Original Article

Utilization of a Computerized Clinical Surveillance System to Increase Acute Myocardial Infarction Core Measure Compliance

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Abstract

Background: Clinical surveillance systems (CSS) are utilized by many health care institutions to help identify at-risk patients, prioritize care, improve the clinical services provided, and increase compliance with the Center for Medicare and Medicaid Services (CMS) core measures.

Objective: This study will assess the accuracy and practicality of a CMS acute myocardial infarction (AMI) alert, provided by the CSS Theradoc, designed to increase compliance with medications required at discharge in AMI patients.

Methods: This is a single-center, retrospective cohort review to determine the sensitivity and specificity of the Theradoc CMS AMI alert. All patients with a Theradoc CMS AMI alert were analyzed for AMI occurrence and omission of CMS-required discharge medications. Secondary endpoints regarding alert times and quantity were also assessed to address the practicality of implementing the alert.

Results: Data were collected on patients with alerts occurring between January 1, 2011, and December 31, 2011 ($N = 962$). The Theradoc CSS alert was found to have a sensitivity of 100% and specificity of 4.79%, signifying a gross amount of false positives. No modifications to the alert definitions or timing were able to increase the specificity to >10%.

Conclusions: Regardless of the high sensitivity, the Theradoc CMS AMI alert does not have the appropriate level of specificity to utilize at the study institution at this time.

Key Words—acute myocardial infarction, core measure compliance, computerized alert

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Clinical surveillance systems (CSS) are computer systems utilized by many health care organizations to help identify at risk patients, prioritize care, and improve the clinical services provided. Theradoc is a CSS and is utilized by over 400 hospitals in the United States, predominantly to augment clinical pharmacy and infection control departments.¹ With the new value-based purchasing (VBP) program being implemented after October 1, 2012, it is assumed to be utilized not only to improve patient care, but also to ensure maximum incentive payments for the institution by increasing compliance with core measures.²

The goal of VBP is to measure hospitals' performance in clinical measures as well as patient satisfaction

and thus encourage improvement in care via incentive payments. The Centers for Medicare & Medicaid Services (CMS) has proposed rules based on several disease states, including acute myocardial infarction (AMI), for the VBP program to help measure each institution's performance. These core measures have increased the prescribing of recommended discharge medications in AMI patients.³ The use of an AMI discharge tool that reaffirms the core measures has also been shown to increase compliance,^{4,5} and increased use of a discharge tool has been shown to decrease mortality in AMI patients.⁶

Because specific and objective clinical core measures must be met for patients experiencing AMI, many

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hospitals have implemented CSS to identify patients whose care is noncompliant with the CMS core measures in order to increase compliance and improve the hospital's performance.

The commonly used CSS, Theradoc, has the ability to integrate data from many source systems in real time. This means, for example, the pharmacy order or lab result will appear in Theradoc almost immediately after being in the source system and a noncompliance alert will occur within seconds.¹ Theradoc is equipped with many alerts already programmed into the system, however these alerts can be modified and custom alerts can be designed by the institution. This study will focus on the CMS AMI core measure alert provided by Theradoc and its ability to identify AMI patients who are noncompliant with CMS AMI core measures for discharge.

CMS has determined several core measures that have to be met for any patient experiencing AMI, including medications on arrival, timing of interventions, and medications on discharge.² Table 1 indicates which of the core measures are addressed by the CSS being analyzed. To remain compliant with CMS AMI core measures, many institutions have implemented CSS and discharge forms. In some cases, a review process of all AMI patients prior to CMS review has also been initiated. The latter process is usually less desirable, as it can be quite time consuming and often occurs after the patient is discharged. This study will examine the accuracy and practicality of the current Theradoc CMS AMI core measure alert. The primary endpoints are the sensitivity and specificity of the alert and will be applied

to determine the accuracy of the alert. Secondary endpoints regarding the timing of the alert and quantity of alerts will be considered when assessing the practicality of the CSS alert. If the Theradoc alert is found to have a sensitivity of greater than 95% and a specificity of greater than 80%, the alert may be an acceptable substitution for the current CMS AMI review process.

