

Lab Stewardship: Eliminating Unnecessary Blood Testing by Improving Evidence-based Ordering of Cardiac Biomarkers for Acute Coronary Syndrome

Summary: Eliminate excessive troponin I tests and other cardiac injury biomarkers, such as Creatine phosphokinase (CK) or Creatine kinase-MB (CKMB), that are not as effective by using pop-up warnings and rules during the ordering process.

Module: POM

Setting: Emergency Department and Inpatient

Source: Johns Hopkins Bayview Medical Center (JHBMC) is a 555 bed academic medical center in Baltimore, MD. JHBMC offers a wide range of services, including a trauma center and neonatal intensive care unit that are part of the statewide system, and a nationally renowned geriatrics center. As an academic teaching hospital, all of the physicians at Johns Hopkins Bayview are full-time faculty at The Johns Hopkins University School of Medicine.

Objective: Lab Stewardship (the right test at the right time for the right patient), eliminating unnecessary blood testing and decreasing healthcare spending.

Outcome(s): Successful Results in just one year!

- Reduced Laboratory charges by \$1.25 million implementing interventions including CDSi with MEDITECH's CPOE
- 66% decrease in unnecessary blood tests ordered
- 38.4% increase compliance with evidence-based ordering guidelines of cardiac biomarkers - from 57.1 % to 95.5 %

Platform: Client/Server. JHBMC implemented MEDITECH's CPOE with embedded CDS over ten years ago (2003). All medication and laboratory orders are placed using CPOE by providers, primarily residents.

Description

Researchers at Johns Hopkins Bayview Medical Center designed and implemented a multimodal intervention to improve evidence-based ordering of cardiac biomarkers for the diagnosis of acute coronary syndrome (ACS), publishing their successful outcomes and outlining the implementation in the paper *Reducing Excess Cardiac Biomarker Testing at an Academic Medical Center published in the Journal of General Internal Medicine*¹.

The focus of the guideline is on tests to assess the levels of troponin, a contractile protein that increases in serum after myocardial necrosis; it is a sensitive and specific marker of acute MI. Often troponin tests are repeated four or more times in a 24-hour period, which is excessive according to the literature, and often ordered along with tests for other cardiac injury biomarkers, such as Creatine phosphokinase (CK) or Creatine kinase-MB (CKMB) that are not as effective.

Using the clinical decision support (CDS) capabilities in MEDITECH's Computerized Provider Order Entry (CPOE), they implemented the following rules to support guideline-concordant ordering of cardiac biomarkers:

- 1) Their guideline specifies that troponin should be assessed no more than three times, approximately spaced over 18 to 24 hours. The ability to order troponin multiple times up front was eliminated by writing a rule to eliminate series ordering.
- 2) A duplicate order pop-up warning alerts providers when a troponin test is ordered within six hours of another troponin level.
- 3) A pop-up warning displays when a provider attempts to order Creatine phosphokinase (CK) or Creatine kinase-MB (CKMB). The pop up warning states:
 - a) CK: "Creatine phosphokinase (CK) should not be ordered for evaluation of acute coronary syndrome as it offers no additional benefit beyond troponin alone."
 - b) CKMB: "According to national guidelines, troponin is the preferred biomarker for detecting myocardial injury. CK-MB is only appropriate when troponin levels are unavailable."

In response to these pop-up warnings, providers may choose to either erase, override or acknowledge the warning.

In addition to using CDSi, JHBMC removed from all standardized order sets, including several admission and routine daily order sets, orders for Creatine phosphokinase and Creatine kinase-MB. Troponin orders were removed from all order sets, except two that are used for evaluating new acute coronary syndrome symptoms.

Finally, with the exception of ED triage order sets, they eliminated orders for nurses to initiate cardiac biomarker testing, and educated nursing and providers that orders for cardiac biomarkers should be ordered directly by providers.

