Chest Pain Risk Stratification
Moving Beyond the HEART Score

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Disclosures

- Research funding or Advisor:
  - HRSA
  - Abbott Laboratories
  - Roche Diagnostics
  - Siemens Healthcare
  - Pathfast
  - Quidel/Ortho Clinical Diagnostics
  - Genetesis
  - Grifols
  - Cytovale
  - Inflammatix
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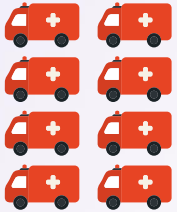
- Up-to-Date
- Chief Medical Officer: Impathiq, Inc.

Learning Objectives

- Identify the current challenges and inefficiencies of ED chest pain evaluations
- Discuss the importance and limitations of troponins
- Explain how accelerated diagnostic protocols aid in risk stratification
- Assess how clinical decision support tools can help standardize care and improve pathway adherence

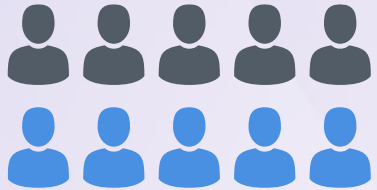
Chest Pain

5,000
emergency
departments



>6,500,000
chest pain
visits

>50%



admission rate

<10%
diagnosed
with ACS

$13,000,000,000
in chest pain evaluations

2-4 out of 100
Patients with ACS are missed

Negative impact of over- and under- triage

Over-triage:

- Crowding
- Increased costs
- Radiation exposure
- False-positive/non-diagnostic tests
- Not patient-centered

Under-triage:

- Missed ACS
- Malpractice

Care Variability

Providers:

- Experience/Training
- Risk tolerance
- Fear of malpractice
- Use of gestalt or old and unreliable tools for risk stratification

Care Variability

Providers:

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Pines et al. *AJEM* 2010:

- Measured providers risk aversion using a risk taking scale(RTS)
- Most risk-averse providers → higher admission rates. ($P < 0.001$)

Clinician Gestalt

Multiple studies show gestalt is inaccurate:

- Most clinicians overestimate risk
- Some underestimate risk
  - Atypical presentations
  - Women

Clinician Gestalt

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- Some underestimate risk
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  - Women

Body et al. *EMJ*. 2014

458 chest pain patients

Gestalt:

Probable ACS = 77% had NO MACE

Definite ACS = 47% NO MACE

Definitely Not ACS = 9% HAD MACE

What is the acceptable miss rate

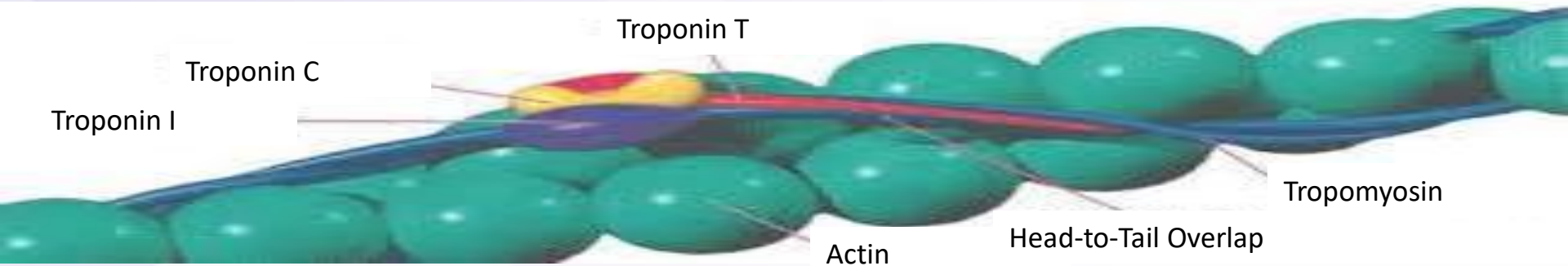
How Do We Send Home Patients and Achieve a Low Miss Rate

Risk Stratification Toolbox

- **Troponin**
- **Risk Scores**
- **Accelerated Diagnostic Pathways (ADPs)**

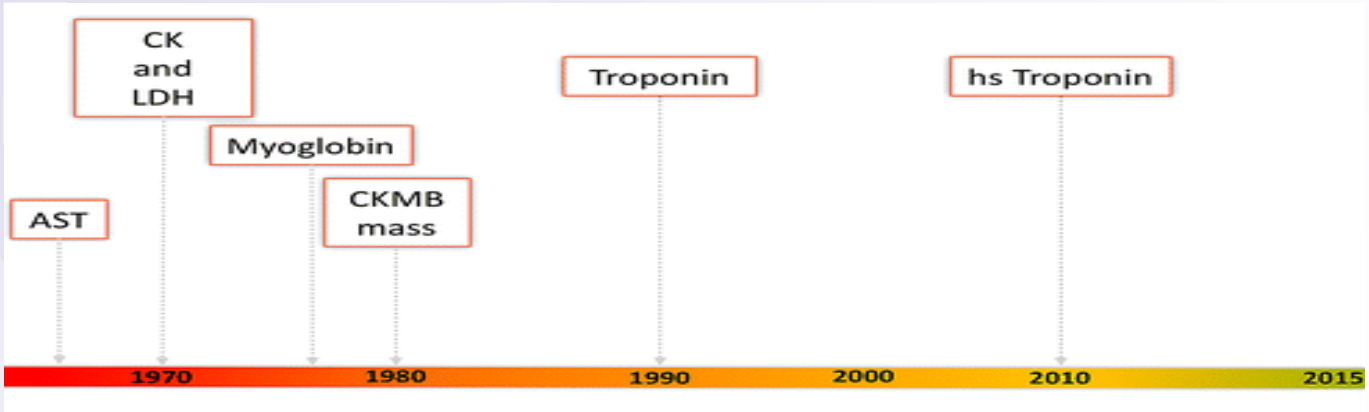
Biomarkers: Cardiac Troponin (cTn)

- Cardiac myocyte protein
- Myocardial injury results in extracellular leak
  - Detected in the patient's peripheral blood
  - Used to identify and quantify myocardial damage



High Sensitivity Troponin Assays Defined

- Measure same cardiac troponin protein
- Are more precise, can detect lower levels; measurable levels in at least 50% of healthy patients

