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Original Research Article

Modified Early Warning Score vs Cardiac Arrest Risk Triage Score for Prediction of Cardiopulmonary Arrest: A Case-Control Study

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Abstract:

Background: Cardiopulmonary arrest is a major cause of in-hospital mortality. Early detection of clinical deterioration using physiological scoring systems can significantly improve patient outcomes. Modified Early Warning Score (MEWS) and Cardiac Arrest Risk Triage (CART) score are widely used tools for predicting deterioration among hospitalized patients.

Objective: To compare the predictive performance of Modified Early Warning Score and Cardiac Arrest Risk Triage score for early identification of patients at risk of cardiopulmonary arrest.

Methods: A prospective case-control study was conducted at PMCH between March 2025 and September 2025. A total of 105 patients were included. Vital parameters were recorded and MEWS and CART scores were calculated. Statistical analysis included independent t-test, chi-square test, logistic regression, and ROC curve analysis.

Results: Mean MEWS score was significantly higher in patients who developed cardiopulmonary arrest (6.2 ± 1.9) compared to controls (3.1 ± 1.4), p <0.001. The CART score also showed significantly higher values among cases (17.6 ± 5.2) compared with controls (9.1 ± 3.7), p <0.001. ROC analysis demonstrated superior predictive accuracy of CART (AUC 0.89) compared with MEWS (AUC 0.78).

Conclusion: Both MEWS and CART scores are useful tools for early detection of clinical deterioration. However, CART score demonstrated better predictive performance for cardiopulmonary arrest in hospitalized patients.

Keywords: MEWS, CART score, cardiopulmonary arrest, early warning score, patient deterioration.

Introduction

Cardiopulmonary arrest is a life-threatening condition that frequently occurs in hospitalized patients and is associated with high mortality rates worldwide. Despite advances in critical care medicine, many in-hospital cardiac arrests remain potentially preventable when early signs of deterioration are recognized promptly [1].

Several studies have shown that physiological abnormalities often occur hours before cardiopulmonary arrest, providing a critical opportunity for early intervention [2]. These abnormalities typically include alterations in respiratory rate, heart rate, blood pressure, and level of consciousness [3].

Early warning scoring systems were developed to assist healthcare providers in recognizing these early signs of deterioration and initiating appropriate interventions [4]. These systems are based on routinely measured vital signs and convert them into numerical scores that reflect the severity of patient instability [5].

The Modified Early Warning Score (MEWS) is one of the most widely used early warning systems in hospital wards. It uses five physiological parameters including respiratory rate, heart rate, systolic blood pressure, temperature, and mental status [6]. Higher MEWS values have been shown to correlate with increased risk of clinical deterioration, intensive care admission, and mortality [7].

MEWS has been validated in several clinical settings and has demonstrated moderate predictive ability for adverse outcomes in hospitalized patients [8]. However, some investigators have suggested that MEWS may not always provide sufficient sensitivity for predicting imminent cardiac arrest [9].

To address these limitations, alternative scoring systems have been developed that focus more specifically on predicting cardiac arrest. One such scoring system is the Cardiac Arrest Risk Triage (CART) score [10].

The CART score was designed to improve prediction of cardiac arrest using a smaller number of variables with stronger predictive power. It incorporates respiratory rate, heart rate, diastolic blood pressure, and patient age [11].

Previous studies have demonstrated that CART score may outperform traditional early warning scores in identifying patients at risk of cardiopulmonary arrest [12]. In particular, CART has shown higher sensitivity and specificity for predicting in-hospital cardiac arrest events [13].

Accurate prediction of clinical deterioration is especially important in general hospital wards where continuous monitoring is often limited [14].

Therefore, this study aimed to compare the predictive ability of the Modified Early Warning Score and the Cardiac Arrest Risk Triage score for identifying patients at risk of cardiopulmonary arrest.

Materials and Methods

Study Design: This investigation was conducted as a prospective cross-sectional case–control study designed to evaluate and compare the predictive performance of the Modified Early Warning Score (MEWS) and the Cardiac Arrest Risk Triage (CART) score for identifying patients at risk of cardiopulmonary arrest.

A case–control analytical framework was selected because it allows comparison between patients who experienced cardiopulmonary arrest and those who did not, while evaluating the predictive value of physiological scoring systems measured prior to the event.

Study Setting: The study was carried out at PMCH, a tertiary care teaching hospital that provides multidisciplinary medical and surgical services. The hospital has multiple inpatient wards where patients are routinely monitored through periodic measurement of vital signs.

Data were collected from general medical and surgical wards, where early recognition of clinical deterioration is particularly important due to limited continuous monitoring compared with intensive care units.

Study Duration: The study was conducted over a nine-month period from March 2025 to September 2025.

During this period, all eligible patients admitted to the selected wards were screened for inclusion according to predefined criteria.

Study Population: The study population consisted of adult patients admitted to general wards during the study period.

