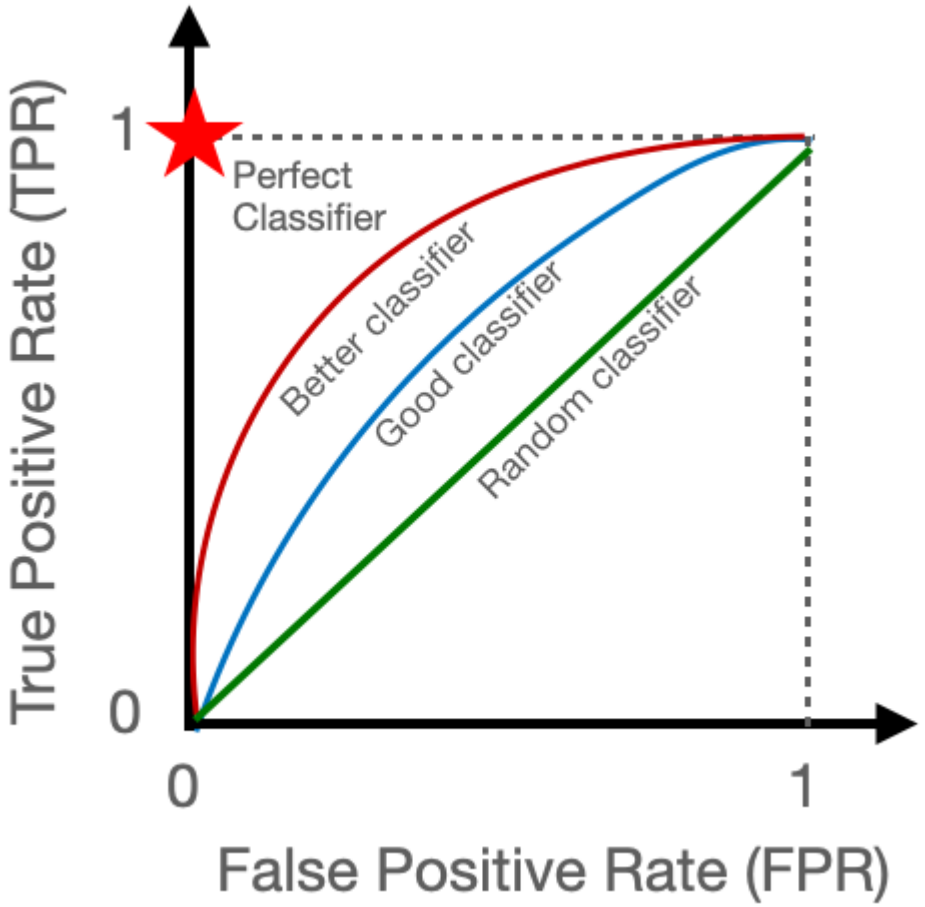
**Risk Factor Relative Significance (%)**

- Positive assoc. with HF in **red**, meaning a patient is more *likely* to have chronic HF
- Negative assoc. with HF in **green**, meaning a patient is *less likely* to have chronic HF

| Category | Feature Name | Odds Ratio | Relative Significance (%) |
|---|---|---|---|
| Signs and Symptoms | Acute Pain* | 1.12 | 0.76 |
| | angina* | 1.21 | 1.30 |
| | associated symptoms* | 1.15 | 0.95 |
| | back pain* | 1.13 | 0.85 |
| | calf pain* | 0.91 | -0.64 |
| | cough* | 0.94 | -0.40 |
| | Dizziness* | 1.05 | 0.34 |
| | dry skin* | 1.18 | 1.17 |
| | dyspnea on exertion* | 1.21 | 1.33 |
| | eye pain* | 1.20 | 1.27 |
| | fatigue* | 1.23 | 1.44 |
| | Heartburn* | 1.17 | 1.09 |
| | nervousness* | 0.88 | -0.89 |
| | photophobia* | 1.16 | 1.04 |
| | rashes* | 1.16 | 1.03 |
| | rest pain* | 0.92 | -0.56 |
| | stridor* | 1.16 | 1.04 |
| | tarry stools* | 0.90 | -0.75 |
| | urinary symptoms* | 1.18 | 1.12 |
| | wheezing* | 1.43 | 2.44 |
| Past HF History | Cardiomyopathy | 1.45 | 2.55 |
| | Heart Failure | 1.85 | 4.25 |
| Past Medical History | Disorders of fluid, electrolyte, and acid-base balan | 1.14 | 0.91 |
| | Other and unspecified anemias (285.X) | 1.11 | 0.69 |
| | Cardiac dysrhythmias (427.X) | 1.26 | 1.61 |
| | apnea* | 0.93 | -0.52 |
| | Comorbidity Chronic Pulmonary Disease | 1.13 | 0.84 |
| | Comorbidity Diabetes Complicated | 1.28 | 1.73 |
| | Comorbidity Hypertension Complicated | 1.32 | 1.92 |
| | Comorbidity Hypertension Uncomplicated | 1.28 | 1.71 |
| | Comorbidity Peripheral Vascular Disorders | 1.43 | 2.45 |
| | Comorbidity Pulmonary Circulation Disorders | 1.24 | 1.49 |
| | Comorbidity Valvular Disease | 1.28 | 1.72 |
| | Coronary Artery Disease | 1.40 | 2.31 |
| | Other anemias (D64.X) | 0.90 | -0.73 |
| | Other disorders of fluid, electrolyte and acid-base l | 0.95 | -0.36 |
| | Nicotine dependence (F17.X) | 1.12 | 0.80 |
| | Other anxiety disorders (F41.X) | 0.84 | -1.16 |
| | Essential (primary) hypertension (I10.X) | 1.22 | 1.38 |
| Past Medical History | Gastro-esophageal reflux disease (K21.X) | 0.85 | -1.10 |
| | Abnormalities of breathing (R06.X) | 1.31 | 1.87 |
| | Abnormal findings on diagnostic imaging of lung (R | 0.89 | -0.78 |
| | Abnormal results of function studies (R94.X) | 0.92 | -0.55 |
| | Smoking Classification - Former Smoker | 0.91 | -0.67 |
| | Personal history of malignant neoplasm (Z85.X) | 0.84 | -1.22 |
| Past Surgical History | Presence of cardiac and vascular implants and gra | 1.77 | 3.92 |
| Medications | ANTIBIOTICS | 1.13 | 0.83 |
| | ANTIVIRALS | 0.88 | -0.91 |
| | AUTONOMIC_DRUGS | 1.11 | 0.72 |
| | MUSCLE_RELAXANTS | 0.81 | -1.44 |
| | SEDATIVE_HYPNOTICS | 1.14 | 0.89 |
| | SKIN_PREPS | 1.21 | 1.33 |
| Physical Exam | Age In Years | 1.15 | 0.99 |
| | Baseline Blood Pressure Diastolic | 1.23 | 1.43 |
| | Baseline Blood Pressure Systolic | 0.83 | -1.28 |
| | BMI max | 1.23 | 1.41 |
| | BP Systolic mean | 0.94 | -0.39 |
| | Heart Rate max | 1.08 | 0.54 |
| | Heart Rate min | 1.11 | 0.69 |
| | Heart Rate var | 0.95 | -0.35 |
| | Physical Exam Resp Rate | 1.10 | 0.64 |
| | Physical Exam Temperature | 0.92 | -0.55 |
| | pitting edema* | 1.28 | 1.72 |
| | Race African American | 1.16 | 1.04 |
| | Respiratory Rate max | 0.91 | -0.64 |
| | SaO2 | 0.97 | -0.20 |
| | SPO2 min | 0.84 | -1.18 |
| | Temperature max | 0.98 | -0.11 |
| Test - Lab | Albumin max | 0.89 | -0.84 |
| | Creatinine var | 1.23 | 1.41 |
| | HbA1c last is below 5.7 | 0.85 | -1.12 |
| | Hematocrit var | 0.89 | -0.83 |
| | No INR Test | 0.80 | -1.53 |
| | INR variance | 0.92 | -0.60 |
| | PlateletCount last is b/w 150-449.99 K/uL | 0.90 | -0.71 |
| | PlateletCount var | 0.72 | -2.22 |
| | Potassium last is b/w 3.5-4.99 mmol/L | 1.12 | 0.77 |
| | Troponin var | 0.97 | -0.23 |
| | WBC var | 0.92 | -0.61 |
| Test - Image | LVEF min is below 50 | 2.04 | 4.92 |
| | No LVEF Test | 0.57 | -3.84 |
| Test - ECG | Atrioventricular and left bundle-branch block | 1.24 | 1.45 |