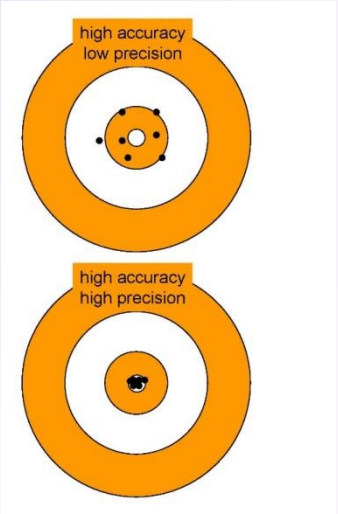


2017 FDA approves hs-cTnT

2018/2019 FDA approves 3 hs-cTnI assays

High Accuracy, Different Precision

Earlier Generation Troponin

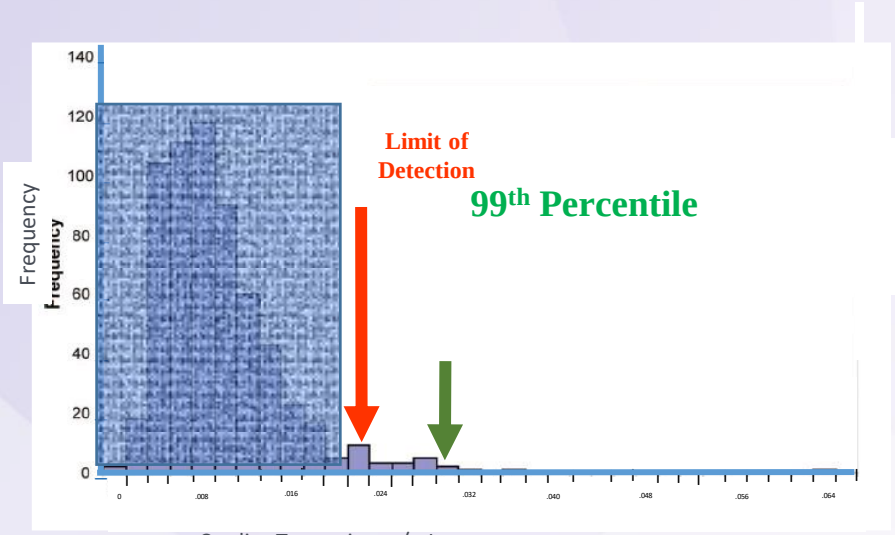


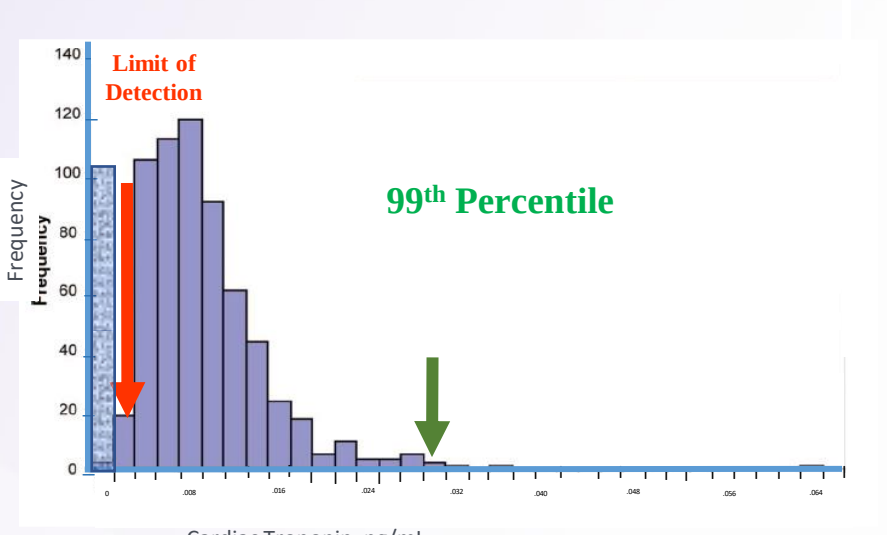
15% CV

5% CV

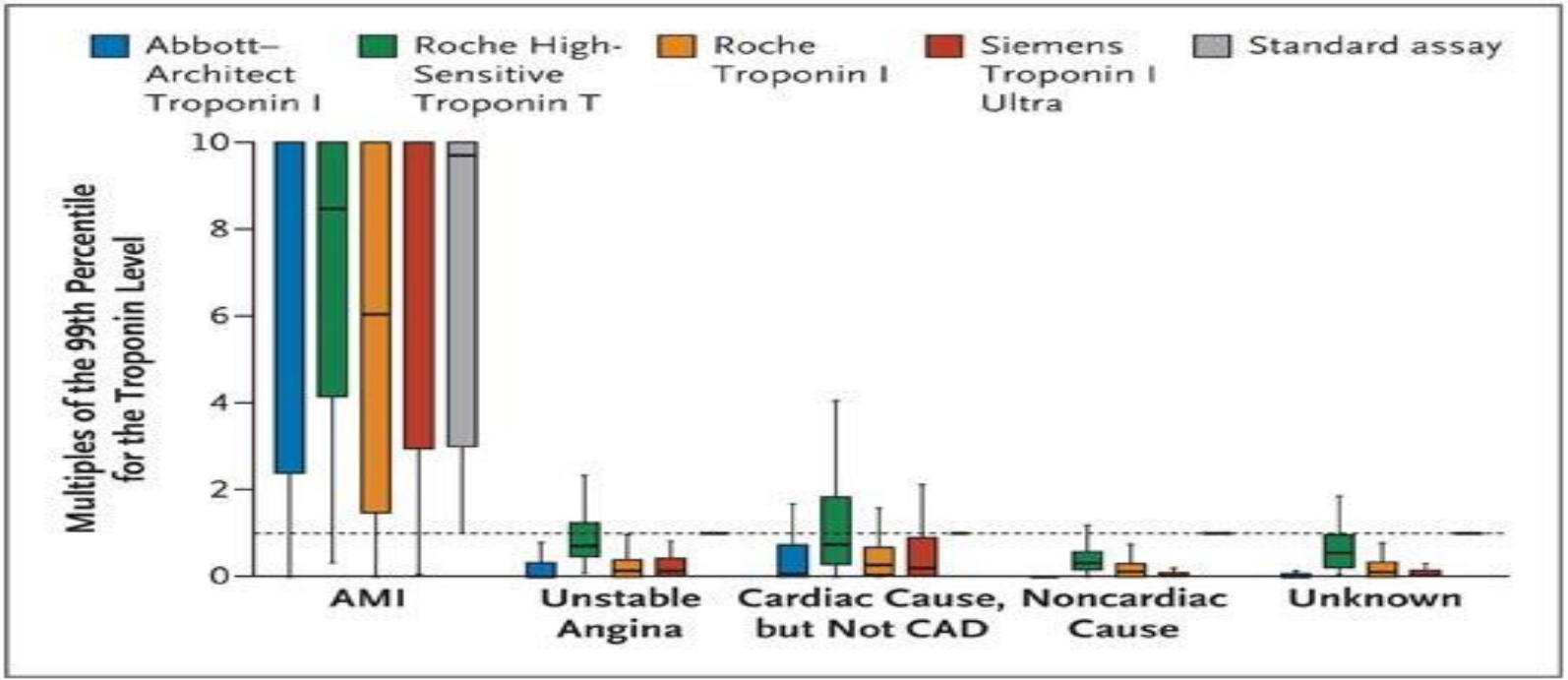
High-sensitivity Troponin

Contemporary vs High-sensitivity Cardiac Troponin Assays





Detection of more patients with non-AMI cTn elevations



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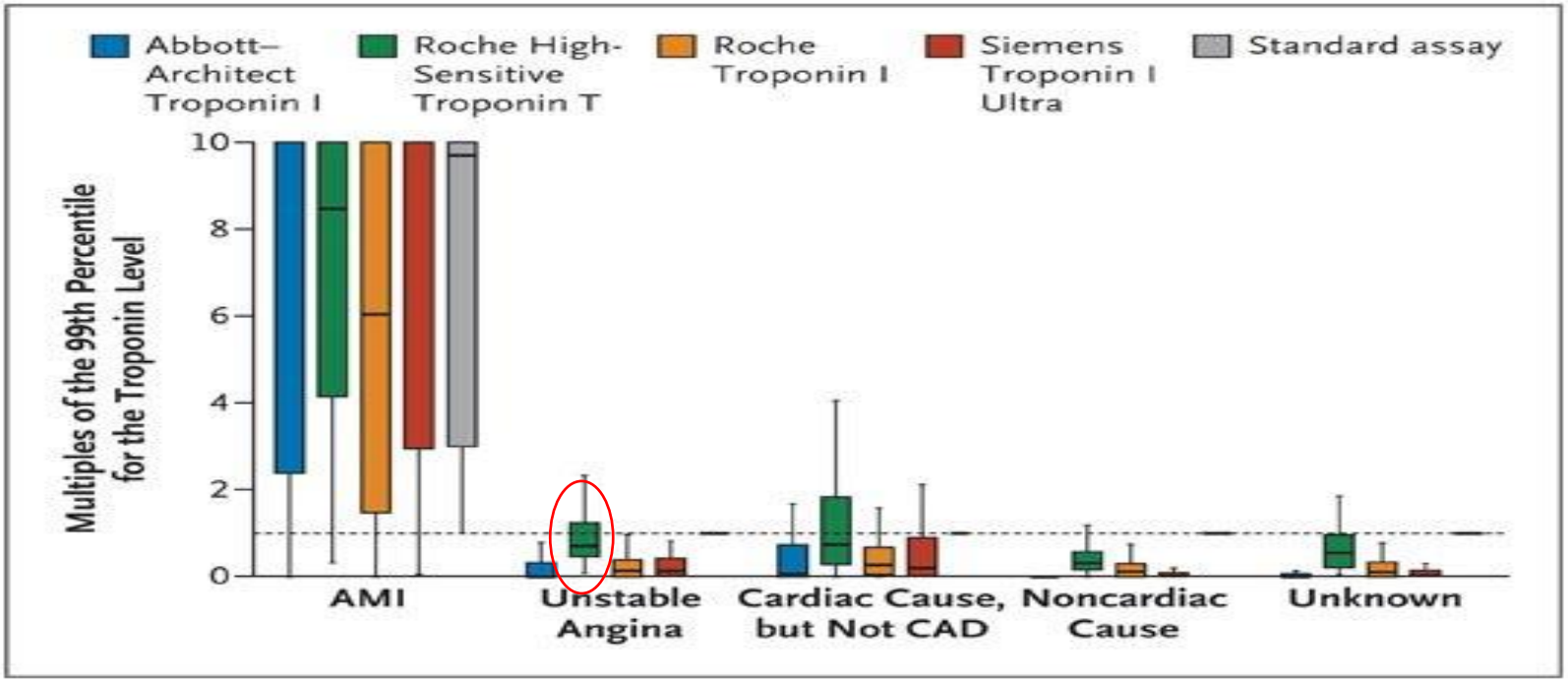

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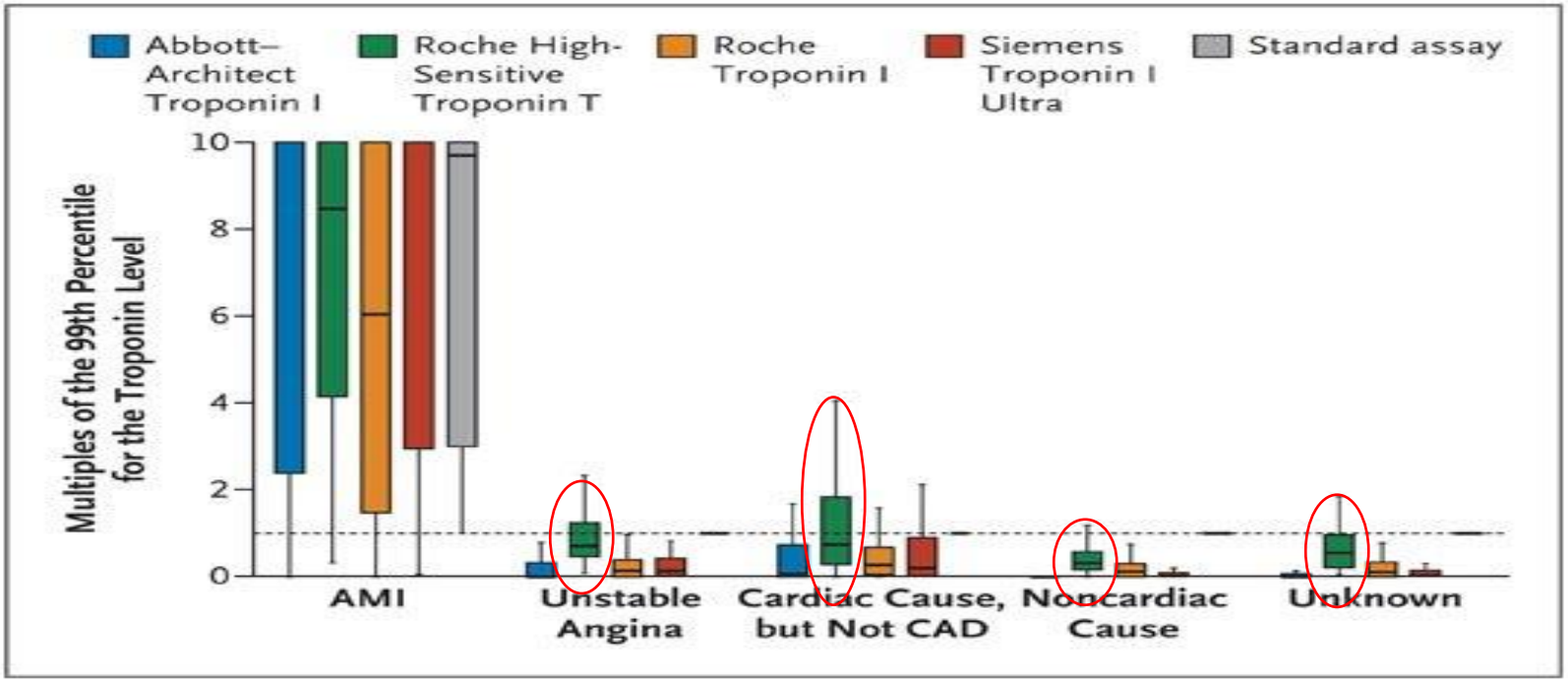


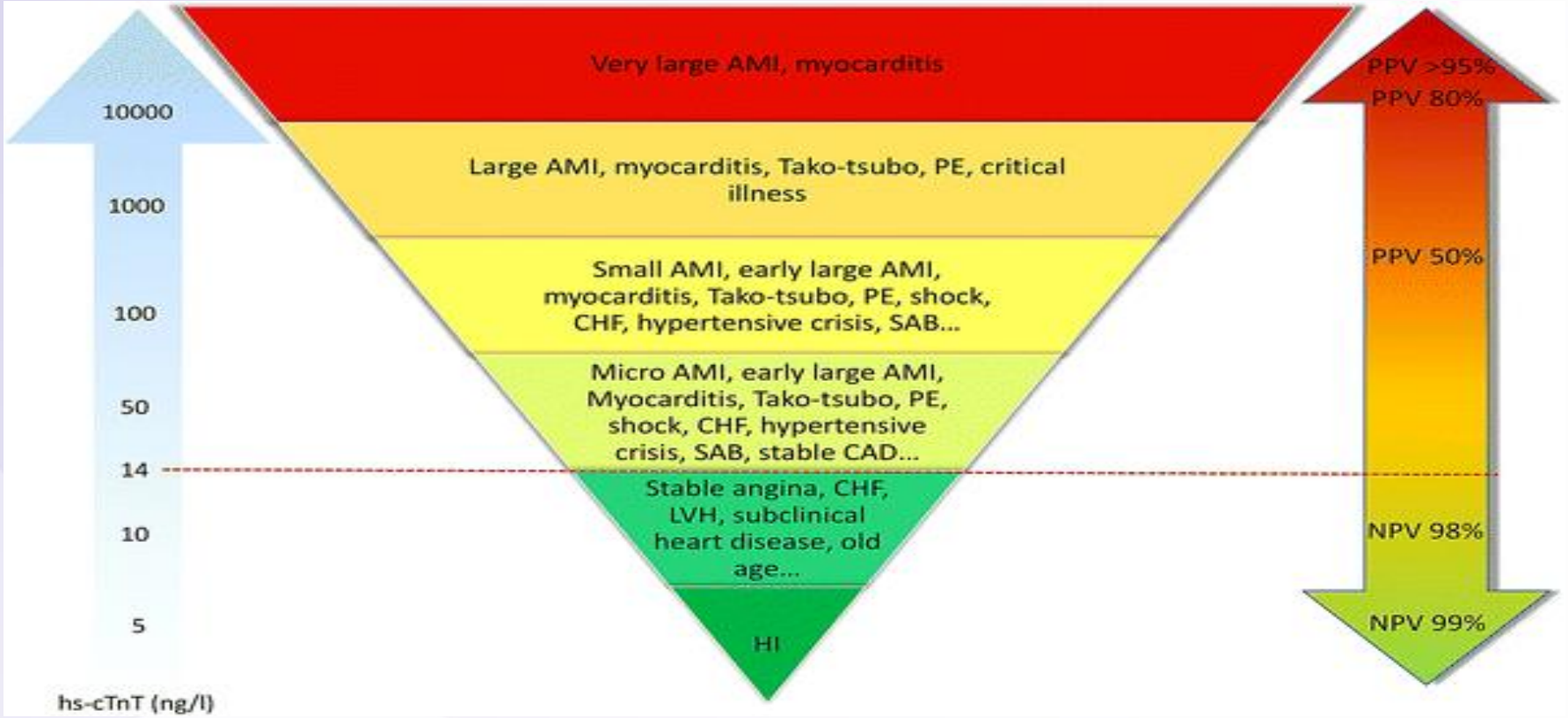
Elevation = Injury

Elevation does not indicate the mechanism of injury

Conditions Associated with Elevated cTn Levels in the Absence of Ischemic Heart Disease

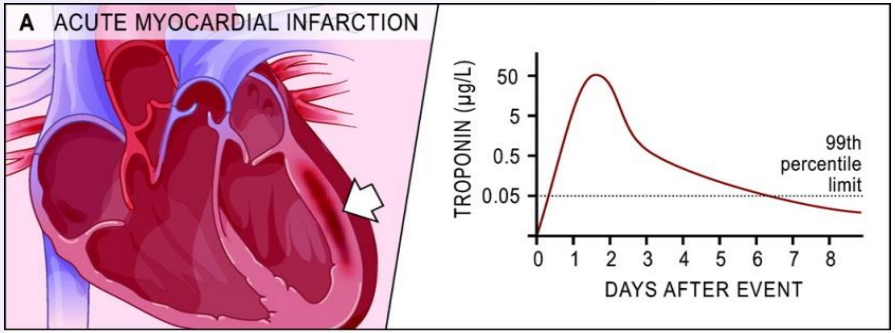
Cardiac contusion
Cardiac procedures (surgery, ablation, pacing, stenting)
Acute or chronic congestive heart failure
Aortic dissection
Aortic valve disease
Hypertrophic cardiomyopathy
Arrhythmias (tachy- or brady-)
Apical ballooning syndrome
Rhabdomyolysis with cardiac injury
Pulmonary hypertension
Pulmonary embolism
Acute neurologic disease (e.g., stroke, subarachnoid hemorrhage)
Myocardial infiltrative diseases (amyloid, sarcoid, hemochromatosis, scleroderma)
Inflammatory cardiac diseases (myocarditis, endocarditis, pericarditis)
Drug toxicity
Respiratory failure
Sepsis
Burns
Extreme exertion (e.g., endurance athletes)

