etiometry

Retrospective Assessment Of The Etiometry Platform For Cardiogenic Shock

Executive Summary

Cardiogenic shock (CS) is a high-mortality syndrome driven by progressive hemodynamic compromise, heterogeneous presentation, and inconsistent clinical recognition. This white paper presents a retrospective evaluation of the Etiometry Platform across medical and surgical cardiac populations, assessing its utility in automated shock severity classification, continuous tracking of hemodynamic and oxygen deficit, and improved clinical recognition and coding of cardiogenic shock.

Using high-frequency physiologic data fused with EHR, laboratory, and device information, Etiometry demonstrates earlier classification of shock progression, strong associations between quantified hemodynamic compromise and outcomes, and substantial opportunity to reduce under-documentation and missed reimbursement.

Background

Despite advances in invasive monitoring, vasoactive therapy, and mechanical circulatory support (MCS), cardiogenic shock remains difficult to identify consistently and early. Reliance on intermittently charted EHR data limits the ability to recognize evolving hypotension and hypoperfusion, resulting in delayed staging, undertreatment, and under-documentation. These challenges span both medical cardiac ICU patients and post-cardiac surgery populations.

The Etiometry Platform continuously acquires physiologic data, integrates it with labs, medications, procedures, and devices, and applies analytics to quantify hemodynamic deficit relative to a desired physiologic state (Figure 1). This framework enables automated shock classification, staging, and longitudinal assessment of response to therapy.

Study Hypotheses

Hypothesis 1 – Automated Shock Severity Assessment

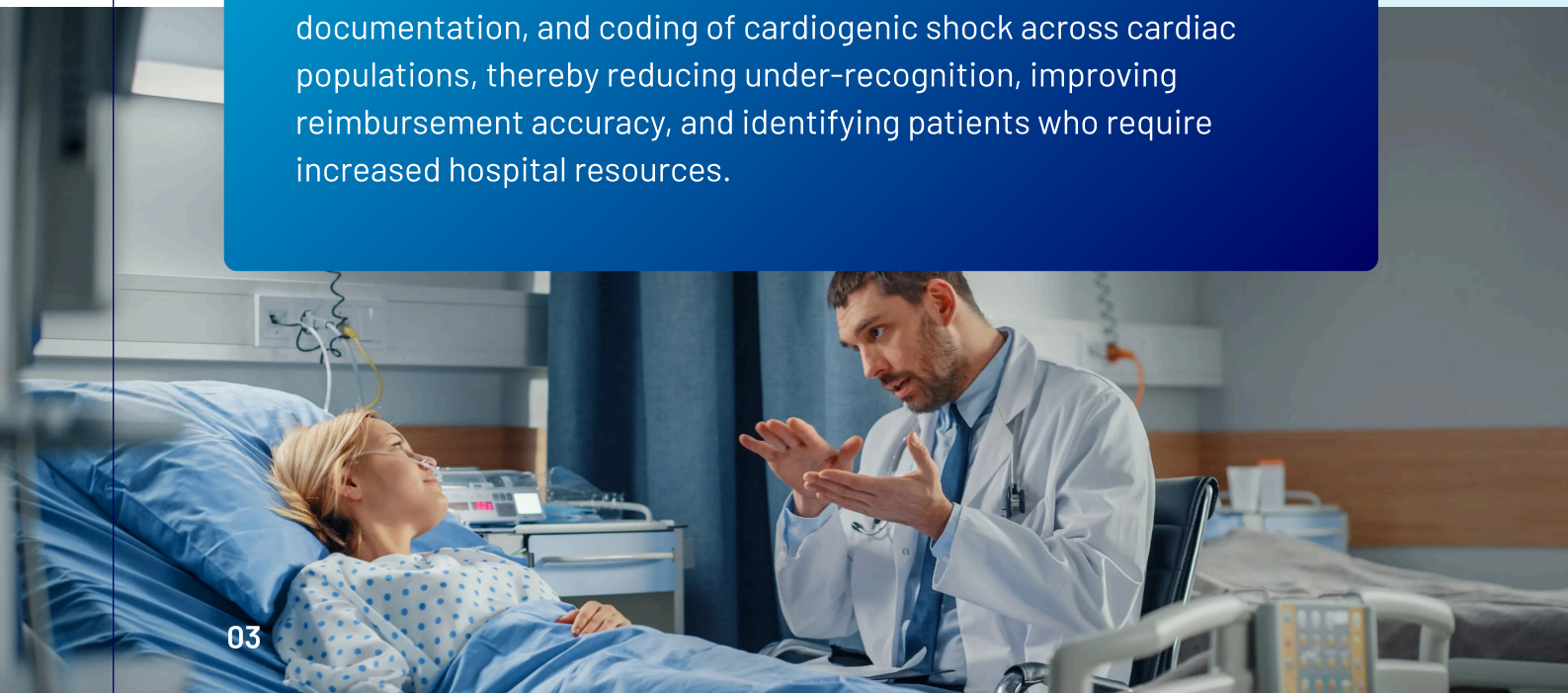
The incorporation of high-frequency physiologic monitoring with EHR, laboratory, and device data may improve the timing and accuracy of cardiogenic shock classification relative to the use of EHR data alone.