# ML Quick Review – Evaluation Metrics

Area Under the Receiver Operating characteristic Curve (AUROC or AUC)



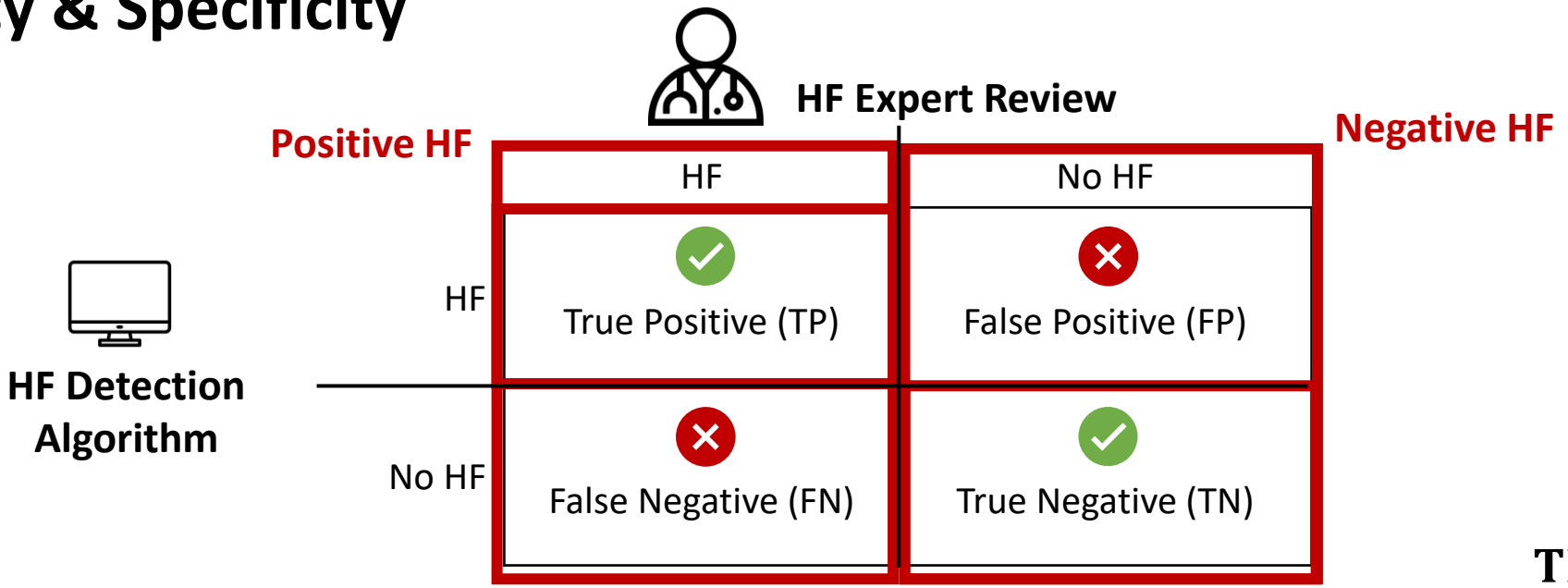

| AUROC Values | Test Quality |
|---|---|
| 1.00 | Perfect test; 100% accurate |
| 0.90 | Better, Excellent |
| 0.80 | Good, Acceptable |
| 0.70 | Poor |
| 0.50 | No better than coin flip |

$$\mathbf{TPR} = \text{Sensitivity}$$

$$\mathbf{FPR} = 1 - \text{Specificity}$$

# ML Quick Review – Evaluation Metrics

## Sensitivity & Specificity




$$\textbf{Sensitivity} = \frac{TP}{TP + FN}$$

The ability of HF algorithm to correctly detect patients **with** HF.