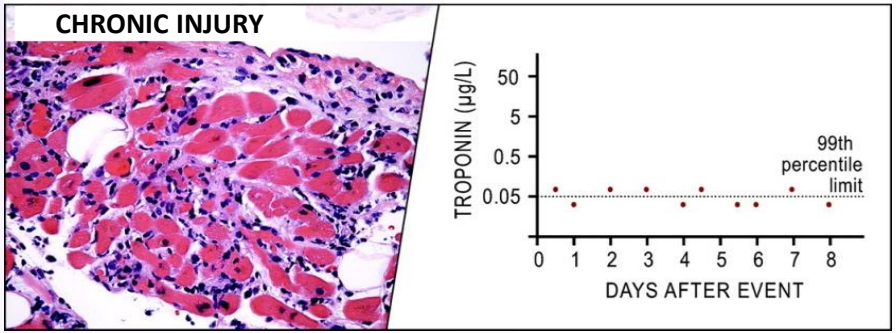
The larger the elevation the more likely it is from MI



Pattern of Elevation

- AMI differentiated from non-ischemic cTn elevations based on:
  - Pattern of elevation
  - Clinical context





hs-cTn Strategies

One-and-Done

- A single very-low hs-cTn measure used to exclude MI
- When to consider it:
  - Onset of most recent chest pain ≥3 hours ago
  - Or >3 hours of constant (non-waxing/waning) pain

- Pitfalls:
  - Early presenters
  - Waxing and Waning CP
  - MI defined based on pattern of serial troponins
  - Should be used with other clinical variables

hs-cTn Serial and “Delta” Strategies

- **Serial troponins**: Sequential cTn Measurement (more than one measure)
  - In ED short time interval used, such as 1-3 hours
- **Delta troponin**: Serial Measurement to evaluate for serial change
  - More sensitive for MI than a single troponin approach
  - Helpful in early presenters

Limitations of Serial and Delta Troponins

- Negative serial cTn exclude acute myocardial injury
  - **Does not predict/exclude an ACS event in the near future**

- Unstable Angina
  - Patients at high risk for MI
  - Not a biomarker diagnosis

Troponin Bottom Line

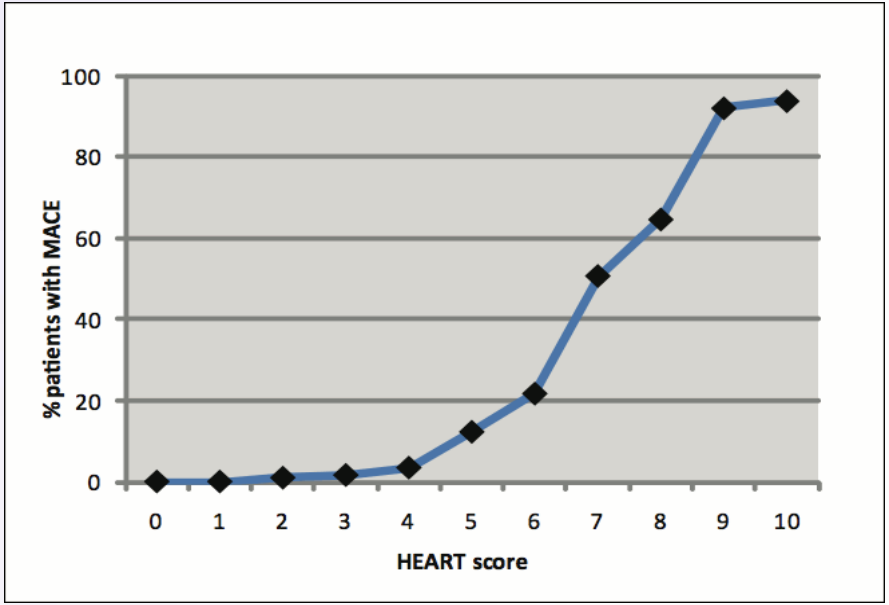
- Should be obtained in all patients with suspected ACS
- Elevation = Injury
- 2 measurements are better than one
- Negative troponins alone do not exclude ACS
- Should be used as part of a risk stratification model/ADP with the ECG and Clinical/Historical data

Risk Scores

- Tools that objectively combine data to risk stratify a patient:
  - History
  - Risk factors
  - ECG
  - Biomarker data (troponin)

HEART Score

- Designed to identify chest pain patients for early discharge without stress testing.
- Validated in >5000 patients.
- >98 % negative predictive value, >96% sensitivity for ACS.



Backus, et al., Int J Cardiol, 2013

Six, et al., Crit Path Cardiol, 2013

HEART Score

HEART Score		Points
History	Highly Suspicious	2
	Moderately Suspicious	1
	Slightly Suspicious	0
ECG	Significant ST-depression	2
	Non-specific repolarization abnormality	1
	Normal	0
Age	≥ 65	2
	45-65	1
	≤ 45	0
Risk factors	3 or more risk factors	2
	1-2 risk factors	1
	No risk factors	0
Troponin	≥ 3x normal limit	2
	1-3x normal limit	1
	≤ normal limit	0
Total		

Low: 0-3
Moderate: 4-6
High: 7 or more

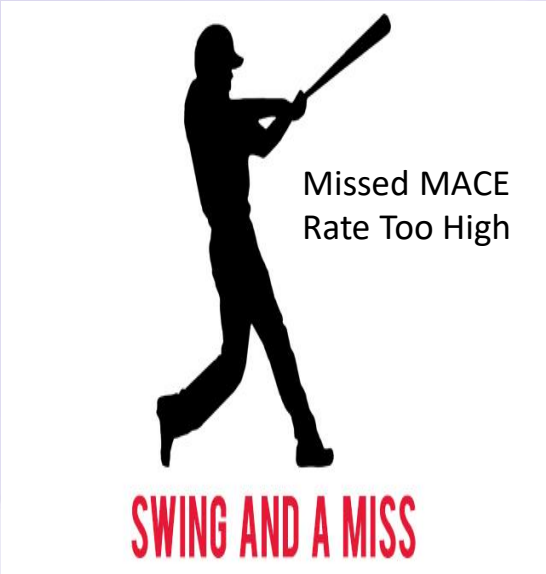
HEART Score Meta-Analyses

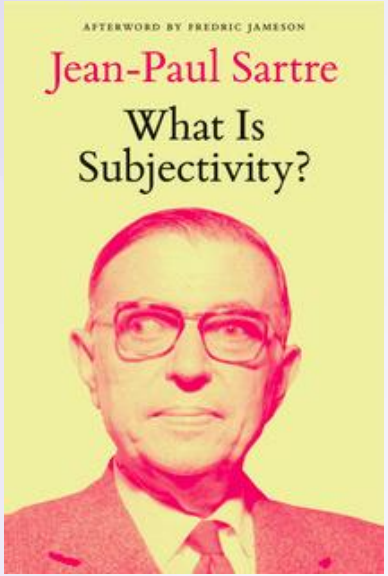
1) Data from 11,217 patients
   - Pooled missed MACE rate of 1.6%

2) Data from patients 25,266 patients
   - Pooled missed MACE rate of 2.1%

Van Den Berg et al., EHJ Acute Cardiovasc Care, 2018
Laureano-Phillips et al., Annals of EM, 2019

Problems with the HEART Score





Logical Inconsistency

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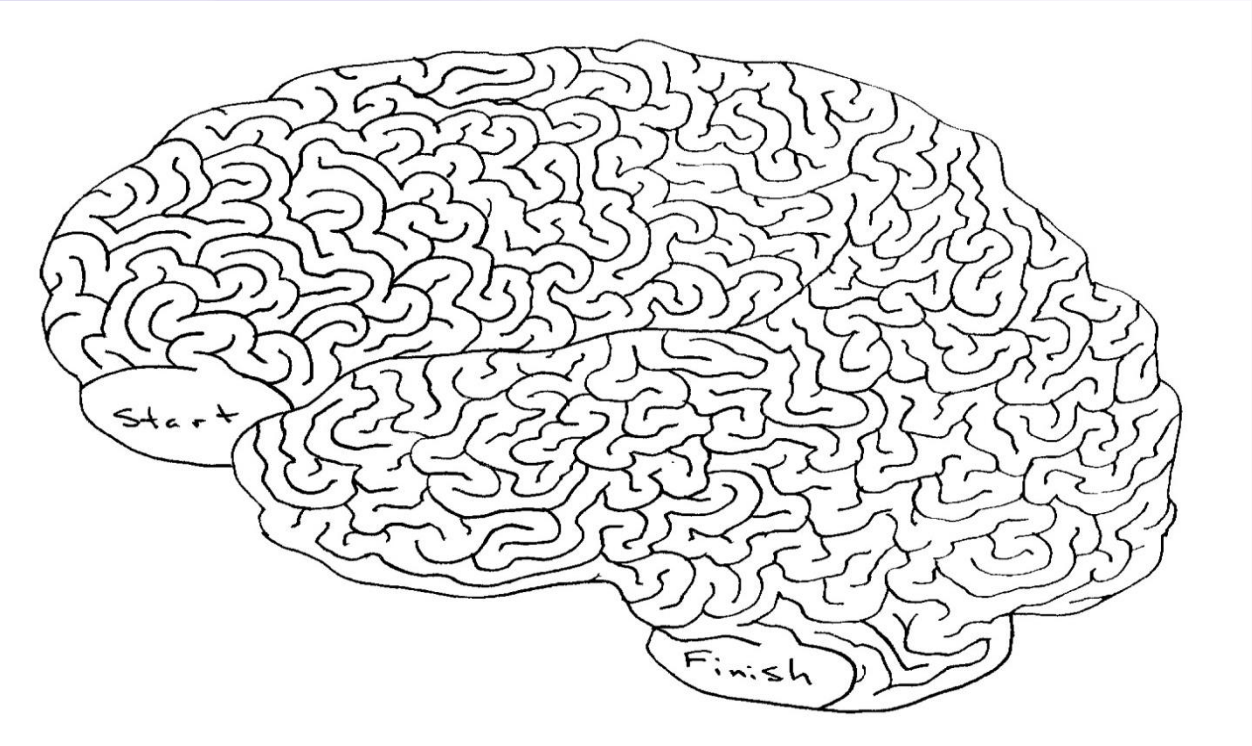
Moving Beyond The HEART Score



Accelerated Diagnostic Pathways

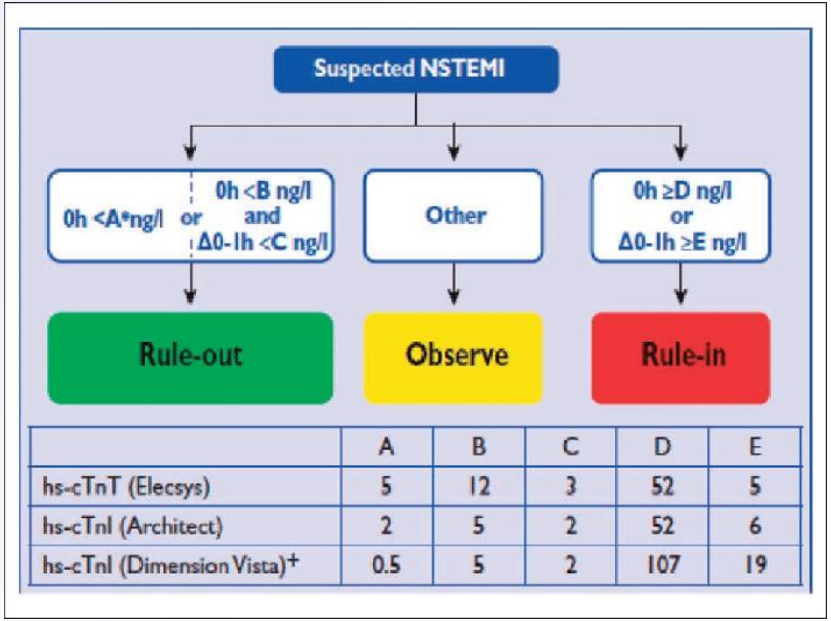
- Clinical pathways for chest pain risk stratification:
  - Biomarkers
  - ECG
  - Decision Aid or Risk Score

- Benefits:
  - Standardize care
  - Decrease Malpractice Risk
  - Efficiently use resources
  - Enhance through-put

ADP Types

Troponin only ADPs (i.e. ESC 0/1 hr)
- Combine serial measures at 0 & 1 hours or 0 & 2 hours, evaluate the delta change.
- **Unclear if sufficiently sensitive in US**

Multivariable ADPs (i.e. hs-HEART Pathway, Parkland Algorithm, ACC Framework)
- Combines clinical variables/risk scores with serial hs-cTn measures/deltas.
- **Standard of care at most AMCs**