Where the Rule is Triggered

Physician presented with a Rule that Series Orders for Troponin are Not Permitted:

Patient presents to the Emergency Department with Chest Pain. ED Physician orders the Chest Pain Protocol order set, which includes a Troponin I test.



The Physician edits the Troponin to be ordered as a series and upon filing is presented with the error "Series ordering is not allowed for this procedure."

Provider Order Management - Rose, Lucy

Serta, Henry V000000528 / L000000361 / CSOPTVE0002110
DOB: 3/4/45 69 M Emergency Department REG ER
Ht: 73 in / Wt: 214 lb BSA: 2.25 m2 BMI: 28.2 kg/m2 Full Code: [+]
Allergy/AdvReac: morphine

Enter Detail for TROPONIN I (LAB)

Software by MEDITECH

TROPONIN I (LAB)

Order

TROPONIN I (LAB)

* Priority	S	Series?	Y
Quantity		Directions	Q6H
* Date	12/31/14	Stop Date	
Time	0811	Stop Time	
		Count	3

Collected By Care Area?

Has This Specimen Been Collected?

Add Favorite Cancel OK ? [Icons]

Select All Add Favorite View Review Renew Hold/Resume Stop Undo Edit Link/Unlink Select Prev Next Cancel Save ? [Icons]

Rule Check: Do not order troponin series

TROPONIN I (LAB)

Rule Message

Series ordering not allowed for this procedure.

Erase Order

Duplicate Order Check

Troponin I level comes back as 0.4 ng/mL and 4 (less than 6) hours later another Troponin I test is ordered in CPOE. The following alert is triggered, to warn the user another Troponin was ordered within 6 hours:

Provider Order Management - Rose, Lucy

Serta, Henry DOB: 3/4/45 69 M
V000000528 / L000000361 / CSOPTVE0002110
Emergency Department REG ER
Full Code: [+]

Ht: 73 in / Wt: 214 lb BSA: 2.25 m2 BMI: 28.2 kg/m2
Allergy/AdvReac: morphine

0 Selected Orders

By Procedure

No.	Current Order	Pri	Date	Time	Status	Stop/Renew	My	Link
+ Cardiology (1)								
+ Laboratory (2)								
+ Nursing (1)								
+ General (1)								
+ Imaging (1)								
- New Orders (1)								

7 TR

Duplicate Order Check

TROPONIN I (LAB)

This order is already on the patient. This order will be a duplicate if ordered within 6 hours. Enter a reason or edit the order to continue. Cancel to exit and discard.

Date	Time	Priority	Provider	Status
12/02/14	1114	S	CFJPHY Rose, Lucy	COMP

* Duplicate Reason

Choice of Therapy

Edit Order Prev Next Cancel Save

Select All Add Favorite View Review Renew Hold/Resume Stop Undo Edit Link/Unlink Select Prev Next Cancel Save

MEDITECH Tip: We are aware that certain emergency departments use accelerated diagnostic protocols to help them differentiate high and medium risk ACS patients from lower risk ones. In these cases, a second troponin is obtained as early as 2 hours after the first and a soft stop rule allowing the provider to proceed to order is appropriate.

A pop-up warning alerts providers when she/he attempts to order Creatine phosphokinase (CK):

Physician attempts to place a Creatine phosphokinase (CK) order and is presented with an alert that prevents it from being ordered.

JHBMC set this rule up as a 'soft stop' and it will always flag the user. The provider may proceed to place the order and will not be prompted to document an override reason.

Of note, the provider may be considering other diagnoses such as rhabdomyolysis, malignant neuroleptic syndrome, polymyositis, and others, when ordering CK is beneficial, and a soft stop enables the provider to move forward.