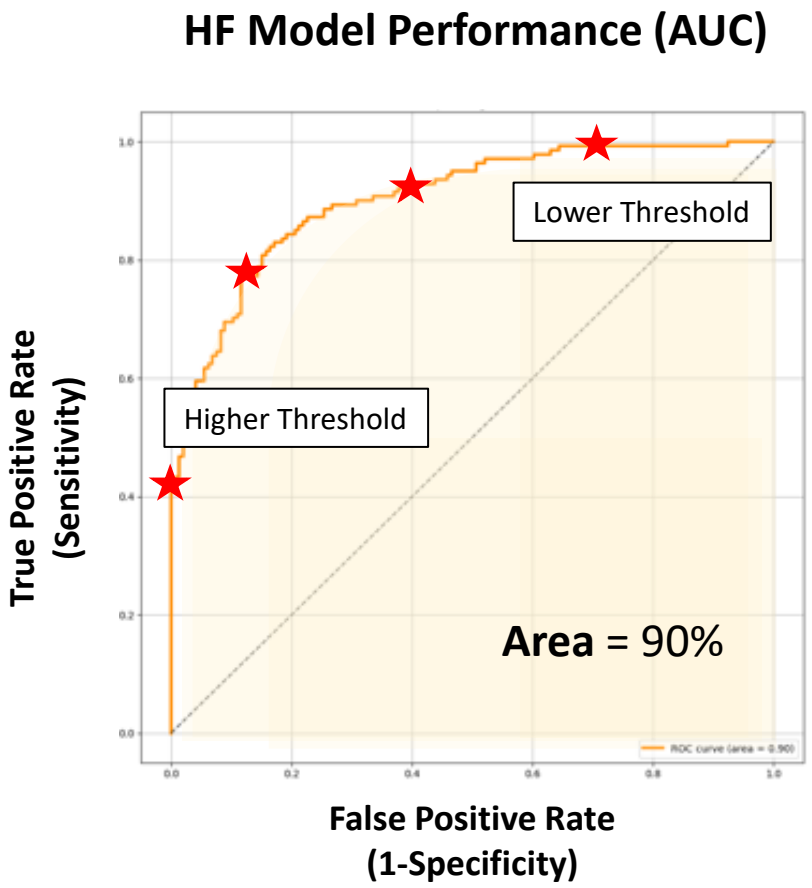
$$\textbf{Specificity} = \frac{TN}{FP + TN}$$

The ability of HF algorithm correctly detect patients **without** HF.

$$\textbf{TPR} = \text{Sensitivity}$$

$$\textbf{FPR} = 1 - \text{Specificity}$$

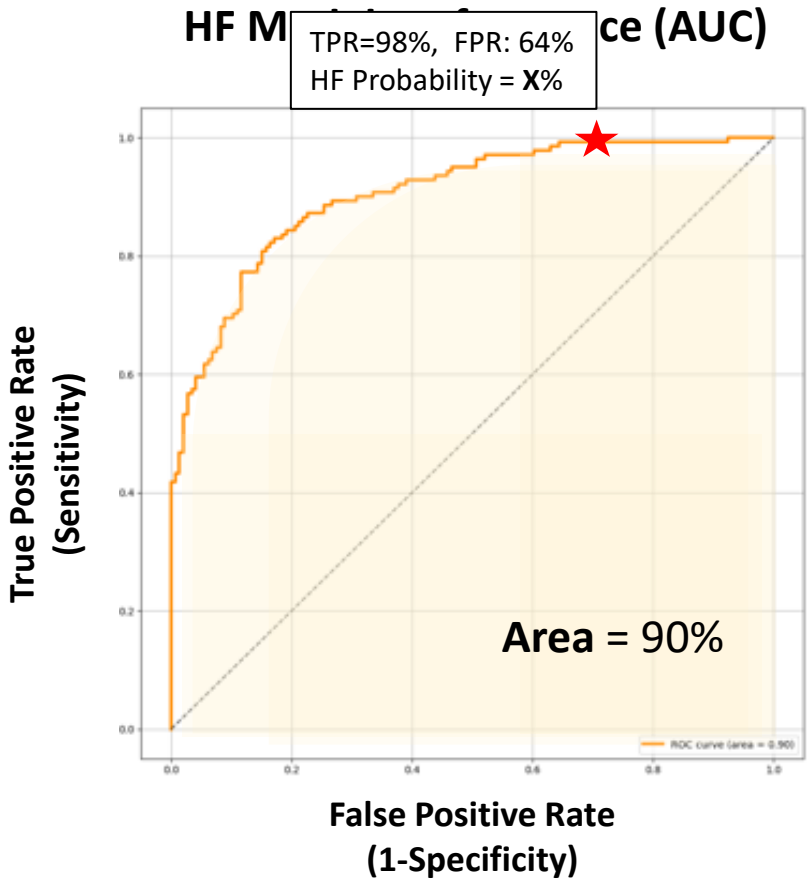
# Interpretation of AUC




- **AUC** is a curve that plots TPR against FPR at various thresholds.
- **Threshold** is a cut-off probability to discriminate *HF* from *No HF,* a probability between 0 – 1 estimated by the HF model.
- **Lower** vs. **High** threshold

- In this study, we show TPR and FPR when ***threshold*** *is set to the HF probability, estimated by the algorithm*.