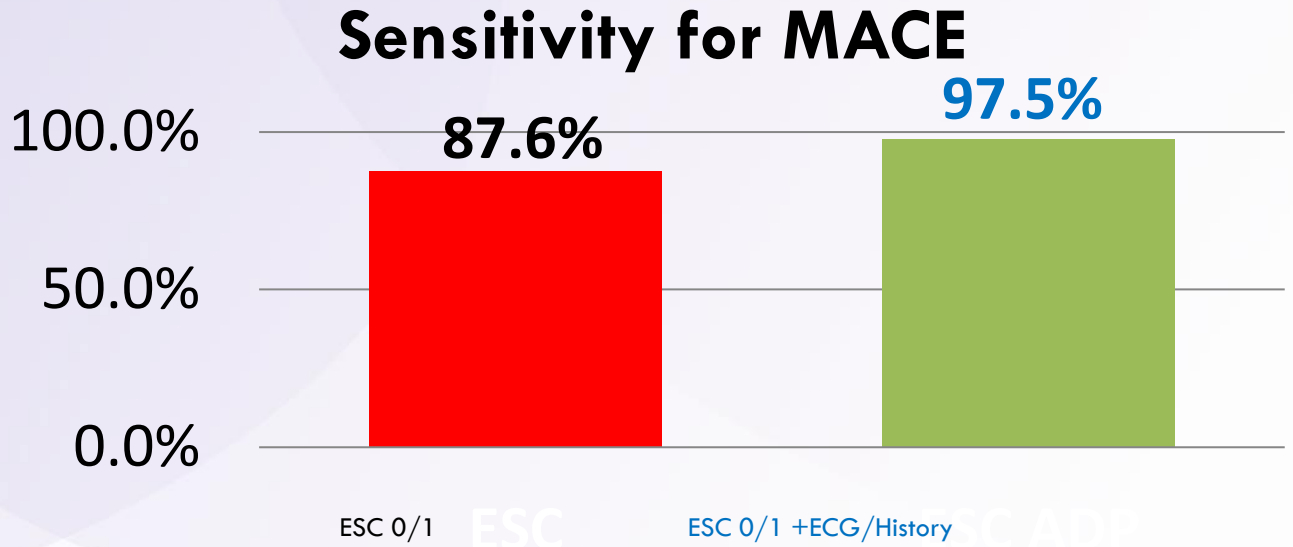
	A	B	C	D	E
hs-cTnT (Elecsys)	5	12	3	52	5
hs-cTnI (Architect)	2	5	2	52	6
hs-cTnI (Dimension Vista)+	0.5	5	2	107	19

Troponin only ADPs…are hs-cTn measures all we need?

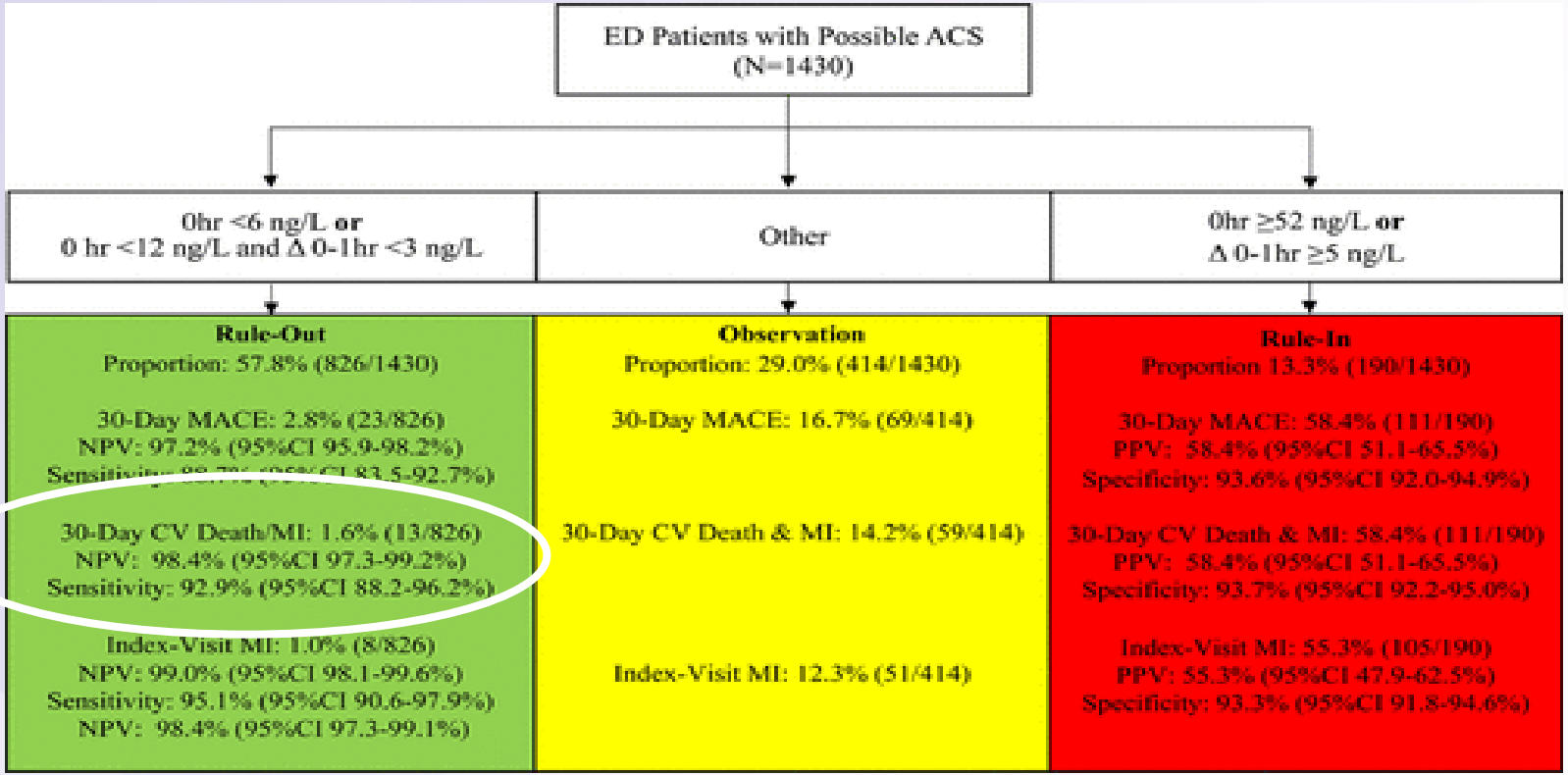
1038 patients with CP followed for 30 day events in Sweden

ESC 0/1-hr hs-cTnT algorithm vs

ESC 0/1-hr hs-cTnT algorithm + ECG + Physician History Assessment

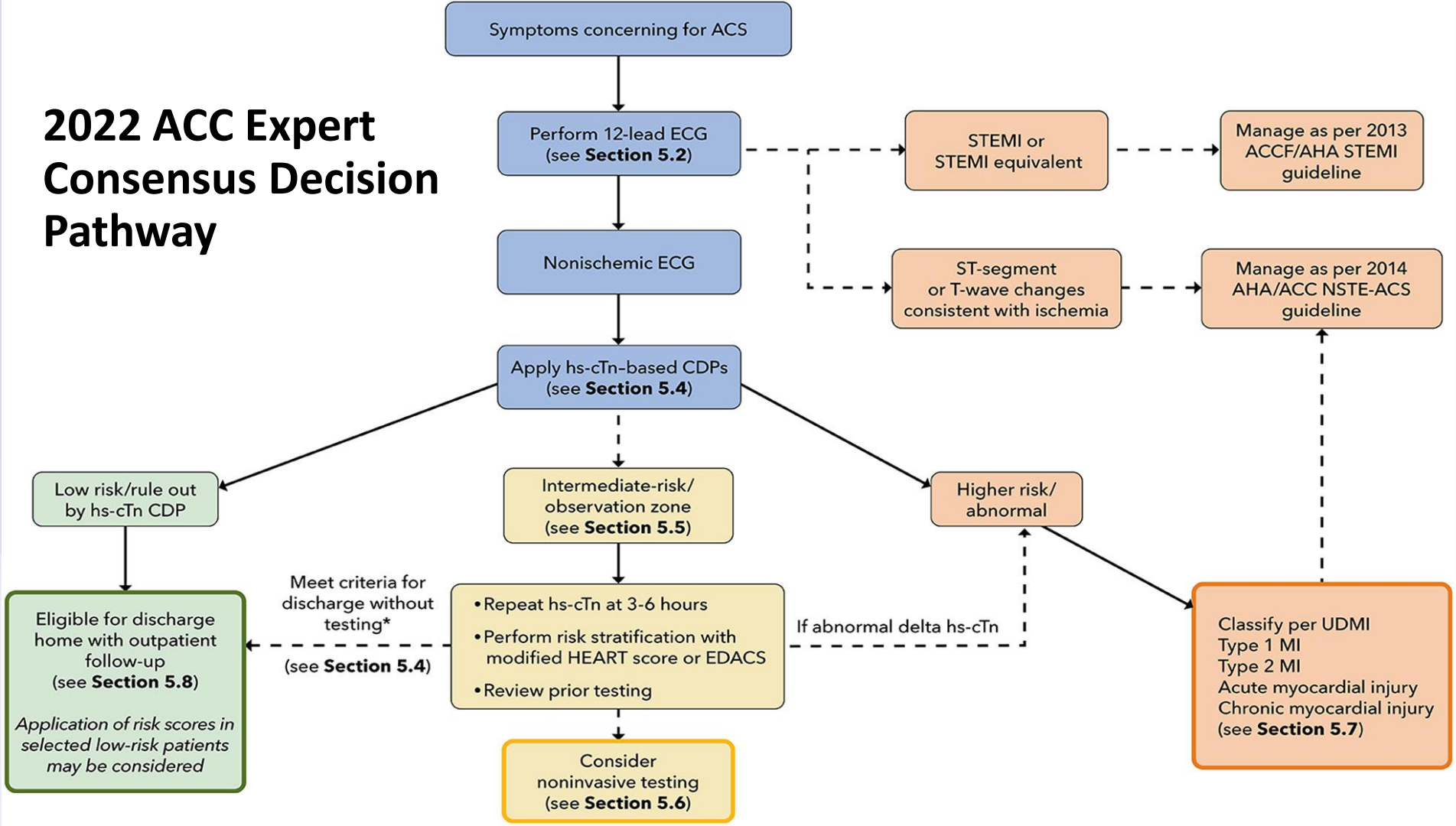


Mokhtari et. al, JACC, 2016



Brandon R. Allen. Circulation. Diagnostic Performance of High-Sensitivity Cardiac Troponin T Strategies and Clinical Variables in a Multisite US Cohort, Volume: 143, Issue: 17, Pages: 1659-1672, DOI: (10.1161/CIRCULATIONAHA.120.049298)

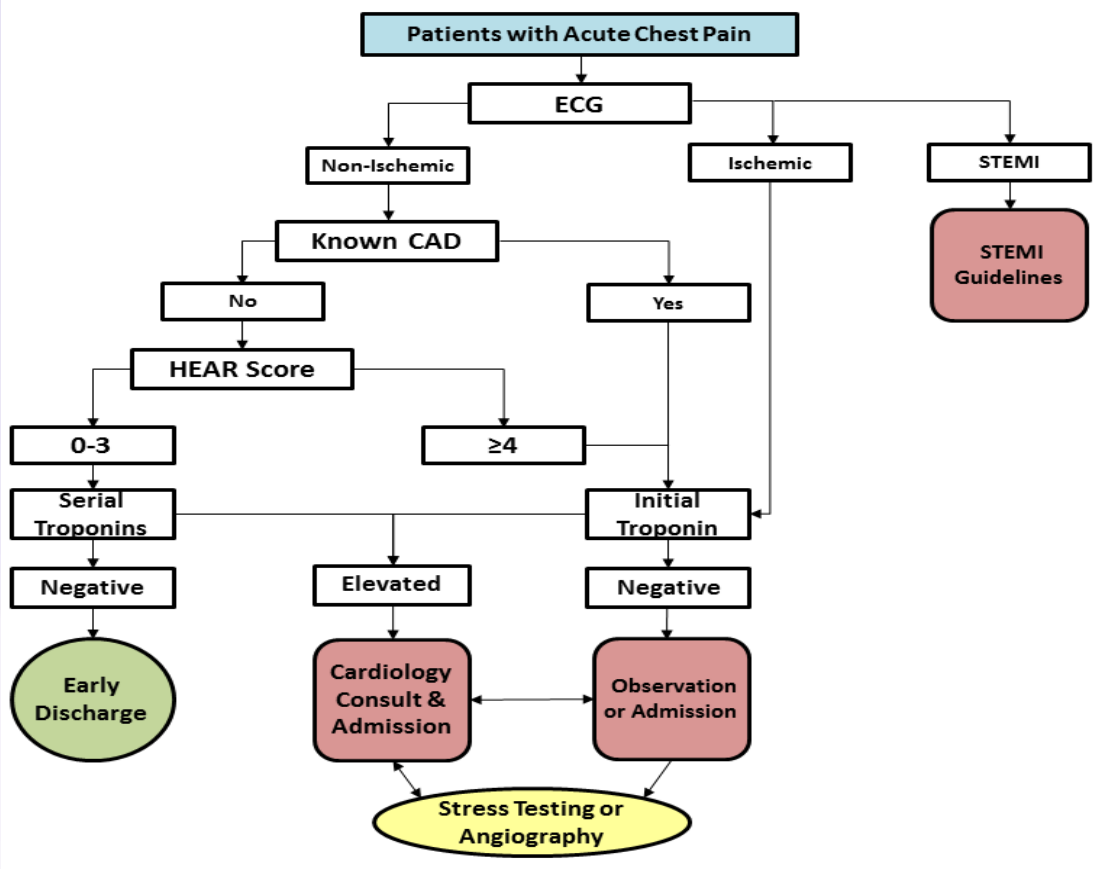
2022 ACC Expert Consensus Decision Pathway