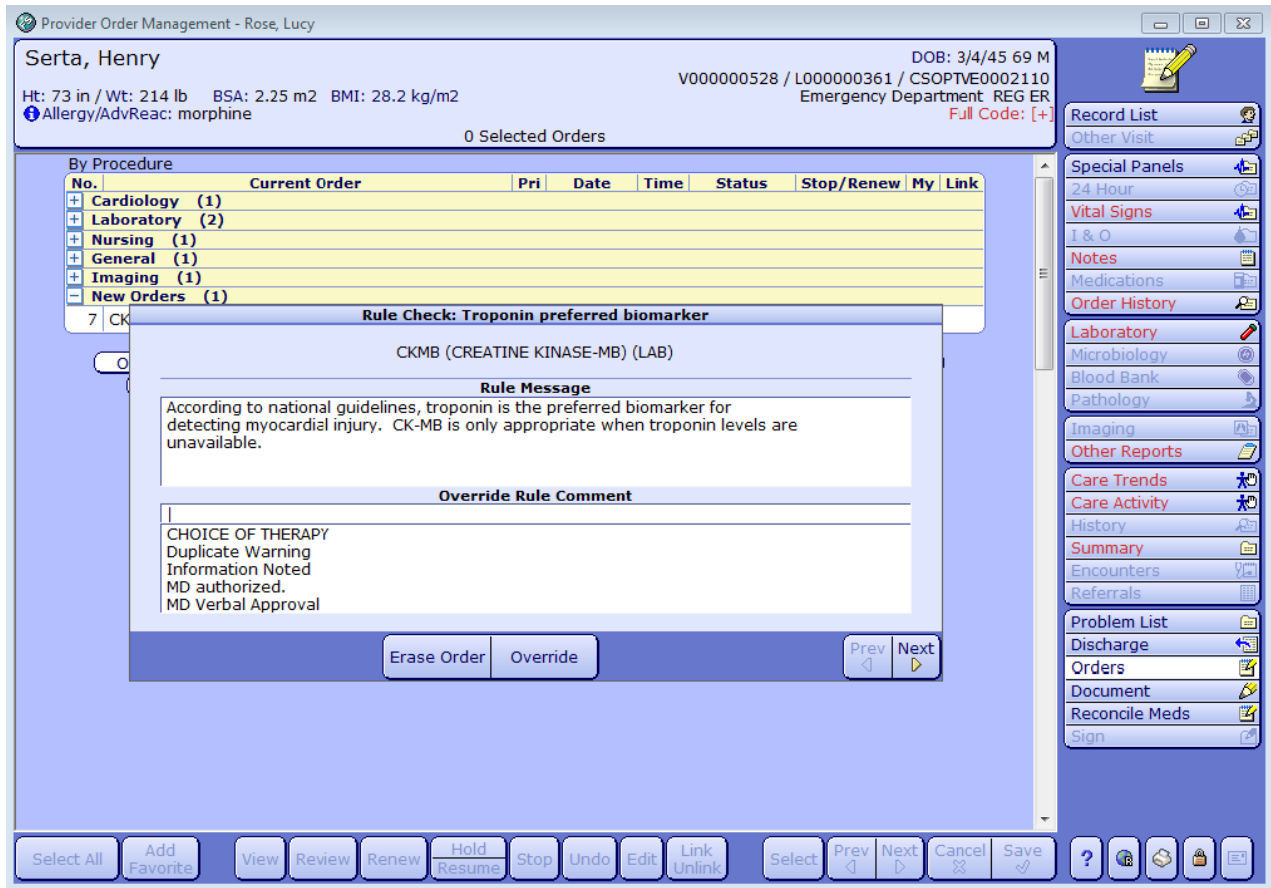
The screenshot displays the 'Provider Order Management' interface for a patient named Henry Serta. The patient's information includes DOB: 3/4/45 69 M, V000000528 / L000000361 / CSOPTVE0002110, Emergency Department REG ER, and an allergy to morphine. The interface shows a list of orders by procedure, with a 'New Orders' section containing one order for CK (Creatine Phosphokinase). A pop-up window titled 'Rule Check: Do not use CK to evaluate ACS' is displayed, containing the following message:

Rule Message
Creatine phosphokinase (CK) should not be ordered for evaluation of acute coronary syndrome as it offers no additional benefit beyond troponin alone.