METHODS

This was a single-center, retrospective cohort review at The University of Michigan Hospitals and Health Centers (UMHHC). UMHHC is an academic medical center with more than 850 beds and a service-based pharmacy practice model. Institutional research board approval was obtained for all information gathered. Data collection was conducted on included patients with a hospital discharge from January 1, 2011, to December 31, 2011.

The goal of the Theradoc CSS alert is to identify patients experiencing AMI who may not be compliant with CMS AMI core measures. The alert recognizes any patient with a positive troponin I lab result (>0.5 $\mu\text{g/L}$) and without an order for one of the required CMS AMI discharge medications that are listed in the alert description as aspirin, beta blocker, angiotensin converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB), and/or antihyperlipidemic medication. It is important to note that this alert does not address all the core measures but only the discharge medication core measures denoted in Table 1. Consequently this study will only focus on the accuracy of the alert in

Table 1. CMS AMI core measures

Set measure ID	Measure short name
AMI-1	Aspirin at Arrival
AMI-2 ^a	Aspirin Prescribed at Discharge
AMI-3 ^a	ACEI or ARB for LVSD (EF < 40%)
AMI-4	Adult Smoking Cessation Advice/Counseling
AMI-5 ^a	Beta-Blocker Prescribed at Discharge
AMI-7	Median Time to Fibrinolysis
AMI-7a	Fibrinolytic Therapy Received Within 30 Minutes of Hospital Arrival
AMI-8	Median Time to Primary PCI
AMI-8a	Primary PCI Received Within 90 Minutes of Hospital Arrival
AMI-10 ^a	Statin Prescribed at Discharge

Note: AMI-6 "Beta Blocker on Arrival" and AMI-9 "Inpatient Mortality" are no longer core measures. ACEI = angiotensin converting enzyme inhibitor; AMI = acute myocardial infarction; ARB = angiotensin receptor blocker; CMS = Centers for Medicare & Medicaid Services; ID = identification; LVSD = left ventricular systolic dysfunction; EF = ejection fraction; PCI = percutaneous coronary intervention; Statin = HMG Co-A reductase inhibitor.

^aCore measure addressed by clinical surveillance system alert.

regard to the 4 CMS AMI core measures concerning the discharge medications.

To assess the CSS alert's sensitivity and specificity, a gold standard for comparison is required. The current method used at the institution involved is a quality assurance employee (QA). This individual checks all documentation, including discharge notes, of patients experiencing AMI during the current hospital stay. If any CMS core measures were not met, the QA contacts the clinician that discharged the patient. The clinician will either write an addendum to the patient's discharge note explaining the medically necessary reason the CMS core measure was not met or that patient will be found to be noncompliant by AMI CMS standards. Because this study's methodology demands a comparison of 2 different sources for patients, the patient population consists of any patient with the CMS AMI alert or any patient undergoing AMI QA review. The patients with AMI alerts will represent the population for the new tool being examined for sensitivity and specificity, whereas the patients undergoing AMI QA review will represent the population for the gold standard and be used for comparison of the new tool's accuracy.

The inclusion criteria consisted of any patient with a Theradoc CMS AMI core measure alert or any patient reviewed by the institution's QA for CMS AMI compliance discharged in 2011. Because the CSS alert focuses on compliance with discharge medications, patients were excluded if they expired prior to discharge or left the institution against medical advice (AMA). Exclusion criteria also included any patients younger than 18 years old.

The primary endpoint is to determine the sensitivity and specificity of the Theradoc CMS AMI alert against the current QA review method as the gold standard. The sensitivity of the alert was examined by comparing all AMI patients determined to be noncompliant by QA review who had a Theradoc CMS AMI alert during their hospitalization. The specificity of the alert was examined by comparing the number of patients with a false-positive CSS alert to the number of AMI patients undergoing QA review who were not found to be CMS AMI noncompliant. Secondary endpoints included the increase in pharmacist/clinician workload and any modifiable factors leading to a decrease in the sensitivity or specificity of the alert. When analyzing the secondary endpoints, data regarding the quantity of alerts (number of patients with alerts and number of alerts/patient) and team assignment (cardiology, surgery, or medicine) were collected to determine workload requirements for the pharmacist if

the alert were implemented. The timing of the CSS alerts from the time of troponin lab collection was also examined to assess whether a change to alert time could lead to an optimization of sensitivity and specificity.