HEART Pathway

ADP version of the HEART score

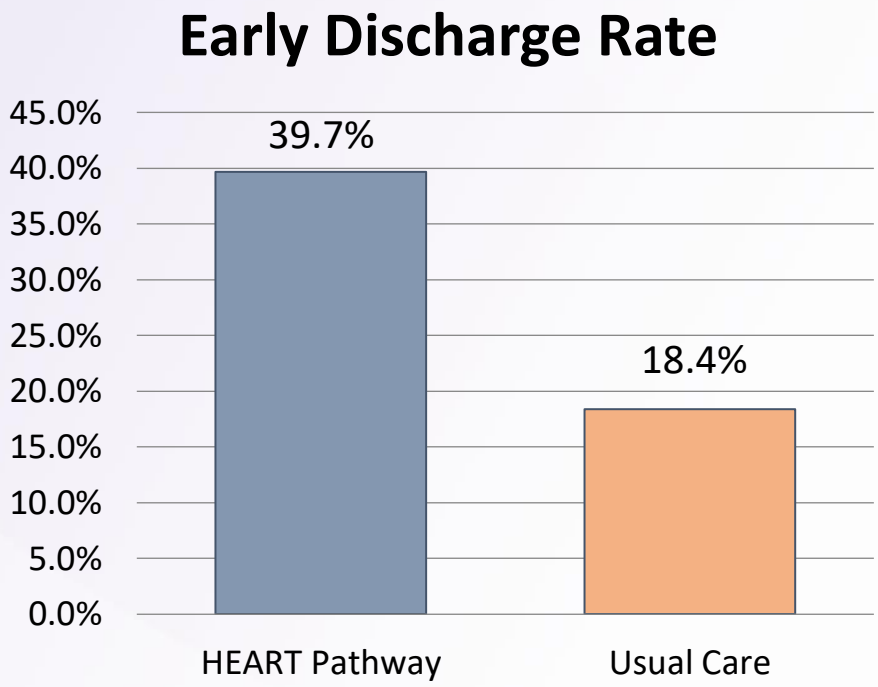
- No ischemic ECG changes
- No known CAD
  (prior AMI, revascularization, >70% coronary stenosis)
- Low risk = HEAR score: 0-3
- Negative serial troponins
- Objective history score



Mahler et. al, Crit Path Cardiol, 2011
Mahler et. al, Int J Cardiol, 2013
Mahler et al, Circ CVQO J, 2015
Mahler et al, Circulation, 2018

HEART Pathway RCT

- HEART Pathway increased the early discharge rate by 21% (p=0.0002).
- Reduced LOS
- Reduced costs
- No difference in adverse events

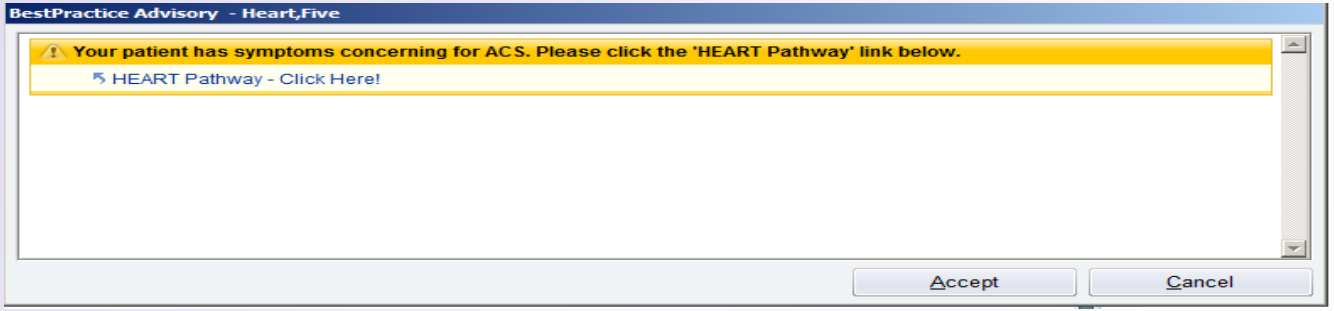


Mahler et al, Circ CVQO J, 2015.

Riley RF, et al. Amer J of Emerg Med. 2016.

HEART Pathway EMR Integration

- Decision support integrated into EMR on 11/3/2014
- Intelligent contextual launch within the provider workflow



Safely Identifying Emergency Department Patients with Acute Chest Pain for Early Discharge: The HEART Pathway Accelerated Diagnostic Protocol

Simon A. Mahler, Kristin M Lenoir, Brian J Wells, Gregory L. Burke, Pamela W Duncan, L. Douglas Case, David M. Herrington, Jose-Franck Diaz-Garelli, Wendell M Futrell, ... Show all Authors

Originally published 28 Sep 2018 | Circulation. 2018;0

Abstract

Background: The HEART Pathway is an accelerated diagnostic protocol (ADP) designed to identify low-risk Emergency Department (ED) patients with chest pain for early discharge without stress testing or angiography. The objective of this study was to determine whether implementation of the HEART Pathway is safe (30 day death and myocardial infarction rate <1% in low-risk patients) and effective (reduces 30 day hospitalizations) in ED patients with possible acute coronary syndrome (ACS).

Methods: A prospective pre/post study was conducted at three US sites among 8,474 adult ED patients with possible ACS. Patients included were >21 years old, investigated for possible ACS, and had no evidence of ST-segment elevation myocardial infarction on electrocardiography. Accrual occurred for 12 months before and after HEART Pathway implementation from November 2013- January 2016. The HEART Pathway ADP was integrated into each site's electronic health record as an interactive clinical decision support tool. Following ADP integration, ED providers prospectively utilized the HEART Pathway to identify patients with possible ACS as low-risk (appropriate for early discharge without stress testing or angiography) or non-low-risk (appropriate for further in-hospital evaluation). The primary safety and effectiveness outcomes, death and myocardial infarction (MI) and hospitalization rates at 30 days, were determined from health records, insurance claims, and death index data.

Article Information

Manuscript received June 21, 2018
Manuscript accepted August 16, 2018
Originally published September 28, 2018

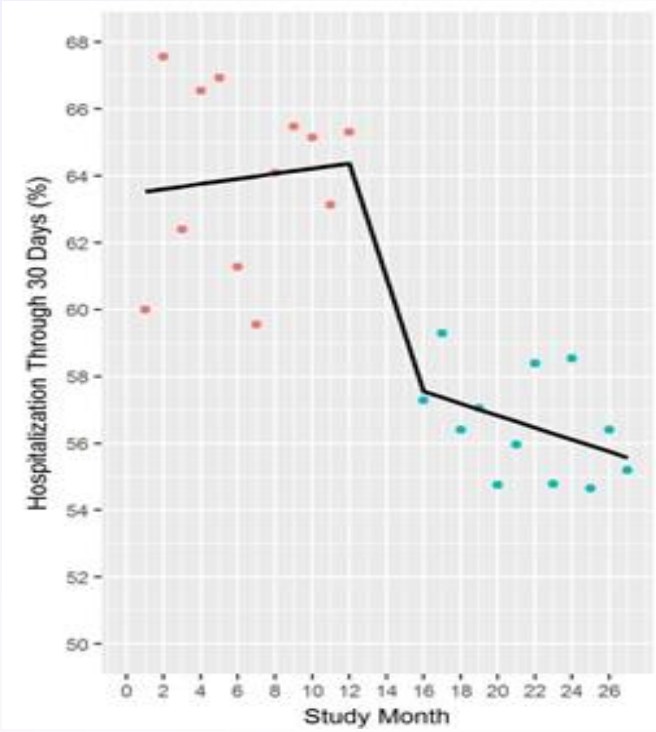
Impact

91% Adherence

Death and MI 0.4% among low-risk

6% Reduction in Hospitalizations

Reduced LOS



Mahler et al, Circulation, 2018

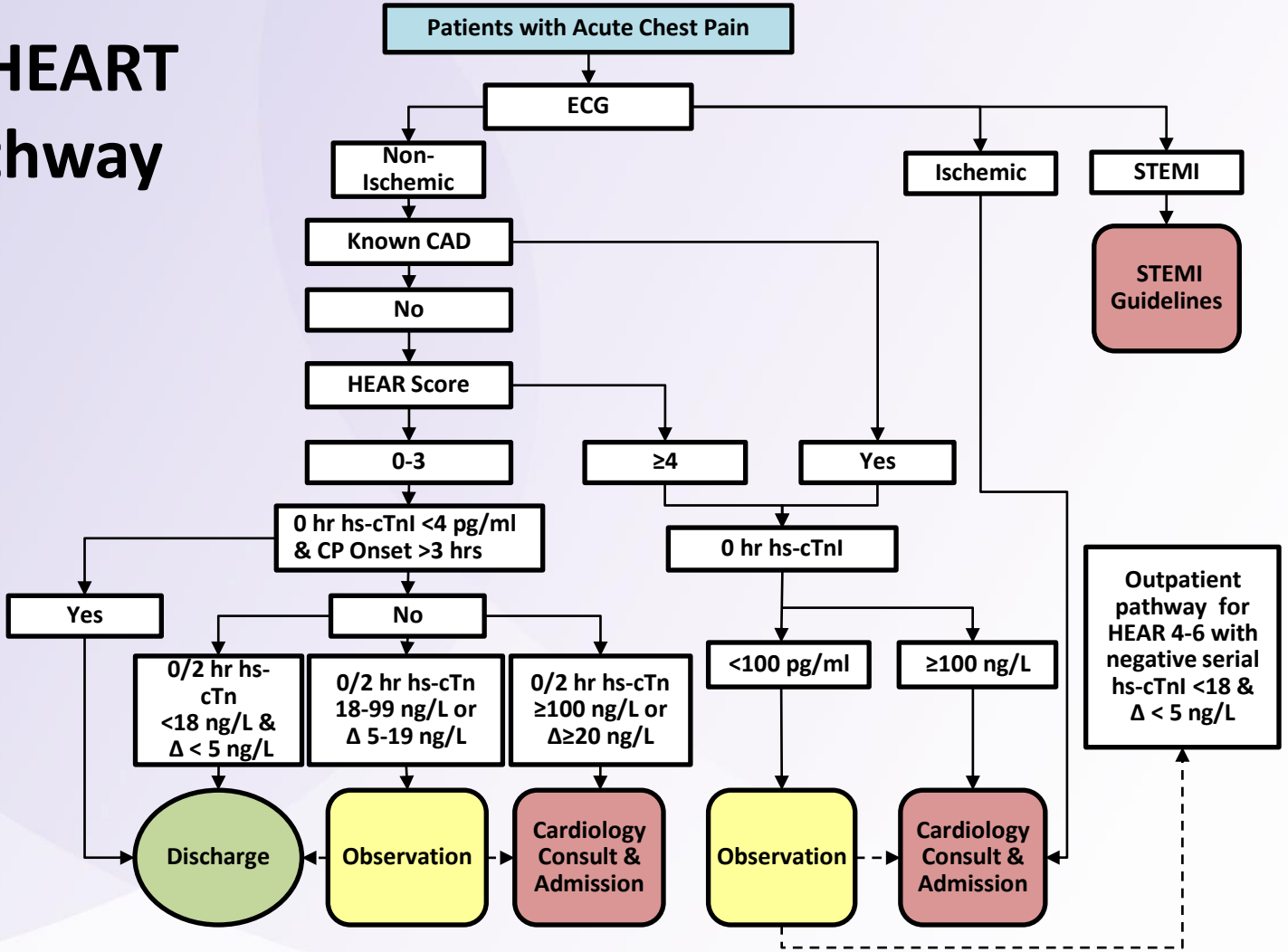
Key Differences Between HEART Pathway & HEART Score:

Features	HEART Pathway	HEART Score
Missed ACS rate <1%	+	-
Objective History	+	-
Acute Ischemic ECG Change = High Risk	+	-
Positive Troponin = High Risk	+	-
Known CAD = High Risk	+	-