The interface also includes a 'Record List' on the right side with various panels like '24 Hour', 'Vital Signs', 'Notes', 'Medications', 'Order History', 'Laboratory', 'Microbiology', 'Blood Bank', 'Pathology', 'Imaging', and 'Other Reports'. At the bottom, there is a toolbar with buttons for 'Select All', 'Add Favorite', 'View', 'Review', 'Renew', 'Hold/Resume', 'Stop', 'Undo', 'Edit', 'Link/Unlink', 'Select', 'Prev', 'Next', 'Cancel', and 'Save'.

A pop-up warning alerts providers when she/he attempts to order Creatine Kinase-MB (CKMB):

Physician places an order for Creatine kinase-MB (CKMB) and is alerted that CKMB is not the preferred biomarker test for myocardial injury. This rule is set up as a 'hard stop' so the user is provided the option to Override the message or Erase the order:



The warning is always triggered, even in valid scenarios, but JHBMC felt its benefits justified its existence. They initially lobbied to remove the procedure as orderable at the organizational level, but were met with enough resistance from Cardiologists to allow it to remain.

Implementation Recommendations

JHBMC details in their paper *Reducing Excess Cardiac Biomarker Testing at an Academic Medical Center published in the Journal of General Internal Medicine*¹ and in the *online Appendix 1*² the strategies for achieving success. The areas JHBMC's recommends hospitals focus resources is on culture change, physician education, and order set review and implementation of IT system changes. A summary of each is outlined below:

Culture Change

For JHBMC, culture change was the hardest part of the process. They recognized early in the process the need to identify a strong physician within the organization to support the change.

They successfully obtained buy in from the Chief in the Division of Cardiology who helped them fully engage the cardiologists in the intervention.

In addition, they engaged in direct outreach with the providers, 87% represented the specialities of General Internal Medicine, Pulmonary services and the Emergency Department, who most frequently ordered cardiac biomarkers. The emergency department providers in particular are fruitful as their research found that for many patients, the first one or two orders for cardiac biomarkers were initiated by emergency department providers. The approach they took was primarily face to face communication with physicians during regularly scheduled meetings. During these meetings they reviewed the evidence. The 2007 *National Academy of Clinical Biochemistry Laboratory Medicine Practice Guidelines: Clinical characteristics and utilization of biochemical markers in acute coronary syndromes*, which was developed in conjunction with the American Heart Association³, is one compelling reference that helped convince their providers.

Once the CDSi went Live in the CPOE system and providers adopted the changes, peer pressure helped to bring on board the remaining providers.

Physician Education

Prior to instituting changes to the CPOE system, an e-mail communication was sent to all providers at JHBMC that outlined the mission and goals of *Physicians for Responsible Ordering*, which is a group of providers at JHBMC representing Internal Medicine, ED, Pathology, and administration, who are committed to reducing low value inpatient diagnostic tests ordering. They also provided:

- summary of the cardiac biomarker ordering guideline
- copy of simple pocket-sized reference card for the house staff
- a review of the changes to cardiac biomarker ordering planned for MEDITECH's CPOE.¹

As noted above, they also provided physician education during regular standing meetings. They estimate that anywhere from 25-75% of providers in the following groups were present for these meetings. Specifically, they met at an internal medicine housestaff morning report, a monthly internal medicine housestaff administrative lunch meeting, and monthly administrative meetings for hospitalists, MICU and CICU nursing staff, and the emergency department.

Order Set Review and IT System Changes

Prior to the start of the project, the system setup encouraged physicians to order more tests than needed. JHBMC started by reviewing their order sets for cardiac biomarkers and their Clinical Decision Support rules to evaluate if there was way to encourage better behavior.