# Interpretation of AUC




**Ex1. TPR=98% and FPR=64%**

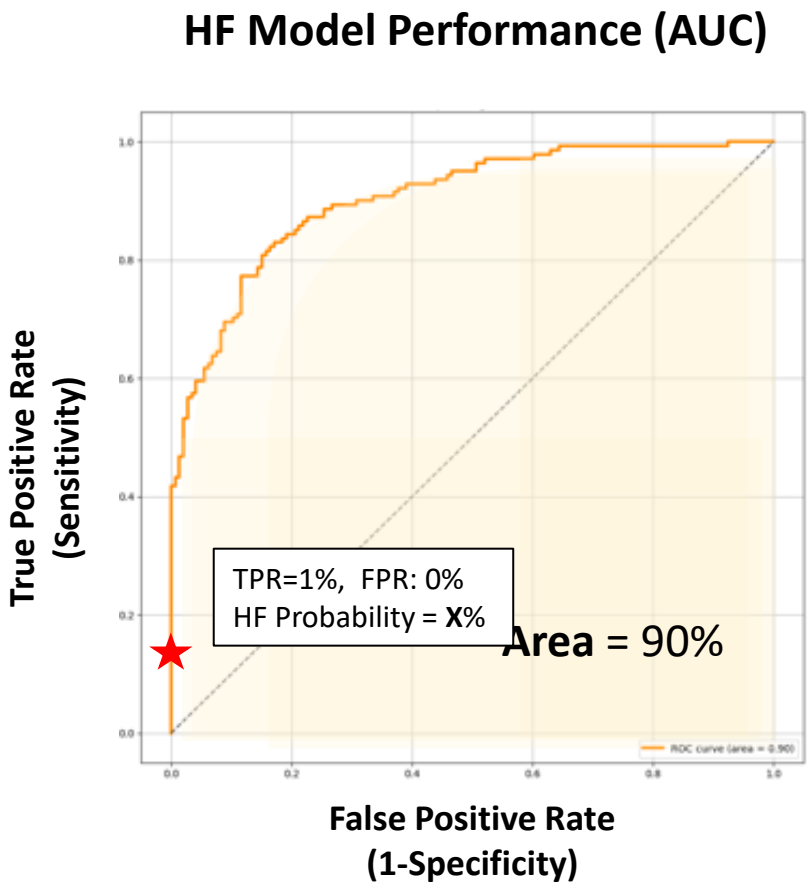
The model was able to *correctly* detect 98% of patients **with HF**, but *incorrectly* detect 64% of patients **without HF**.

**Key takeaways**

- *High true positives* (98%), but also *high false positives* (64%)
- This is due to the **low threshold** (e.g., 12%), HF probability higher than 12% is HF.

**Do you think this patient had HF or No HF?**

# Interpretation of AUC




**Ex2. TPR=1% and FPR=0%**

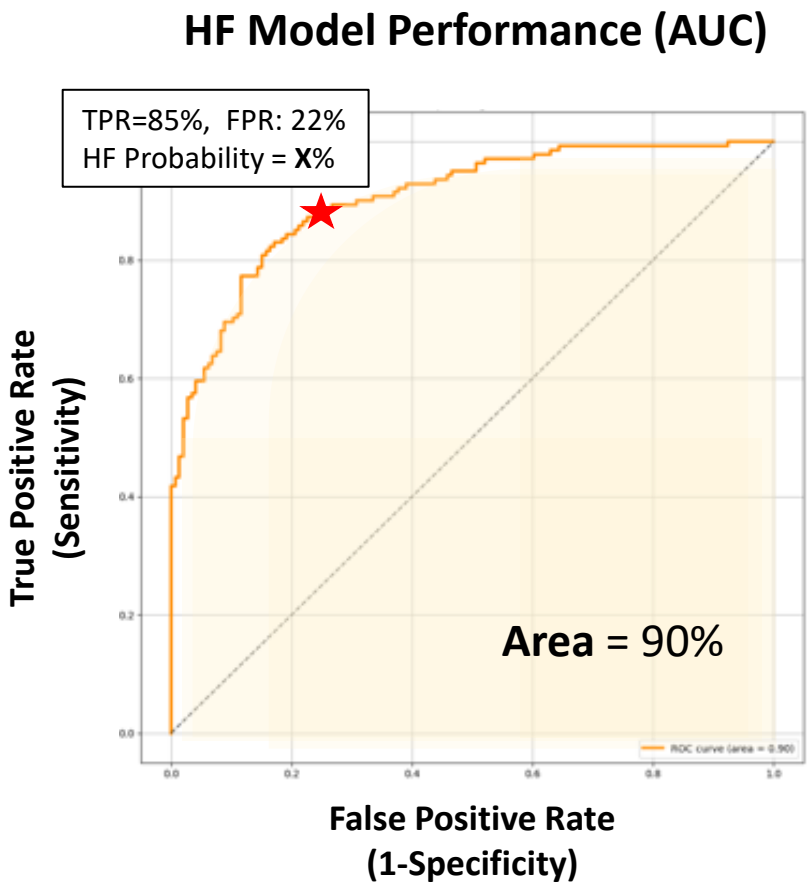
The model was able to *correctly* detect 1% of patients **with HF**, but *incorrectly* detect 0% of patients **without HF**.

**Key takeaways**

- *Low true positives* (1%), but also *low false positives* (0%)
- This is due to the **high threshold** (e.g., 96%), HF probability higher than 96% is HF.