Modernizing the HEART Pathway

- Incorporating hs-cTn
  - Use one-and-done
  - Shorten serial troponin timing
  - Use delta values
  - Create rule-out, observation, and rule-in zones
  - Create Outpatient Pathway for moderate risk patients with negative hs-cTn

hs-HEART Pathway

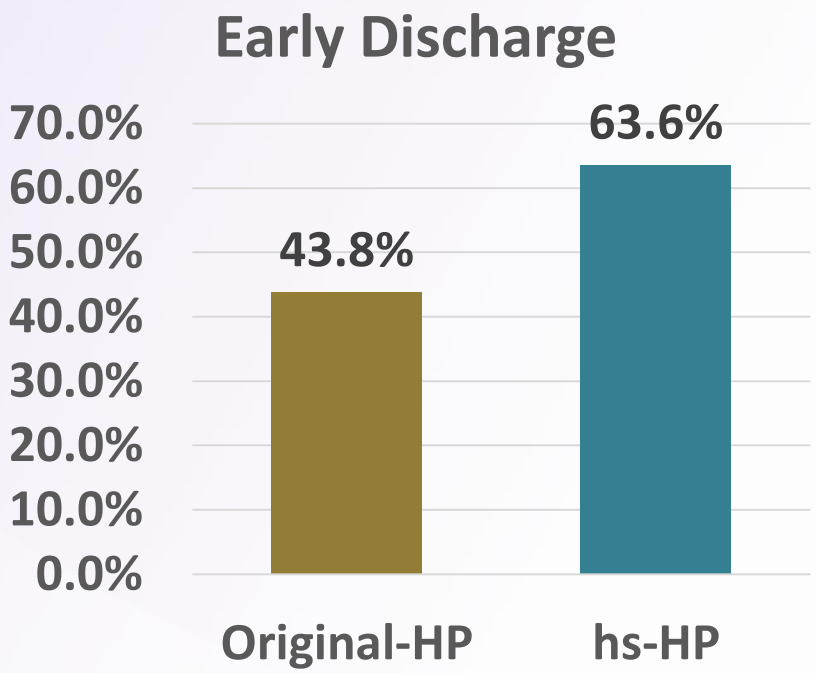


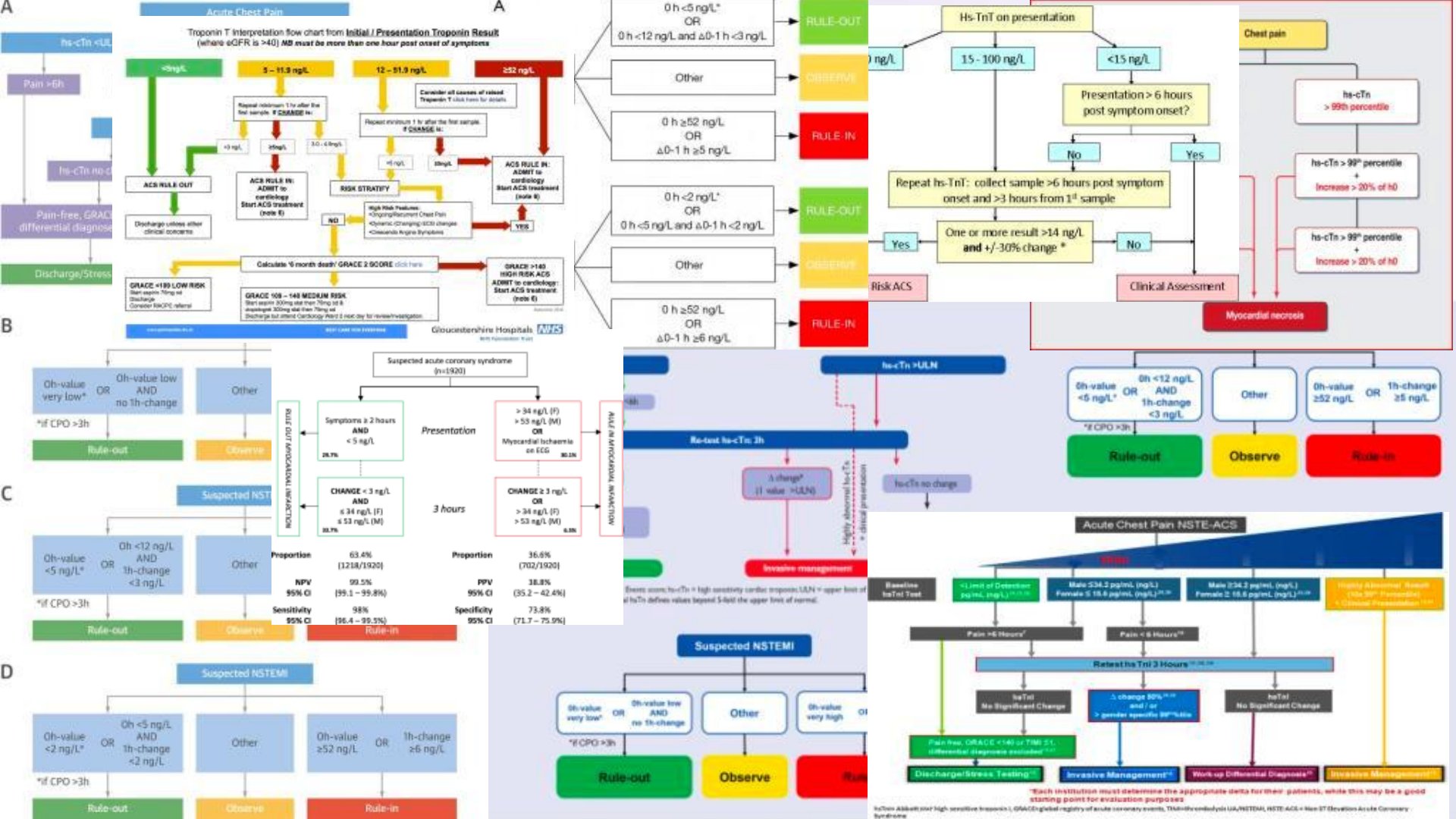
hs-HEART Pathway Implementation: Impact

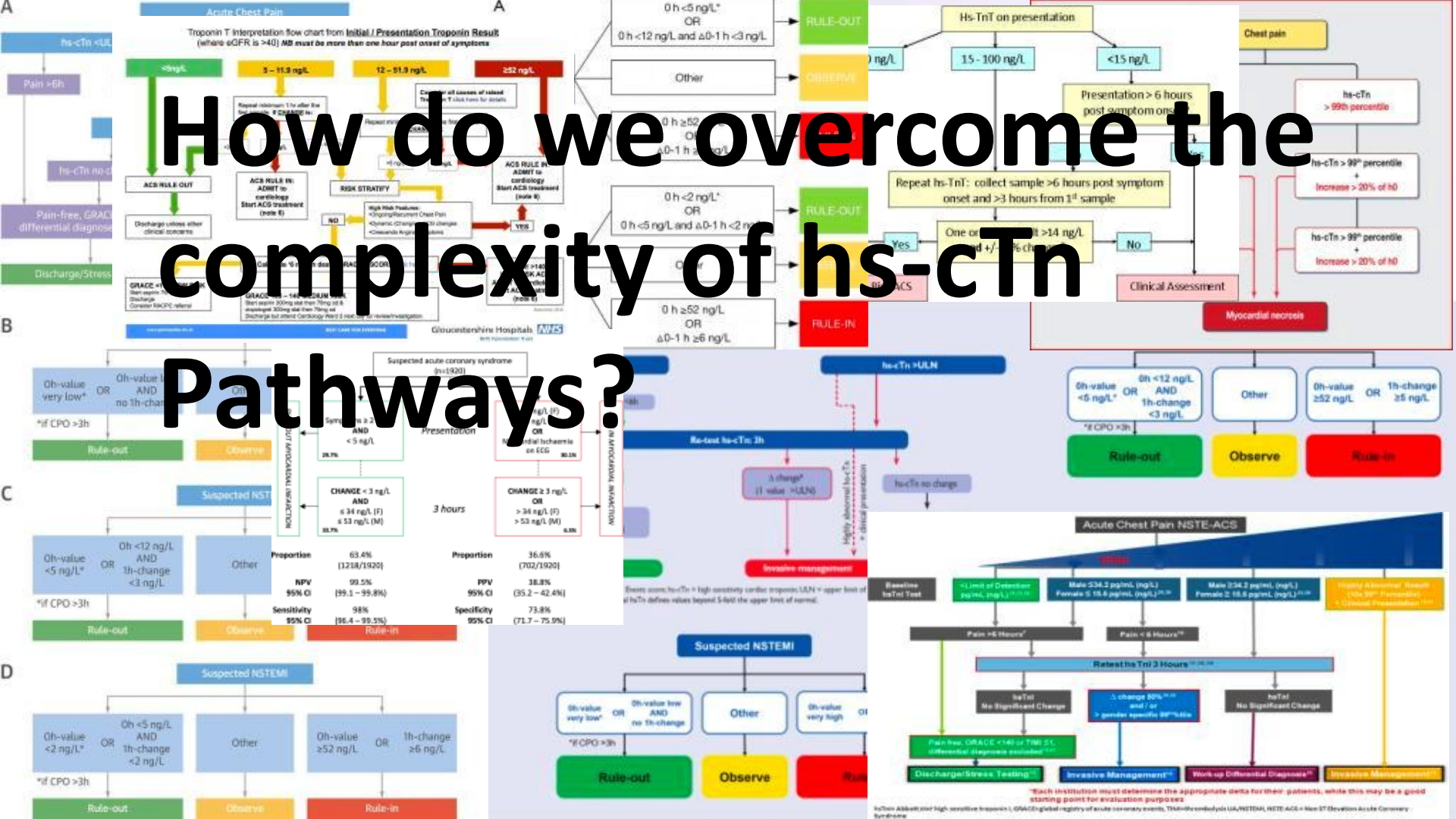
Hs- HEART Pathway **increased** the **early discharge** rate by

19.8% (p<0.0001)

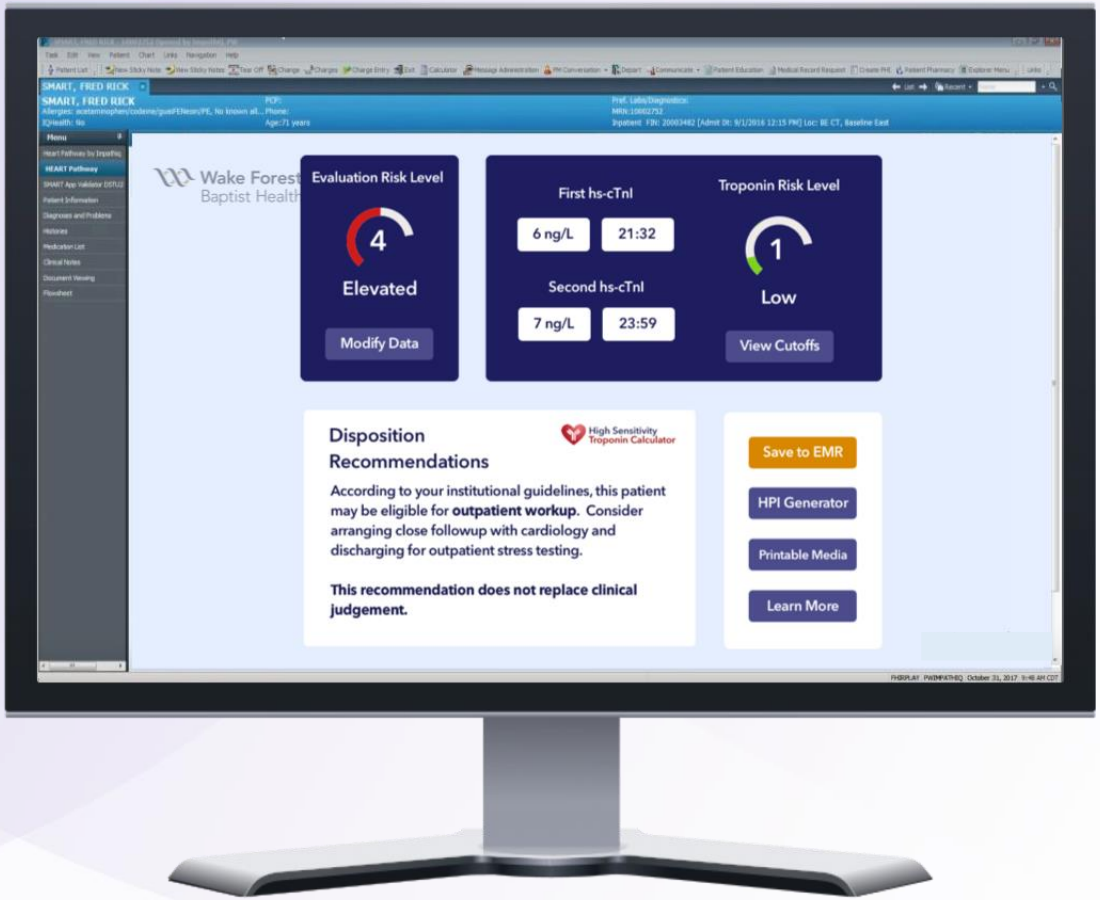
- Reduced LOS
- Reduced stress testing
- 0.2% adverse event rate in low-risk patients