They utilized the Client/Server 'Update Sets' routine to audit all orders sets including favorite order sets to look for orders that contain cardiac biomarkers. Available orders for cardiac biomarkers were troponin-I, total CK, and total CK and CK-MB fraction ordered together (CK-MB could not be ordered independent of total CK). They found:

- 20 order sets containing orders for CK/CK-MB
- Two order sets for CK

¹ *Reducing Excess Cardiac Biomarker Testing at an Academic Medical Center* - Online Appendix 1

- Eight order sets with troponin.
- Two order sets contained an order for nurses to “Start CK Curve for CP, PRN” or they could also be ordered individually.

They printed the list and contacted the appropriate department or content experts to review the proposed order set changes to provide rules to support guideline-concordant ordering of cardiac biomarkers. The Removal discussion was conducted primarily by email and most departments were fine with the changes.

The 'Update Sets' routine can be utilized to identify both the Standard and Favorite Order Sets containing the orders. Once identified and approval is obtained, sets you wish to proceed with automatically removing the orders from can be individually selected from a picklist. You may also wish to review, obtain approvals and update each order set manually.

JHBMC believes that the combination of provider education and changes to the CPOE system were effective in aligning physician ordering behavior of cardiac biomarker test ordering at their institution with national evidence-based guidelines.

Build Process

OE Rule Dictionary

1. Build a rule to prevent the ordering of Troponin as a series.

Entry Screen

Enter/Edit OE Rule Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

P.TROPONIN - Do not order troponin series Last Edit: 08/11/14 13:46

Entry Screen Description Shortcut Editor Info Button

Mnemonic P.TROPONIN

*Active Y

*Description Do not order troponin series

*Data Flds From ORD

*POM Enabled Y

Evaluate at POM ORD

Rule Logic

```
IF{[f ord series info] [ord pom]("P.TROPONIN",1);1};
```

Cancel Save ? [Icons]

Editor

Enter/Edit OE Rule Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

P.TROPONIN - Do not order troponin series Last Edit: 08/11/14 13:46

Entry Screen Description Shortcut Editor Info Button

Type

1 LINE

2 END

3

*If Value ord series info

Associated Data

*Comparison Exists

Value

Associated Data

Outcome

Associated Data

*Link Else

Button

Erase Order

*Message

Series ordering not allowed for this procedure.

NPR

Cancel Save ? [Icons]

2. Build a rule to prevent the ordering of Creatine phosphokinase (CK) to evaluate Acute Coronary Syndrome.

Entry Screen

Enter/Edit OE Rule Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

P.CK - CK not to evaluate ACS Last Edit: 08/11/14 13:50

Entry Screen Description Shortcut Editor Info Button

Mnemonic P.CK

*Active Y

*Description CK not to evaluate ACS

*Data Flds From ORD

*POM Enabled Y

Evaluate at
POM ORD

Rule Logic

```
IF{[f pt name] [ord pom]("P.CK",1);1};
```

Cancel Save ? [Icons]

Editor

Enter/Edit OE Rule Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

P.CK - CK not to evaluate ACS Last Edit: 08/11/14 13:50

Entry Screen Description Shortcut Editor Info Button

Type

1 LINE

2 END

3

*If Value pt name

Associated Data

*Comparison Exists

Value

Associated Data

Outcome

Associated Data

*Link Else

Button

Close

*Message

Creatine phosphokinase (CK) should not be ordered for evaluation of acute coronary syndrome as it offers no additional benefit beyond troponin alone.

NPR

Cancel Save ? [Icons]

3. Build a rule to warn against the ordering of Creatine kinase-MB (CKMB) when Troponin levels are available.

Entry Screen

Enter/Edit OE Rule Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

P.CKMB - Troponin preferred biomarker Last Edit: 11/25/14 10:38

Entry Screen Description Shortcut Editor Info Button

Mnemonic P.CKMB

*Active Y
 *Description Troponin preferred biomarker
 *Data Flds From ORD
 *POM Enabled Y

Evaluate at
 POM ORD

Rule Logic
 IF{[f pt name] [ord pom]("P.CKMB",1);1};

Cancel Save ? ? ? ? ? ?