RESULTS

During 2011, 962 of the 1,199 patients experiencing the CSS alert were included in the study (Figure 1). Baseline characteristics for patients with CSS alerts who were included in the study are provided in Table 2. Over the year, there were more than 3 patients per day with CSS alerts, with many of them having more than 3 alerts within the first 24 hours. When patients with CSS alerts were examined by service, we found that 492 (51.1%) were on a cardiology service, 316 (32.8%) belonged to a medicine service, and 154 (16.0%) were on a surgical service. The number of patients with CSS alerts actually experiencing an AMI was 226 (23.5%). When separated by service, we found that 198 (40.2%) cardiology patients, 14 (4.4%) medicine patients, and 14 (9.1%) surgical patients with computer alerts actually experienced AMI (Figure 2). Eight hundred and seventy-five patients experienced a CSS alert expressing the absence of an ACEI/ARB, even though only 120 (13.7%) required this class of medications with an ejection fraction (EF) less than 40%. However, 99 of these 120 patients would have still incurred the CSS alert as a result of another missing medication. The median time the CSS alert occurred was 1.03 ± 0.67 hours after the troponin lab was collected. The median number of drugs missing at this first computer alert was 4 drugs.

The Theradoc CMS AMI alert was found to have a sensitivity of 100% and a specificity of 4.79% (Table 3). All patients who were found to be noncompliant with CMS AMI core measures on QA review ($n = 7$)

Figure 1. Flow chart of included patients. AMI = acute myocardial infarction, yo = years old.

Table 2. Baseline characteristics

Baseline characteristic	All patients with CSS alert (N = 962)	AMI patients with CSS alert (n = 226)
Mean age, years	62.85 ± 16.25	64.83 ± 14.03
Male, n (%)	599 (62.67)	153 (67.70)
Race, n (%)		
Caucasian	803 (83.47)	196 (86.73)
African American	102 (10.60)	15 (6.64)
Asian	13 (1.35)	3 (1.33)
Hispanic	4 (0.42)	0 (0)
Other ^a	40 (4.16)	12 (5.31)
Median LOS, days	5.33 ± 2.38	3.05 ± 2.15
AMI, n (%)	226 (23.5)	—

Note: AMI = acute myocardial infarction; CSS = clinical surveillance system; LOS = length of stay.

^aOther includes patients who declined to state a race.

were identified by the CSS alert. Of the noncompliant patients, 6 of the 7 were on a cardiology service, and 1 was on a medicine service. The QA review revealed 219 patients who were compliant with CMS AMI core measures (false positives), but 48 of these patients never experienced a CSS alert. The CSS alert identified an additional 955 false positives. A sensitivity and specificity analysis based on time was conducted at every hour up to 24 hours and then at 6-hour intervals until 48 hours in an attempt to determine the time point of highest sensitivity and specificity (Figure 3). The sensitivity fell to 85% after only 3 hours where the specificity was 5.42%. At 48 hours after the positive troponin lab was collected, the specificity did not reach greater than 10%. A separate sensitivity and specificity was calculated for those patients actually experiencing AMI with results of 100% and 16.8%, respectively. When the alert for AMI patients was analyzed based on time (Figure 4), the sensitivity fell to 71.4% at 3 hours, where the specificity was 19.8%.

DISCUSSION

As the results of the study show, the Theradoc computer alert for CMS AMI core measures has a specificity that is too low to be utilized at the study institution. The high sensitivity indicates that all patients who were found to be noncompliant with CMS AMI core measures by QA review were also identified by the CSS alert. The low specificity indicates a large number of false positives. During data collection, causes for the low specificity were examined. The main causes of the false positives were patients with positive troponins not experiencing AMI,

patients experiencing AMI but not requiring an ACEI/ARB based on EF greater than 40%, and patients experiencing AMI and missing required discharge medications early in their stay but ultimately satisfying CMS AMI core measures prior to discharge.