Hypothesis 2 – Hemodynamic and Oxygen Deficit Tracking

Continuous quantification of hypotension and hypoperfusion using hemodynamic and oxygen deficit tracking may be associated with increased mortality risk and can be used to assess the effectiveness of therapeutic interventions.

Hypothesis 3 – Enhanced Clinical Recognition and Coding

Automated, objective, data-driven classification of shock severity and trajectory may improve clinician identification, documentation, and coding of cardiogenic shock across cardiac populations, thereby reducing under-recognition, improving reimbursement accuracy, and identifying patients who require increased hospital resources.



Study Populations and Analysis Cohorts

Analyses were conducted retrospectively at a single tertiary academic medical center over a 12-month period.

Medical Cardiac ICU

- All medical cardiac ICU admissions over 12 months
- Used for Hypotheses 1, 2, and medical cohort of Hypothesis 3

Surgical Cardiac ICU (CABG)

- All patients undergoing CABG admitted to a dedicated cardiothoracic ICU over 12 months
- Used for surgical cohort of Hypothesis 3 and economic analysis

	Medical Cohort	CABG Cohort
Hospitalizations, n	571	406
Patients, n	556	406
Male, n (%)	350 (63%)	296 (73%)
Age, years median [IQR]	65 [54 - 74]	67 [59 - 74]
Hospital LOS, days median [IQR]	9.8 [4.6 - 18.8]	12.0 [8.0 - 18.0]
ICU LOS, days median [IQR]	2.8 [1.3 - 6.9]	2.7 [1.1 - 4.8]
Mortalities, n (%) 30-day post-discharge	171 (31%)	26 (6.4%)

Table 1: Study population collected from two ICUs in a single tertiary academic medical center

Methods

Hypothesis 1 – Shock Severity Detection

Shock severity was classified using SCAI staging derived from two parallel data sources:

1. **EHR-only data:** charted blood pressure, laboratory values, medication administration, and procedures indicating MCS initiation.
2. **Etiometry-acquired data:** all EHR data plus second-by-second invasive arterial pressure and automated cuff blood pressure.

Comparisons included:

- Maximum SCAI stage reached
- Associated mortality and readmission rates
- Time delay to recognition of maximum shock stage

Hypothesis 2 – Hemodynamic Deficit Metrics

Using high-frequency data, Etiometry quantified:

- Cumulative time spent in hypotension
- Cumulative time spent in hypoperfusion

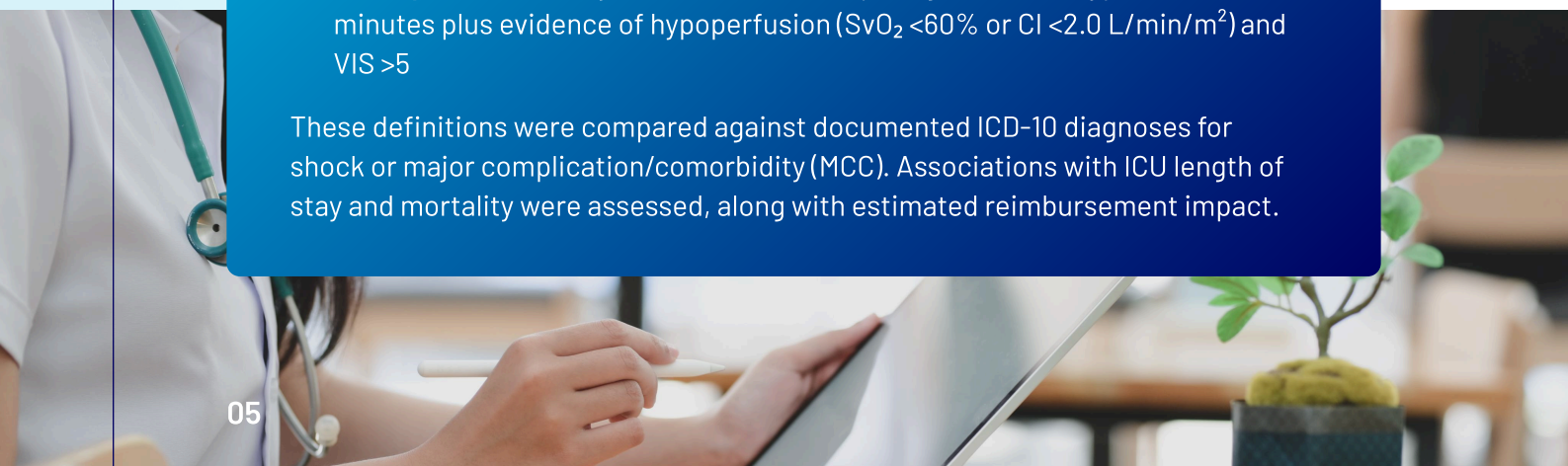
Logistic regression models were developed to associate time under hemodynamic compromise with mortality.

Hypothesis 3 – Documentation and Coding

Two shock definitions were applied:

- **Medical cardiac patients:** shock severity defined by SCAI stage
- **CABG patients:** binary shock definition requiring sustained hypotension ≥30 minutes plus evidence of hypoperfusion (SvO_2 <60% or CI <2.0 L/min/m^2) and VIS >5

These definitions were compared against documented ICD-10 diagnoses for shock or major complication/comorbidity (MCC). Associations with ICU length of stay and mortality were assessed, along with estimated reimbursement impact.



Results

Hypothesis 1 – Automated Shock Detection

Etiometry up-classified a subset of patients to higher shock stages compared with EHR-only classification (Figure 1). These patients experienced significantly higher mortality and readmission rates:

- 1.6× higher risk of mortality
- 1.9× higher risk of hospital readmission

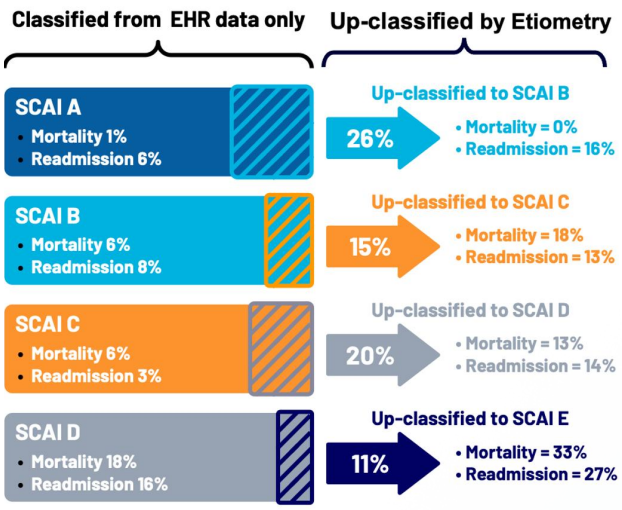


Fig. 1

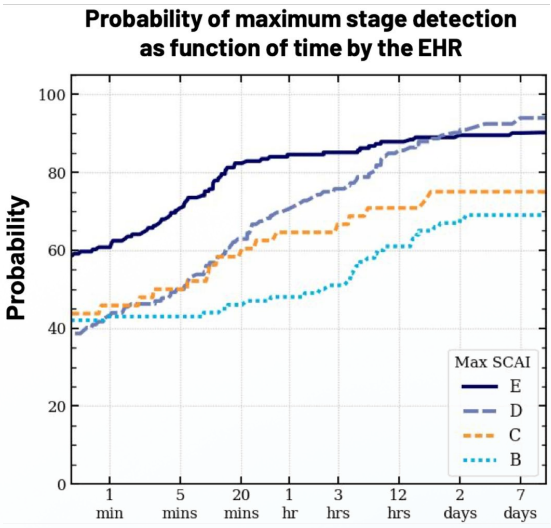


Fig. 2

Even among patients assigned the same maximum SCAI stage by both methods, EHR-based recognition lagged substantially behind Etiometry detection (Figure 2).

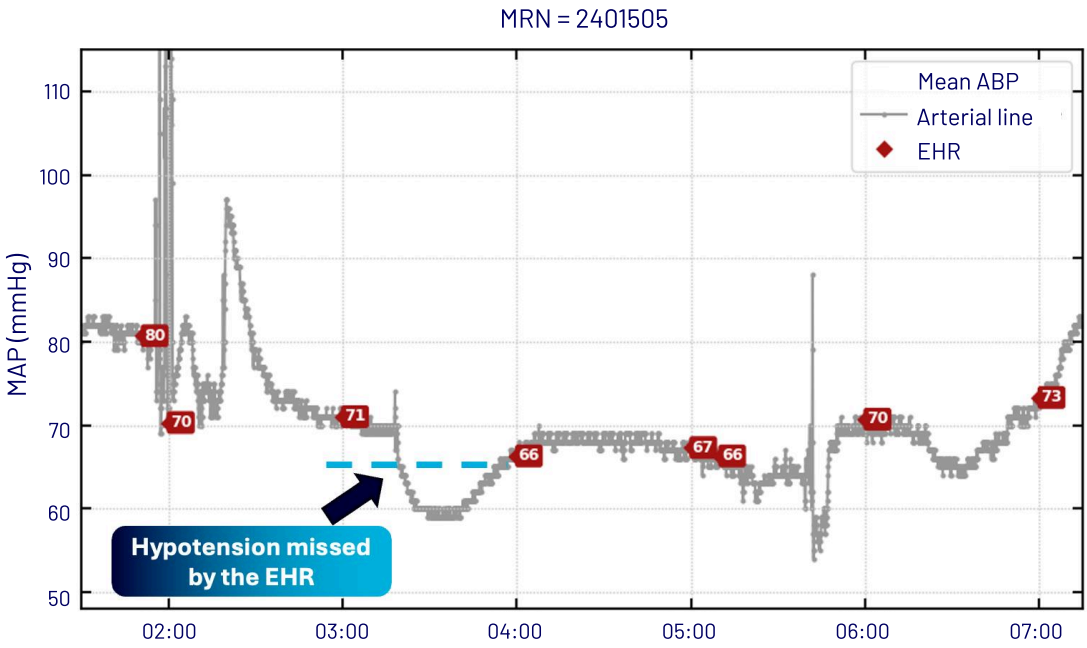
Hypothesis 2 – Hemodynamic Deficit and Outcomes

		In-hospital 30-day mortality	
		OR of death (95% CI)	*p*
Age, year	19-44	*Reference*	
	45-64	1.65 (0.66-4.15)	0.28
	>=65	3.25 (1.35-7.85)	<0.01**
Sex	Female	*Reference*	
	Male	1.47 (0.89-2.43)	0.14
Time, hour	Hypotension	1.11 (1.07-1.16)	<0.001***
	Hypoperfusion	1.05 (1.03-1.08)	<0.001***

Table 2

Continuous tracking of hemodynamic compromise demonstrated strong associations with mortality (Table 2). Risk of death increased by approximately 11% for each additional hour spent in hypotension, highlighting the clinical relevance of cumulative hemodynamic burden rather than isolated measurements.