Editor

Enter/Edit OE Rule Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

P.CKMB - Troponin preferred biomarker Last Edit: 11/25/14 10:38

Entry Screen Description Shortcut Editor Info Button

Type
 1 LINE
 2 END
 3

*If Value pt name
 Associated Data
 *Comparison Exists
 Value
 Associated Data
 Outcome
 Associated Data
 *Link Else

Button
 Erase Order
 Override

*Message
 According to national guidelines, troponin is the preferred biomarker for detecting myocardial injury. CK-MB is only appropriate when troponin levels are unavailable.

NPR

Cancel Save ? ? ? ? ? ?

OE Procedure Dictionary

1. Define 'Duplicate Order Hours' to alert Provider if Troponin has been ordered within 6 hours.

Troponin Duplicate Order Hours

Enter/Edit OE Procedure Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty

TRO - TROPONIN LAB - LAB Last Edit: 08/11/14 13:47

General Information General Information 2 Locations Scheduling Rules/CDS Printing Billing

Category LAB
Number 400.4460

*Mnemonic TRO
*Name TROPONIN I
*Active Y

Nomenclature Map

Interface Mnemonic
Interface Argument

Duplicate Order Hours 6
Turnaround Time Hours
ED Overdue Time

*Ask Quantity N
Default Quantity
Quantity Limit

Series Days Limit 1
Continuous
Confidential
Include in Stats
View Only N
Order From
Renewable Order Period
AM Time for POM Ordering

Restorable Statuses
Inventory Status
Default Service Time to Now Y
LIS Test View Group
Display on Path Y
*Intervention Header ORD
Send Procedure to Status Board
Submerge from Transfer

Cancel Save ? ? ? ? ?

2. Attach rule to prevent the ordering of Troponin as a series.

Troponin Rule

Enter/Edit OE Procedure Dictionary (TRN/CSOPT5.66/CSOPT) - Smith,Betty

TRO - TROPONIN Last Edit: 08/11/14 13:47

LAB - LAB

General Information | General Information 2 | Locations | Scheduling | **Rules/CDS** | Printing | Billing

Default

Order Rules 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/>	POM Order Rule 1 P.TROPONIN ▼ Do not order trop 2 <input type="text"/> 3 <input type="text"/>
--	--

Inpatient Order CDS	Outpatient Order CDS	Emergency Dept CDS
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Site Specific

Site <input type="text"/>

Order Rule 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/>	POM Order Rule 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/>
---	---

Inpatient Order CDS	Outpatient Order CDS	Emergency Dept CDS
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Cancel Save ? [Icons]

3. Attach rule to prevent the ordering of Creatine kinase (CK) to evaluate Acute Coronary Syndrome.

CK rule

Enter/Edit OE Procedure Dictionary (TRN/CSOPT5.66/CSOPT) - Smith,Betty

CK - CREATINE PHOSPHOKINASE LAB - LAB Last Edit: 08/11/14 13:50

General Information | General Information 2 | Locations | Scheduling | Rules/CDS | Printing | Billing

Default

Order Rules		POM Order Rule	
1		1	P.CK Do not use CK to
2		2	
3		3	

Inpatient Order CDS Outpatient Order CDS Emergency Dept CDS

Site Specific

Site

Order Rule		POM Order Rule	
1		1	
2		2	
3		3	

Inpatient Order CDS Outpatient Order CDS Emergency Dept CDS

Cancel Save ? [Icons]

4. Attach rule to warn against the ordering of Creatine kinase-MB (CKMB) when Troponin levels are available.

CKMB rule

The screenshot shows a software window titled "Enter/Edit OE Procedure Dictionary (TRN/CSOPT5.66/CSOPT) - Smith, Betty". The main content area is for "CKMB - CREATINE KINASE-MB" with "LAB - LAB" and "Last Edit: 08/11/14 13:53".

Navigation tabs include: General Information, General Information 2, Locations, Scheduling, Rules/CDS, Printing, Billing.