These causes for the high occurrence of false positives do not appear to be able to be modified to increase the specificity. A positive troponin lab is a major requirement to identify patients experiencing AMI, yet it is used for other diagnoses as well. This leads to a large number of patients identified by the CSS alert not experiencing AMI, and therefore CMS AMI core measures are not necessary to review for compliance. Also at UMHC, the EF result is listed as text in an echocardiogram report and is unable to be interpreted by the Theradoc system. Therefore, the false positives caused by identifying patients missing

Figure 2. Patients with clinical surveillance system alerts by service. AMI = acute myocardial infarction.

Table 3. Sensitivity and specificity analysis

	QA noncompliance Yes (+) (<i>n</i> = 7)	QA noncompliance No (-) (<i>n</i> = 1,003)
CSS noncompliance Yes (+) (<i>n</i> = 962)	7	955
CSS noncompliance No (-) (<i>n</i> = 48)	0	48

Note: CCS= computerized clinical surveillance system; QA = quality assurance employee review.

ACEI/ARB where these drugs are not required is also unable to be modified. The timing of the alert is modifiable; it was hypothesized that if the median first alert occurrence was timed later in the patient's hospital stay (as opposed to 1.03 hour), the number of false-positive alerts may decrease as many of these patients did have orders for all required medications prior to discharge. Although the specificity did increase as the time increased, it only achieved 7.41%, and the sensitivity decreased to an undesirable rate.

Other challenges the CSS alert posed were the increase in pharmacist workload and the alert's definition of antihyperlipidemic medication. Because 76.5% of patients with a computer alert did not experience an AMI, it was determined that the increase in workload by the number of patients with alerts and total number of alerts was not ideal. Another finding during data collection led to the discovery that the Therdoc CMS AMI alert includes medications other than statins in its definition of "antihyperlipidemic medication." There were 2 instances when a patient was receiving ezetimibe and not a statin, and the alert did not recognize this patient as missing their "antihyperlipidemic medication." This aspect of the CSS alert was found to be unacceptable because CMS core measures require that AMI patients be discharged on

a statin, and these patients would be overlooked by the CSS alert.

The present study has several limitations. This was a retrospective, single-center trial. It is recognized that some of the results may be reflective of institution-specific characteristics. If the Therdoc CSS alert was able to integrate data from an institution's source system regarding EF results or diagnosis code, the results may have fared differently regarding the amount of false positives. The CSS alert was not active during the year of analysis, but under the scope of the Therdoc system it was performed as a simulation during this time period. The CSS alert was purposely left inactive during the analysis to first determine the practicality and accuracy of the alert prior to its implementation. The stimulation is not expected to change the results, but the ultimate effect is unknown at this time.

CONCLUSION

This study assessed the sensitivity, specificity, and practicality of the Therdoc CMS AMI core measure alert. Although the sensitivity was found to be 100%,

Figure 3. Sensitivity and specificity of clinical surveillance system alert and time (*N* = 962).

Figure 4. Sensitivity and specificity of clinical surveillance systems alert and time in acute myocardial infarction patients (*n* = 226).

the specificity was far too low to be implemented at our institution regardless of the timing of the alert. Other challenges with the CSS alert were also discovered, such as its inability to identify patients with an EF less than 40% and its definition of antihyperlipidemic medication. This computer alert focuses only on discharge medications and would fail to identify any patients who were missing all other CMS AMI core measure requirements. Although a CSS shown to increase CMS AMI core measure compliance could be advantageous by ensuring incentive payments and possibly decreasing mortality, it was determined that the Theradoc CMS AMI alert would not be a suitable substitute for our current CMS core measure compliance analysis. We expect many institutions would experience similar challenges. More sensitivity and specificity analyses should to be conducted by pharmacists prior to implementing CSS tools to determine accuracy and areas for improvement. Shared results from other institutions, whether positive or negative findings, may prove to be highly beneficial to many organizations.

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