A
Acute Chest Pain
Troponin T interpretation flow chart from Initial / Presentation Troponin Result
(where eGFR is >40) MB must be more than one hour post onset of symptoms
<5ng/L
5 – 11.9 ng/L
12 – 51.9 ng/L
≥52 ng/L
ACS RULE OUT
ACS RULE IN: ADMIT to cardiology Start ACS treatment (note 6)
RISK STRATIFY
ACS RULE IN: ADMIT to cardiology Start ACS treatment (note 6)
Discharge unless other clinical concerns
NO
YES
Calculate '6 month death' GRACE 2 SCORE
GRACE <109 LOW RISK
GRACE 109 – 140 MEDIUM RISK
GRACE >140 HIGH RISK ACS ADMIT to cardiology: Start ACS treatment (note 6)
Gloucestershire Hospitals NHS
0 h <5 ng/L*
OR
0 h <12 ng/L and Δ0-1 h <3 ng/L
RULE-OUT
Other
OBSERVE
0 h ≥52 ng/L
OR
Δ0-1 h ≥5 ng/L
RULE-IN
0 h <2 ng/L*
OR
0 h <5 ng/L and Δ0-1 h <2 ng/L
RULE-OUT
Other
OBSERVE
0 h ≥52 ng/L
OR
Δ0-1 h ≥6 ng/L
RULE-IN
Hs-TnT on presentation
15 - 100 ng/L
<15 ng/L
Presentation > 6 hours post symptom onset?
No
Yes
Repeat hs-TnT: collect sample >6 hours post symptom onset and >3 hours from 1st sample
Yes
One or more result >14 ng/L and +/-30% change *
No
Risk ACS
Clinical Assessment
Chest pain
hs-cTn > 99th percentile
hs-cTn > 99th percentile + Increase > 20% of h0
hs-cTn > 99th percentile + Increase > 20% of h0
Myocardial necrosis
B
0h-value very low*
OR
0h-value low AND no 1h-change
Other
*if CPO >3h
Rule-out
Observe
Suspected acute coronary syndrome (n=1920)
Presentation
Symptoms ≥ 2 hours AND < 5 ng/L
28.7%
> 34 ng/L (F) > 53 ng/L (M) OR Myocardial ischaemia on ECG
30.1%
3 hours
CHANGE < 3 ng/L AND ≤ 34 ng/L (F) ≤ 53 ng/L (M)
33.7%
CHANGE ≥ 3 ng/L OR > 34 ng/L (F) > 53 ng/L (M)
6.8%
RULE OUT MYOCARDIAL INFARCTION
RULE IN MYOCARDIAL INFARCTION
Proportion 63.4% (1218/1920)
NPV 99.5% 95% CI (99.1 – 99.8%)
Sensitivity 98% 95% CI (96.4 – 99.5%)
Proportion 36.6% (702/1920)
PPV 38.8% 95% CI (35.2 – 42.4%)
Specificity 73.8% 95% CI (71.7 – 75.9%)
hs-cTn >ULN
Re-test hs-cTn: 3h
Δ change* (1 value >ULN)
hs-cTn no change
Highly abnormal hs-cTn + clinical presentation
Invasive management
0h-value <5 ng/L*
OR
0h <12 ng/L AND 1h-change <3 ng/L
Other
0h-value ≥52 ng/L
OR
1h-change ≥5 ng/L
*if CPO >3h
Rule-out
Observe
Rule-in
C
Suspected NST
0h-value <5 ng/L*
OR
0h <12 ng/L AND 1h-change <3 ng/L
Other
*if CPO >3h
Rule-out
Observe
Rule-in
Suspected NSTEMI
0h-value very low*
OR
0h-value low AND no 1h-change
Other
0h-value very high
*if CPO >3h
Rule-out
Observe
Rule-in
Acute Chest Pain NSTE-ACS
Baseline hsTnI Test
Pain >6 Hours*
Pain < 6 Hours**
Retest hs TnI 3 Hours**
hsTnI No Significant Change
Δ change 50%** and / or > gender specific 99th%tile
hsTnI No Significant Change
Pain free, GRACE <140 or TIMI ≤1, differential diagnosis excluded**
Discharge/Stress Testing**
Invasive Management**
Work up Differential Diagnosis**
Invasive Management**
*Each institution must determine the appropriate delta for their patients, while this may be a good starting point for evaluation purposes
D
Suspected NSTEMI
0h <5 ng/L
OR
0h-value <2 ng/L*
AND 1h-change <2 ng/L
Other
0h-value ≥52 ng/L
OR
1h-change ≥6 ng/L
*if CPO >3h
Rule-out
Observe
Rule-in

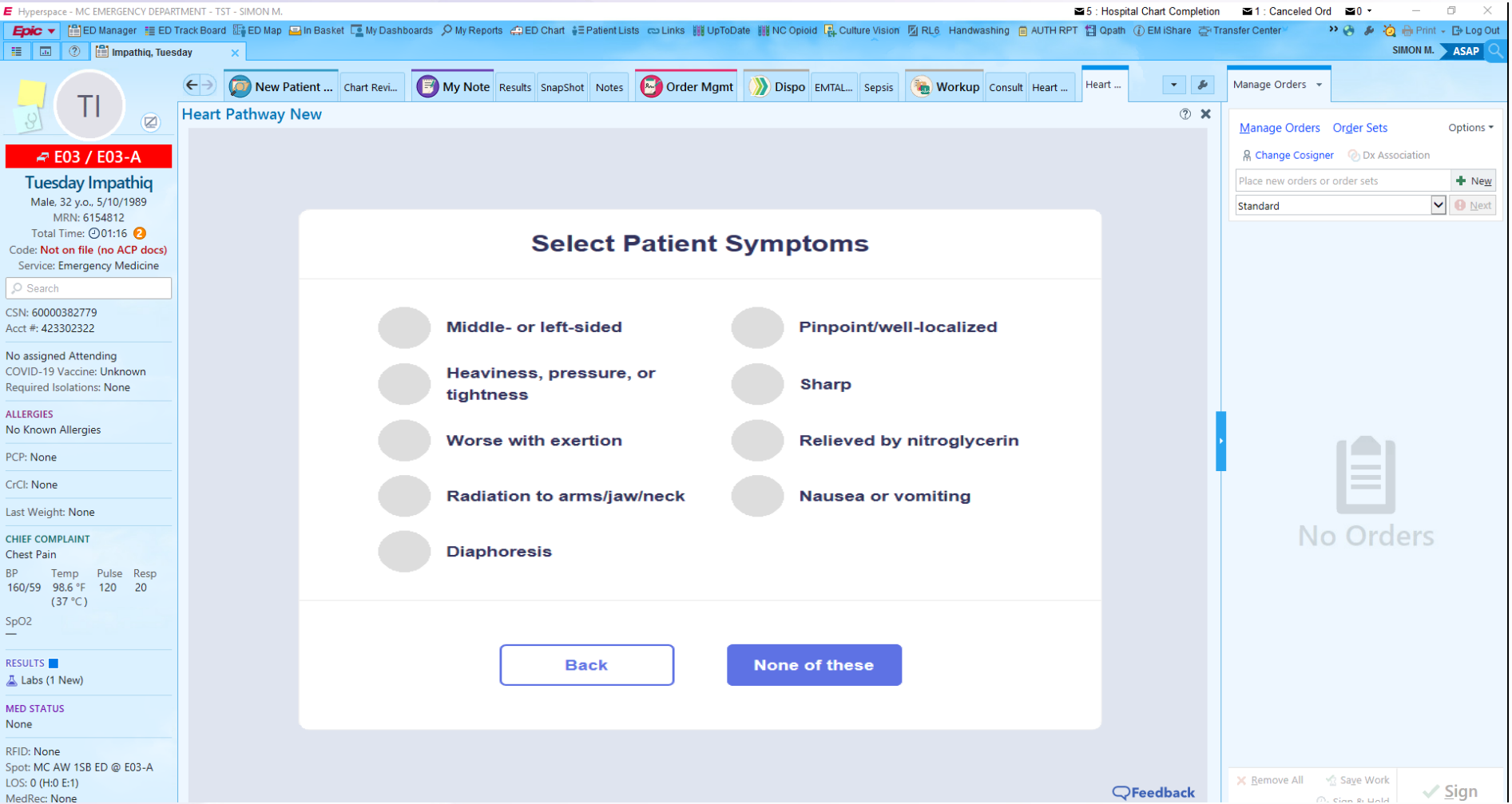

How do we overcome the complexity of hs-cTn Pathways?

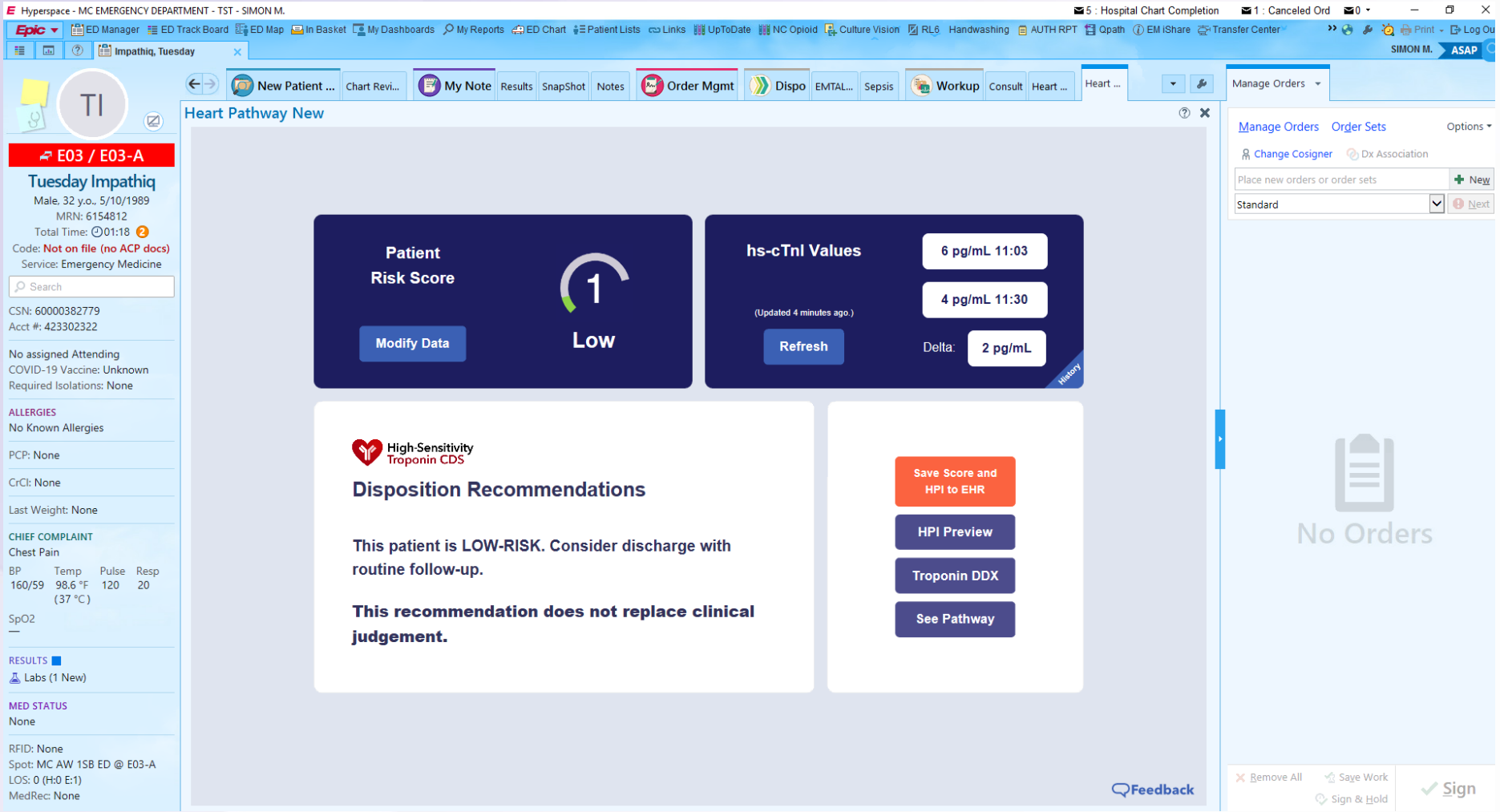
Clinical Decision Support



Modernizing Decision Support

- Enhancing Decision Support
  - Latest technology (SMART FHIR)
  - Enhanced User Interface
  - Real-time Pathway Navigation
  - Enhanced Data Reporting