Default

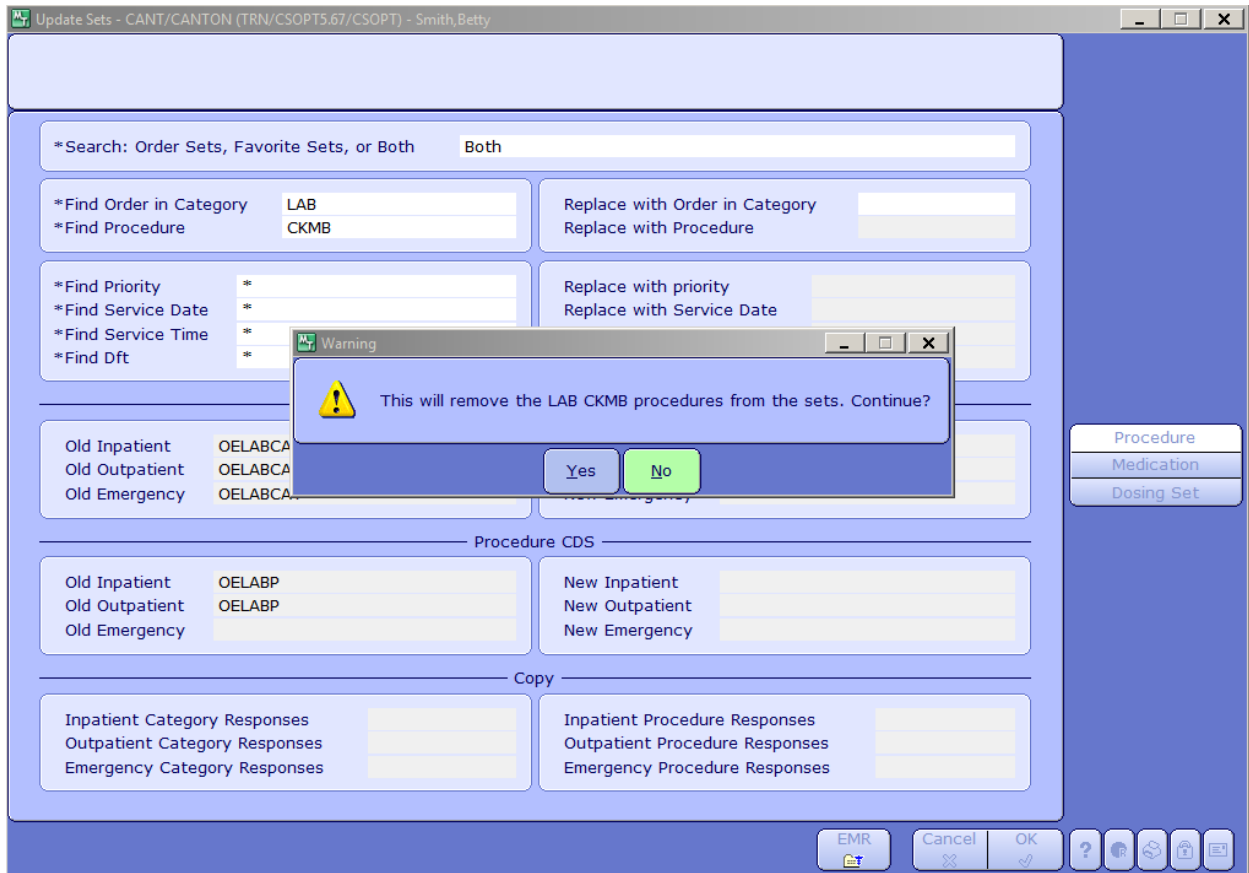
- Order Rules:** A table with 3 rows. Row 1 is highlighted in green.
- POM Order Rule:** A table with 3 rows. Row 1 contains "P.CKMB" and "Troponin preferre".
- CDS:** Inpatient Order CDS (OELABP), Outpatient Order CDS (OELABP), Emergency Dept CDS.