**Do you think this patient had HF or No HF?**

# Interpretation of AUC




**Ex3. TPR=85% and FPR=22%**

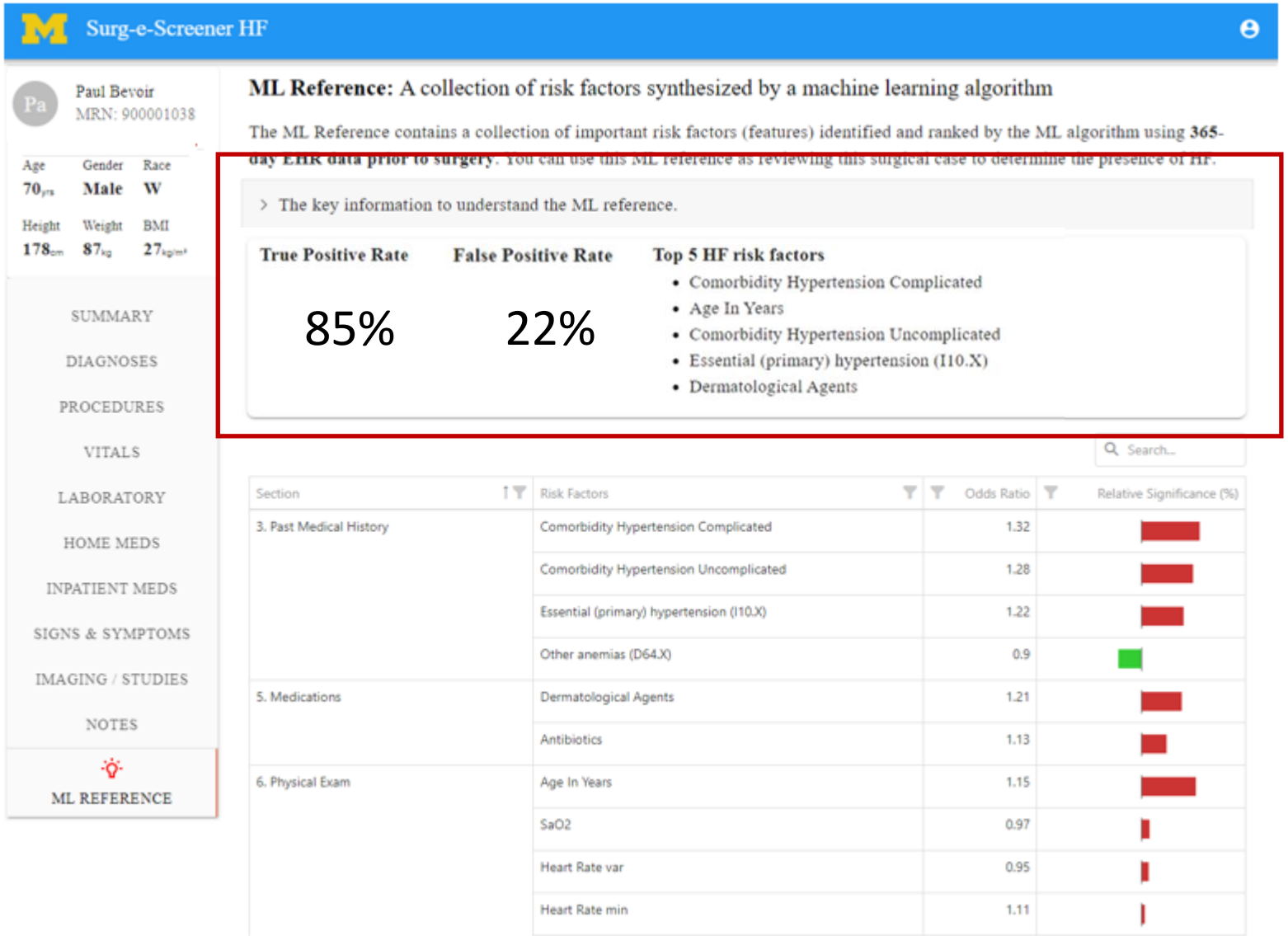
The model was able to *correctly* detect 85% of patients **with HF**, but *incorrectly* detect 22% of patients **without HF**.

**Key takeaways**

- *Relatively high true positives* (85%) and *relatively low false positives* (22%)
- The **threshold** is in gray zone (e.g., 45%) where HF and No HF overlap the most. HF probability higher than 45% is HF.

**Do you think this patient had HF or No HF?**

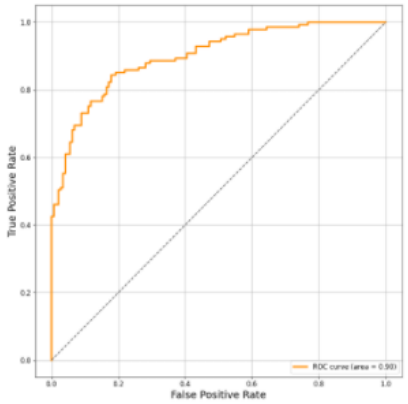
# Step 3. Machine Learning (ML) Reference



# Step 3. Machine Learning (ML) Reference

The key information to understand the ML reference.

**The ML Performance in AUC:**




Click Me!

**Abbreviations:**

- LVEF: Left Ventricular Ejection Fraction
- INR: International Normalized Ratio of prothrombin times
- WBC: White Blood Cell
- SaO2: Oxygen saturation of the arterial blood
- SpO2: Oxygen saturation from a pulse oximeter
- var: variance of the measurements (e.g., Creatinine var)
- min: minimum value (e.g., Heart Rate min)
- max: maximum value (e.g., Heart Rate max)
- last: last (latest) value before surgery (e.g., HbA1c last)