Hyperspace - MC EMERGENCY DEPARTMENT - TST - SIMON M.
5 : Hospital Chart Completion
1 : Canceled Ord
ED Manager
ED Track Board
ED Map
In Basket
My Dashboards
My Reports
ED Chart
Patient Lists
Links
UpToDate
NC Opioid
Culture Vision
RL6
Handwashing
AUTH RPT
Qpath
EM iShare
Transfer Center
Print
Log Out
Impathiq, Tuesday
SIMON M.
ASAP
New Patient ...
Chart Revi...
My Note
Results
SnapShot
Notes
Order Mgmt
Dispo
EMTAL...
Sepsis
Workup
Consult
Heart ...
Heart ...
Manage Orders
TI
E03 / E03-A
Tuesday Impathiq
Male, 32 y.o., 5/10/1989
MRN: 6154812
Total Time: 01:16
Code: Not on file (no ACP docs)
Service: Emergency Medicine
Search
CSN: 60000382779
Acct #: 423302322
No assigned Attending
COVID-19 Vaccine: Unknown
Required Isolations: None
ALLERGIES
No Known Allergies
PCP: None
CrCl: None
Last Weight: None
CHIEF COMPLAINT
Chest Pain
BP
Temp
Pulse
Resp
160/59
98.6 °F (37 °C)
120
20
SpO2
RESULTS
Labs (1 New)
MED STATUS
None
RFID: None
Spot: MC AW 1SB ED @ E03-A
LOS: 0 (H:0 E:1)
MedRec: None
Heart Pathway New
Select Patient Symptoms
Middle- or left-sided
Heaviness, pressure, or tightness
Worse with exertion
Radiation to arms/jaw/neck
Diaphoresis
Pinpoint/well-localized
Sharp
Relieved by nitroglycerin
Nausea or vomiting
Back
None of these
Feedback
Manage Orders
Order Sets
Options
Change Cosigner
Dx Association
Place new orders or order sets
New
Standard
Next
No Orders
Remove All
Save Work
Sign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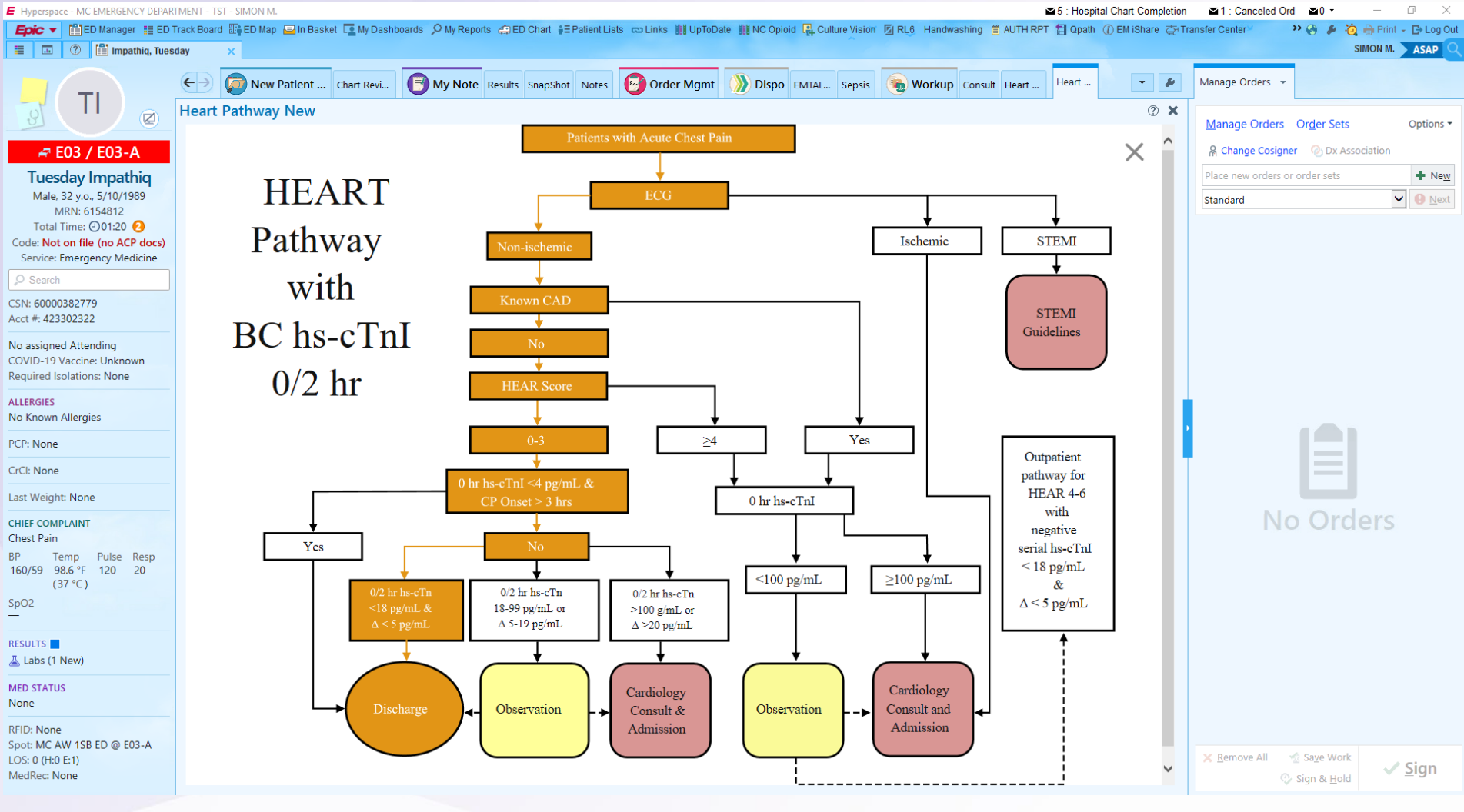
Patient Lists
Links
UpToDate
NC Opioid
Culture Vision
RL6
Handwashing
AUTH RPT
Qpath
EM iShare
Transfer Center
Print
Log Ou
Impathiq, Tuesday
SIMON M.
ASAP
TI
E03 / E03-A
Tuesday Impathiq
Male, 32 y.o., 5/10/1989
MRN: 6154812
Total Time: 01:18
Code: Not on file (no ACP docs)
Service: Emergency Medicine
Search
CSN: 60000382779
Acct #: 423302322
No assigned Attending
COVID-19 Vaccine: Unknown
Required Isolations: None
ALLERGIES
No Known Allergies
PCP: None
CrCl: None
Last Weight: None
CHIEF COMPLAINT
Chest Pain
BP
Temp
Pulse
Resp
160/59
98.6 °F (37 °C)
120
20
SpO2
RESULTS
Labs (1 New)
MED STATUS
None
RFID: None
Spot: MC AW 1SB ED @ E03-A
LOS: 0 (H:0 E:1)
MedRec: None
New Patient ...
Chart Revi...
My Note
Results
SnapShot
Notes
Order Mgmt
Dispo
EMTAL...
Sepsis
Workup
Consult
Heart ...
Heart ...
Manage Orders
Heart Pathway New
Patient Risk Score
1
Low
Modify Data
hs-cTnI Values
6 pg/mL 11:03
4 pg/mL 11:30
(Updated 4 minutes ago.)
Refresh
Delta:
2 pg/mL
History
High-Sensitivity Troponin CDS
Disposition Recommendations
This patient is LOW-RISK. Consider discharge with routine follow-up.
This recommendation does not replace clinical judgement.
Save Score and HPI to EHR
HPI Preview
Troponin DDX
See Pathway
Feedback
Manage Orders
Order Sets
Options
Change Cosigner
Dx Association
Place new orders or order sets
New
Standard
Next
No Orders
Remove All
Save Work
Sign & Hold
Sign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ED Manager
ED Track Board
ED Map
In Basket
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ED Chart
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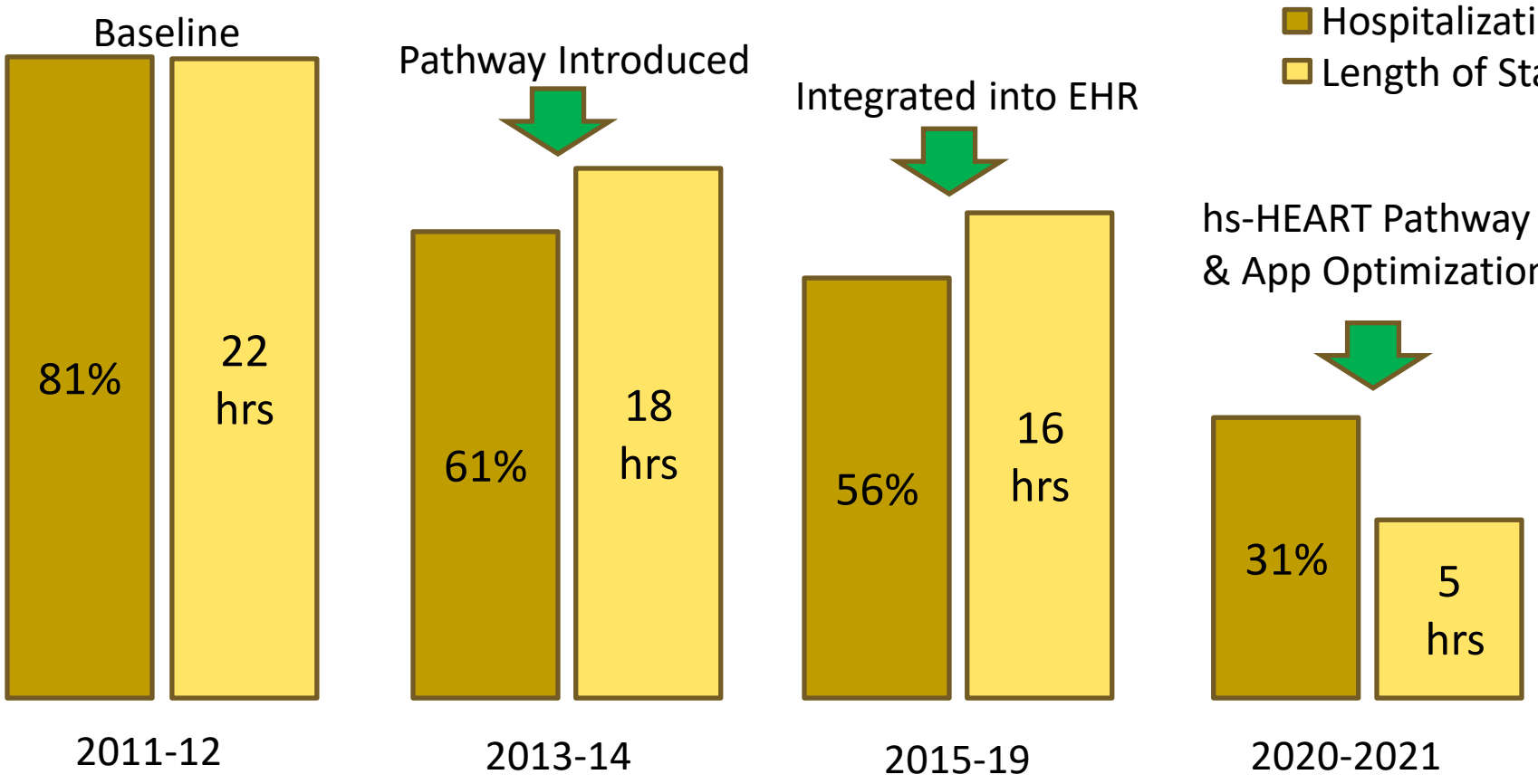
Sepsis
Workup
Consult
Heart ...
Heart ...
Manage Orders
TI
E03 / E03-A
Tuesday Impathiq
Male, 32 y.o., 5/10/1989
MRN: 6154812
Total Time: 01:20
Code: Not on file (no ACP docs)
Service: Emergency Medicine
Search
CSN: 60000382779
Acct #: 423302322
No assigned Attending
COVID-19 Vaccine: Unknown
Required Isolations: None
ALLERGIES
No Known Allergies
PCP: None
CrCl: None
Last Weight: None
CHIEF COMPLAINT
Chest Pain
BP
160/59
Temp
98.6 °F
(37 °C)
Pulse
120
Resp
20
SpO2
—
RESULTS
Labs (1 New)
MED STATUS
None
RFID: None
Spot: MC AW 1SB ED @ E03-A
LOS: 0 (H:0 E:1)
MedRec: None
Heart Pathway New
HEART Pathway with BC hs-cTnI 0/2 hr
Patients with Acute Chest Pain
ECG
Non-ischemic
Ischemic
STEMI
STEMI Guidelines
Known CAD
No
HEAR Score
0-3
≥4
Yes
0 hr hs-cTnI <4 pg/mL & CP Onset > 3 hrs
0 hr hs-cTnI
Outpatient pathway for HEAR 4-6 with negative serial hs-cTnI < 18 pg/mL & Δ < 5 pg/mL
Yes
No
<100 pg/mL
≥100 pg/mL
0/2 hr hs-cTn <18 pg/mL & Δ < 5 pg/mL
0/2 hr hs-cTn 18-99 pg/mL or Δ 5-19 pg/mL
0/2 hr hs-cTn >100 g/mL or Δ >20 pg/mL
Discharge
Observation
Cardiology Consult & Admission
Observation
Cardiology Consult and Admission
Manage Orders
Order Sets
Options
Change Cosigner
Dx Association
Place new orders or order sets
New
Standard
Next
No Orders
Remove All
Save Work
Sign & Hold
Sign

HEART Pathway: Enhancing Value



Summary

- ADPs standardize care and promote efficiency
  - Troponins should be combined with clinical data
    - Multivariable ADP
      - The hs-HEART Pathway increases early discharges and has low missed event rate
  - Clinical decision support can help guide providers in use of complex ADPs