Site Specific

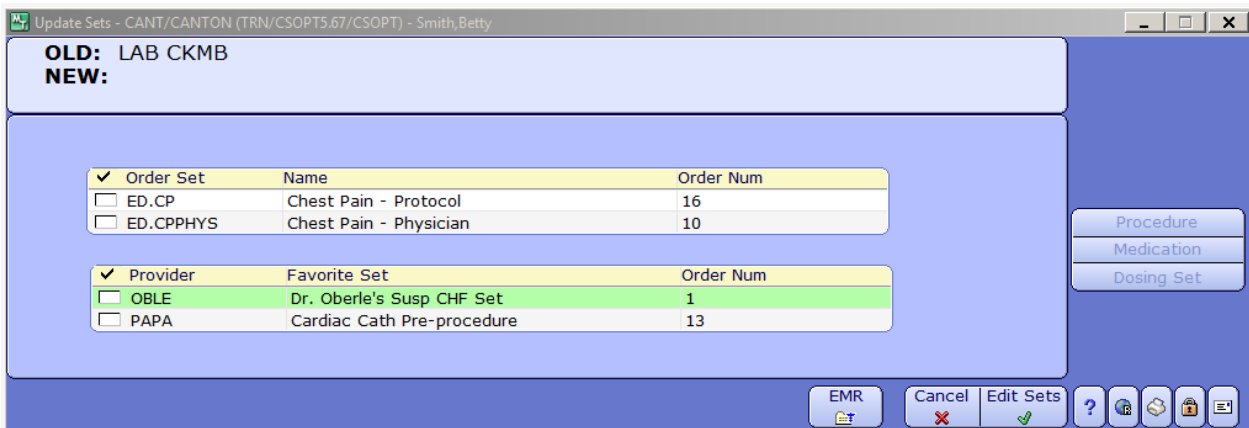
- Site:** A dropdown menu.
- Order Rule:** A table with 3 rows.
- POM Order Rule:** A table with 3 rows.
- CDS:** Inpatient Order CDS, Outpatient Order CDS, Emergency Dept CDS.

Bottom right buttons: Cancel, Save, ?, [lock icon], [help icon], [info icon].

5. Use the 'Update Sets' routine to audit all orders sets, including favorite order sets, to look for orders that contain cardiac biomarkers.



Once identified as containing the specified order, sets can be individually selected to accept the modification.



Supporting Documentation

References:

1. Reducing Excess Cardiac Biomarker Testing at an Academic Medical Center -Marc R. Larochelle, MD, Amy M. Knight, MD, Hardin Pantle, MD, Stefan Riedel, MD, PHD and Jeffrey C. Trost, MD, Journal General Internal Medicine, Published online 28 June 2014
2. [Abstract:](http://link.springer.com/article/10.1007/s11606-014-2919-5) Reducing Excess Cardiac Biomarker Testing at an Academic Medical Center <http://link.springer.com/article/10.1007/s11606-014-2919-5>-Marc R. Larochelle, MD, Amy M. Knight, MD, Hardin Pantle, MD, Stefan Riedel, MD, PHD and Jeffrey C. Trost, MD, Journal General Internal Medicine, Published online 28 June 2014
3. National Academy of Clinical Biochemistry Laboratory Medicine Practice Guidelines: Clinical characteristics and utilization of biochemical markers in acute coronary syndromes. Morrow DA1, Cannon CP, Jesse RL, Newby LK, Ravkilde J, Storrow AB, Wu AH, Christenson RH; National Academy of Clinical Biochemistry. Circulation. 2007 Apr 3;115(13):e356-75. Epub 2007 Mar 23.

[Johns Hopkins Medicine Press Release](#) - Efforts to Cut Unnecessary Blood Testing Bring Major Decreases in Health Care Spending, released June 30, 2014

[Hospital Saves \\$1.25M by nixing excess cardiac biomarker testing](#), Cardiovascular Business, Candace Stuart, July 14, 2014