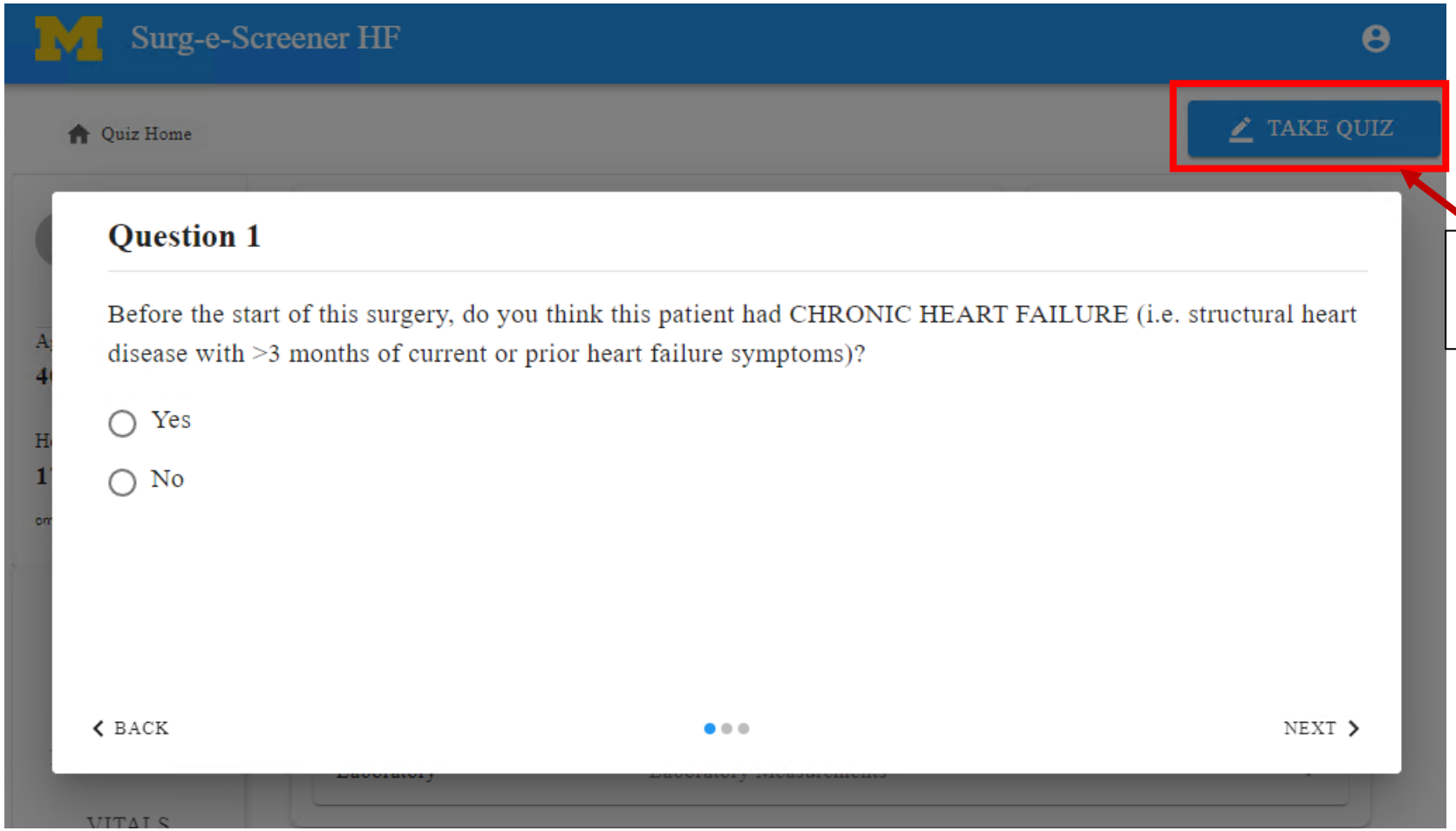
**Note:**

- An **asterisk** next to the risk factor (e.g.,wheezing*) describes that *the risk factor was "mentioned" in clinical notes*, which **does not indicate either *"positive"* or *"negative"***. You can confirm positive/negative by searching the risk factor from Signs and Symptoms or Notes.
- Risk factors or entire section(s) will **not be displayed**if they are older than one year or not documented in EHR.

## Key components

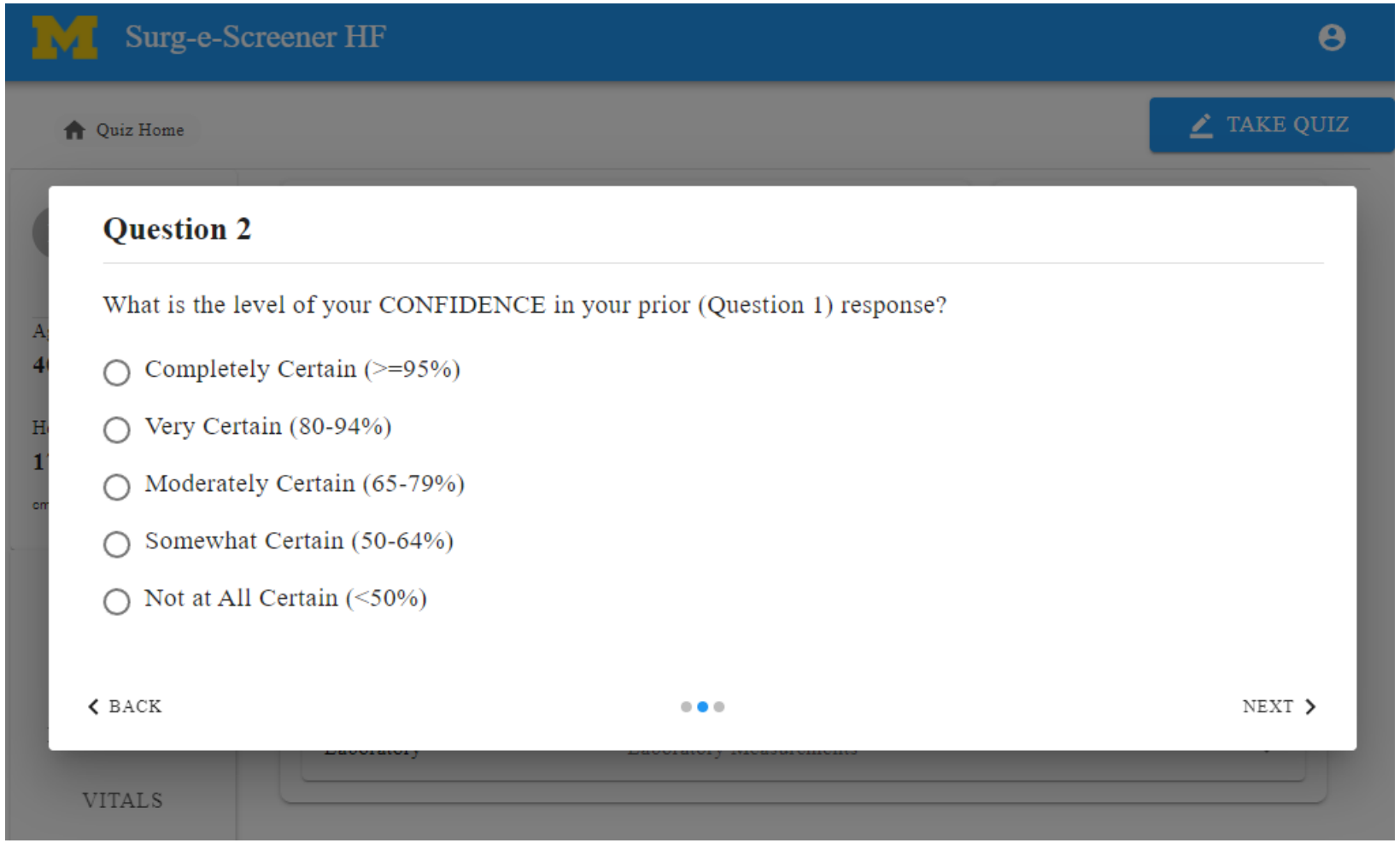
1. The ML Performance in AUC
2. Abbreviations
3. Notes about risk factors