An Example of Monitoring Data vs Validated EHR Data



Hypothesis 3 – Documentation and Economic Impact

The probability of documented shock increased with severity, yet even among patients with extreme shock, documentation occurred only ~52% of the time (Table 3).

SCAI Stage Summary - all Encounters

Maximum SCAI Stage	A	B	C	D	E
# Hospitalizations	91	100	49	133	182
Hospital LOS	3.8 Days [2.7-6.6]	4.4 Days [3.0-8.7]	8.1 Days [3.8-11.2]	10.8 Days [6.0-18.4]	12.4 Days [5.4-21.6]
ICU LOS	1.3 Days [0.9-1.9]	1.8 Days [1.1-2.9]	1.9 Days [1.1-3.4]	3.7 Days [2.0-6.9]	7.3 Days [3.3-14.3]
30-Day In-Hospital Mortality	1%	4%	8%	18%	52%
% Shock Diagnoses	2%	2%	8%	29%	52%
% 30-Day Readmission	9%	10%	12%	21%	13%

Table 3

CABG ICU

	Total patients	Mortality	ICU LOS, days [Median IQR]	Hospital LOS, days [Median IQR]
Patients with no MCC or shock detected by Etiometry	210	4 (1.9%)	1.8 [1.0 - 3.3]	10.0 [7.0 - 14.8]
Patients with MCCs	166	20 (12.0%)	3.6 [1.8 - 7.7]	16.0 [10.0 - 28.0]
Patients with no documented MCCs but with Shock detected by Etiometry	32	2 (6.3%)	3.3 [2.8 - 5.1]	12.0 [8.8 - 15.3]

Automated shock identification revealed a substantial cohort of patients with clear hypotension and hypoperfusion under significant medication support who consumed increased hospital resources but lacked documented MCCs (Table 3). Based on an estimated incremental reimbursement of $15,000–$35,000 per CABG patient with an MCC, identification of 32 undocumented shock cases annually corresponds to $480,000–$1.1M in missed revenue.

Discussion

This retrospective analysis demonstrates that Etiometry's continuous, high-frequency data fusion enables earlier and more accurate identification of cardiogenic shock severity than traditional EHR-based approaches. EHR documentation alone often lags – our platform provides a real-time, objective shock classification that complements clinician charting. Quantification of cumulative hypotension and hypoperfusion provides physiologically meaningful metrics closely linked to outcomes. Importantly, objective shock detection also addresses a critical operational gap by revealing substantial under-documentation of cardiogenic shock across cardiac populations.

These findings suggest that Etiometry can function not only as a clinical decision-support tool, but also as a mechanism to improve diagnostic accuracy, quality reporting, and financial alignment with patient acuity.

Conclusions

The Etiometry Platform:

- Enables **earlier and more accurate staging of cardiogenic shock** than traditional EHR-based methods by leveraging continuous, high-frequency physiologic data rather than intermittent documentation.
- Provides a **real-time, objective shock severity classification** that is independent of, and complementary to, clinician-entered EHR data, which frequently lags behind evolving patient physiology.
- Overcomes key EHR limitations, including **delayed recognition, subjective interpretation, and incomplete documentation**, by applying standardized, data-driven shock criteria at the bedside.
- Quantifies **cumulative hypotension and hypoperfusion burden** using continuously captured signals.
- Reveals **substantial under-recognition and under-coding of cardiogenic shock in the EHR**, identifying patients with objective physiologic evidence of shock who lack corresponding documentation
- These capabilities support Etiometry as an **enabling infrastructure that augments the EHR**, transforming raw physiologic data into actionable, real-time insight for comprehensive cardiogenic shock management

Together, these capabilities support Etiometry's role as an enabling infrastructure for comprehensive, data-driven cardiogenic shock management.