# Step 4. *Post-test*: HF Recognition Quiz

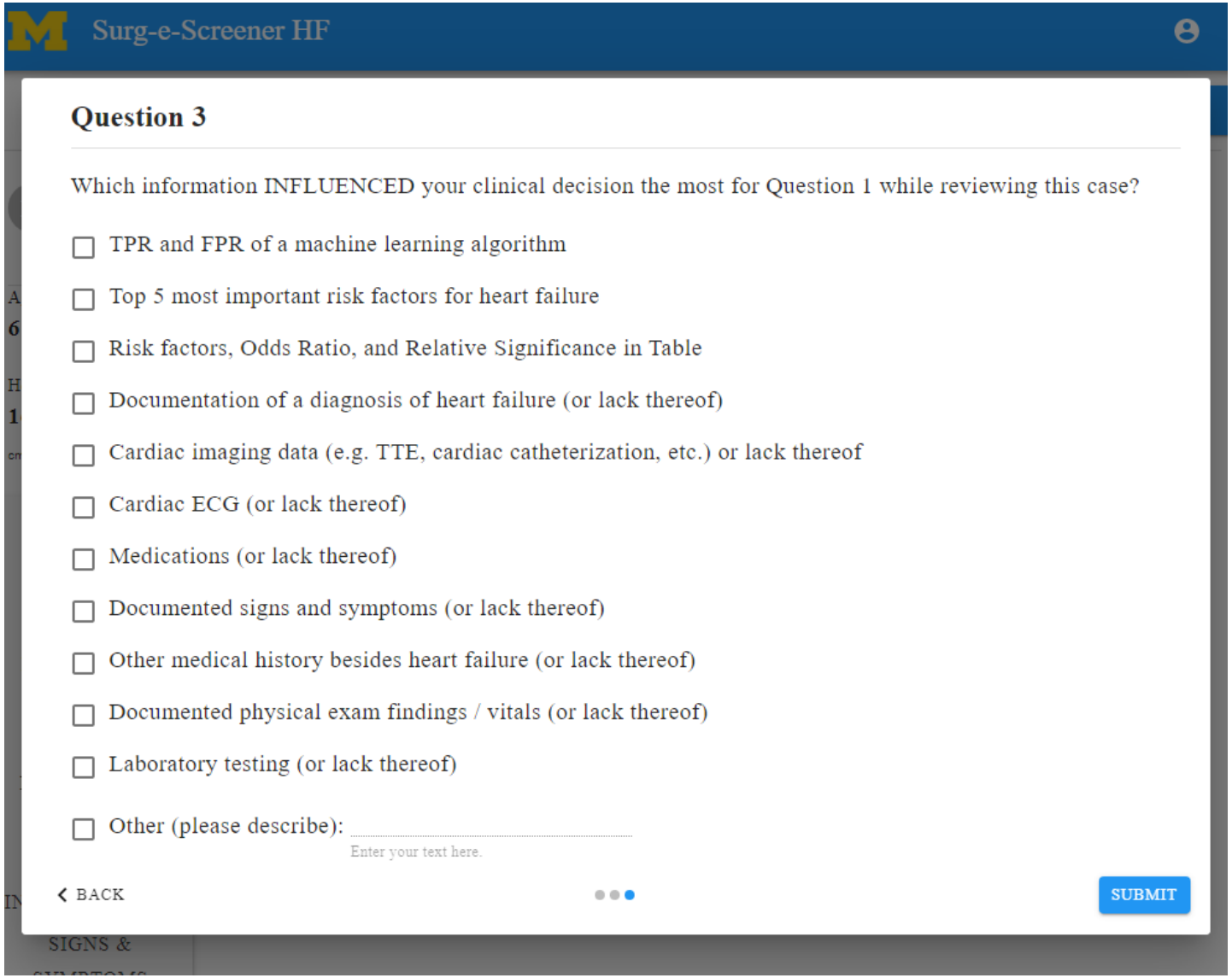



Click “Take Quiz” to answer your decision

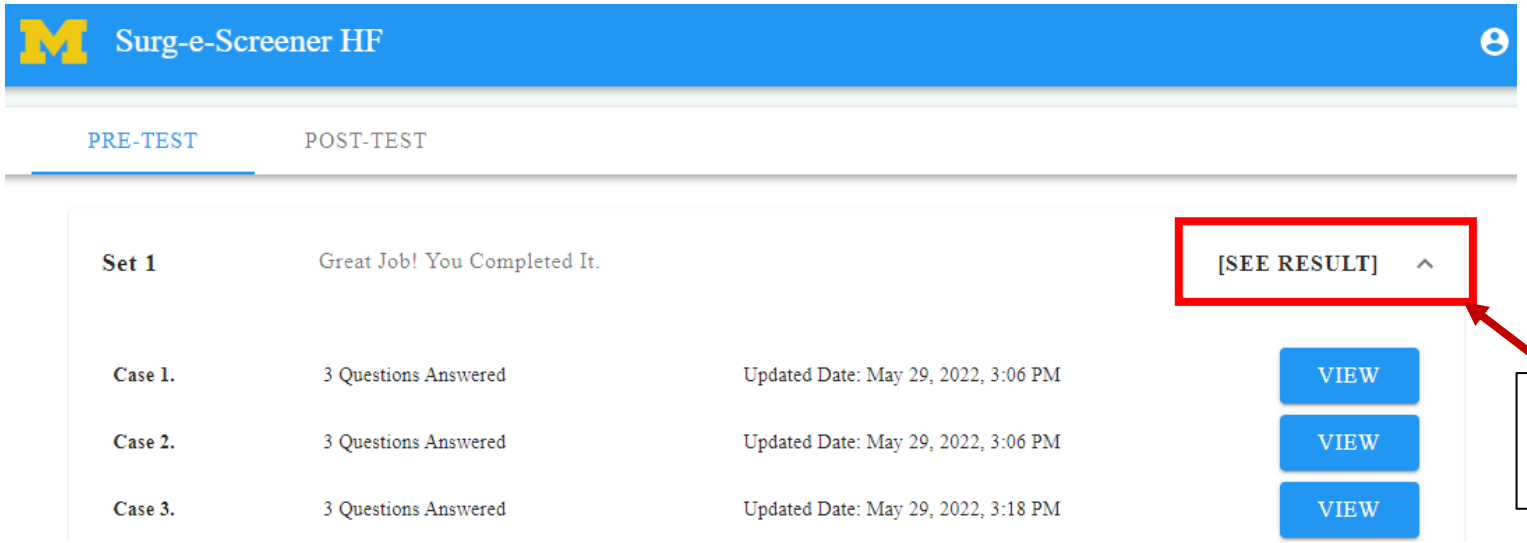
# Step 4. *Post-test*: HF Recognition Quiz



# Step 4. *Post-test*: HF Recognition Quiz



# Step 5. Result Report Access

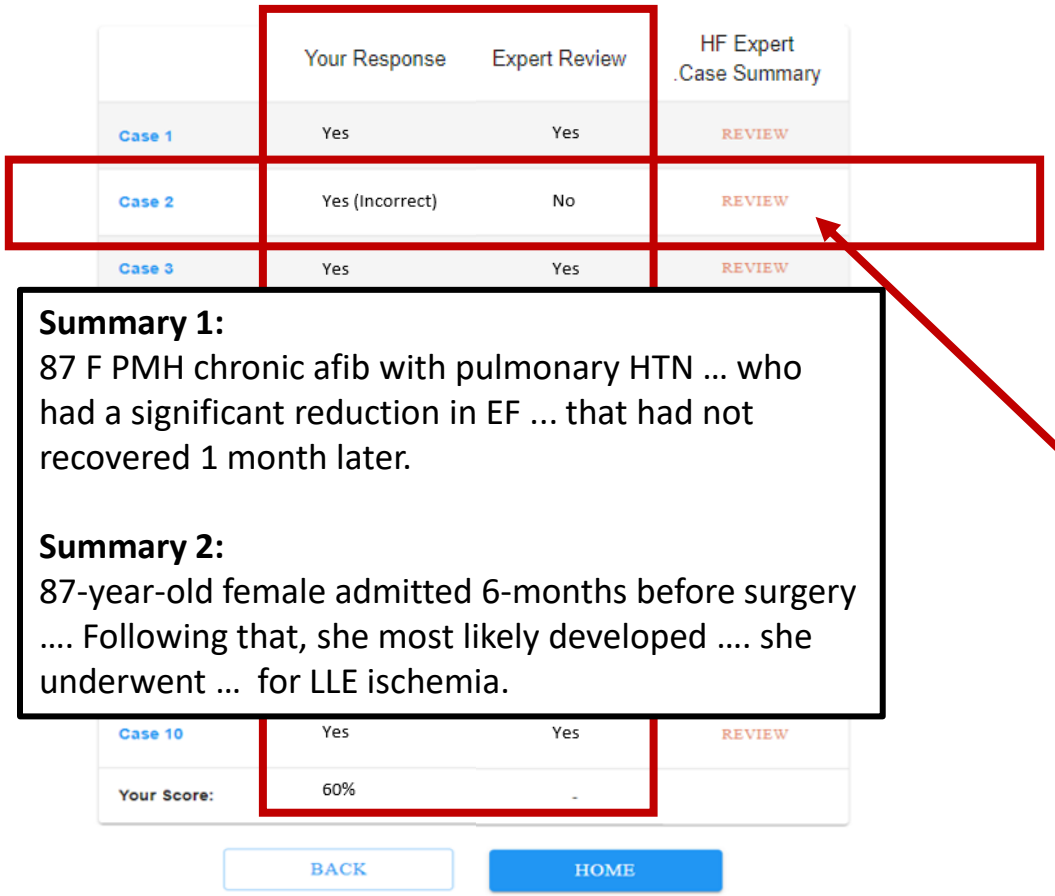



Click “SEE RESULT” to access the report

## Key components

- SEE RESULT will be available after reviewing 20 surgical cases, 10 case review results in PRE-TEST and 10 case review results in POST-TEST.

# Step 5. Expert Review Comparison




## Review your result report

- **Compare your HF recognition** with the pre-determined answers by HF experts in each case.
- **Re-examine cases** when you are misaligned with the answers.
- Review **a short description** of the surgical cases summarized by the HF experts.

# Summary of e-Learning Module

After watching this e-Learning module, you should be able to:

1. Understand the **process and activities required** to complete the HF recognition study
2. Interpret evaluation metrics such as **AUC**, **True Positive Rate (Sensitivity)**, and **False Positive Rate (1-Specificity)**
3. Describe how **TPR and FPR change** as the threshold increases or decreases

The short quiz will ask you mainly about Point 2 and Point 3.

# Demo

# Final Step

- No further actions after completing the test cases. We appreciate your participation.

- Reimbursement:
  - **Follow-up** if any case reviews remain **incomplete**
  - Pending follow-up / completion of all cases, you will receive reimbursement of **$50 as a check** delivered to your mailing address

- Email Hyeon Joo (thejoo@med.umich.edu) if any questions