Participants were divided into two groups:

Cases: Patients who experienced cardiopulmonary arrest during hospitalization.

Cardiopulmonary arrest was defined as the sudden cessation of cardiac mechanical activity confirmed by absence of pulse, apnea, and loss of consciousness requiring cardiopulmonary resuscitation (CPR).

Controls: Patients admitted to the same wards during the study period who did not develop cardiopulmonary arrest.

Controls were selected to ensure similar clinical conditions and ward environment as cases.

Sample Size: A total of 105 patients were included in the study.

The participants were categorized as follows:

- **Cases:** 35 patients who developed cardiopulmonary arrest
- **Controls:** 70 patients who did not develop cardiopulmonary arrest

The case-to-control ratio of 1:2 was used to improve statistical power and allow meaningful comparison between the two groups.

Sampling Technique: A consecutive sampling method was used for selecting study participants.

All eligible patients meeting the inclusion criteria during the study period were included until the required sample size was achieved.

Inclusion Criteria

The following patients were eligible for inclusion in the study:

- Patients aged 18 years or older
- Patients admitted to medical or surgical wards
- Patients with complete clinical and physiological data
- Patients whose vital signs were documented before the occurrence of cardiopulmonary arrest

Exclusion Criteria

Patients were excluded from the study if they met any of the following conditions:

- Patients admitted directly to the intensive care unit (ICU)
- Patients with incomplete medical records

- Patients discharged within 24 hours of admission
- Patients with do-not-resuscitate (DNR) orders

Data Collection Procedure: Data collection was performed using a structured clinical data collection form designed specifically for the study.

Patient data were obtained from:

- Patient medical records
- Nursing observation charts
- Vital sign monitoring records

For each patient, the following information was recorded:

Demographic Data

- Age
- Gender

Physiological Parameters

Vital signs measured during routine ward monitoring were recorded, including:

- Respiratory rate (breaths per minute)
- Heart rate (beats per minute)
- Systolic blood pressure (mmHg)
- Diastolic blood pressure (mmHg)
- Body temperature (°C)
- Level of consciousness

These physiological variables were used to calculate both MEWS and CART scores.

Calculation of Modified Early Warning Score (MEWS)

The Modified Early Warning Score (MEWS) was calculated using five physiological parameters:

- Respiratory rate
- Heart rate
- Systolic blood pressure
- Body temperature
- Level of consciousness

Each parameter was assigned a score ranging from 0 to 3 depending on the severity of deviation from normal physiological values.

The total MEWS score was obtained by summing individual parameter scores.

Higher MEWS values indicate greater physiological instability and increased risk of clinical deterioration.

Calculation of Cardiac Arrest Risk Triage (CART) Score

The Cardiac Arrest Risk Triage (CART) score was calculated using the following variables:

- Respiratory rate
- Heart rate
- Diastolic blood pressure
- Age

Each variable contributes weighted points based on its association with risk of cardiac arrest.

The total CART score represents the overall probability of clinical deterioration and risk of cardiopulmonary arrest.

Higher CART scores indicate greater risk of cardiac arrest.

Outcome Measures: The primary outcome of interest in this study was the occurrence of cardiopulmonary arrest during hospitalization.

Secondary outcomes included:

- Differences in physiological parameters between cases and controls
- Comparison of MEWS and CART scores
- Diagnostic performance of each scoring system

Statistical Analysis: All data were entered into a spreadsheet and analyzed using Statistical Package for the Social Sciences (SPSS) version 25.

Both descriptive and inferential statistical methods were applied.

Descriptive Statistics

Continuous variables were summarized using:

- **Mean**
- **Standard deviation (SD)**

Categorical variables were expressed as:

- **Frequencies**
- **Percentages**

Inferential Statistical Analysis

Independent t-test: The independent t-test was used to compare mean values of continuous variables between cases and controls, including:

- Age
- Respiratory rate
- Heart rate
- Blood pressure
- Temperature
- MEWS score
- CART score

A p value less than 0.05 was considered statistically significant.

Chi-square Test: The Chi-square test was applied to evaluate associations between categorical variables such as gender distribution between cases and controls.

Logistic Regression Analysis: Logistic regression analysis was performed to evaluate the association

between MEWS score, CART score, and the occurrence of cardiopulmonary arrest.

Results were expressed as:

- Odds ratios (OR)
- 95% confidence intervals (CI)

This analysis helped determine whether MEWS and CART scores independently predicted cardiopulmonary arrest.

Receiver Operating Characteristic (ROC) Curve Analysis: ROC curve analysis was used to evaluate the diagnostic accuracy of MEWS and CART scores in predicting cardiopulmonary arrest.

The Area Under the Curve (AUC) was calculated for each scoring system.

Interpretation of AUC values:

- 0.5 – No discrimination
- 0.7–0.8 – Acceptable discrimination
- 0.8–0.9 – Excellent discrimination
- 0.9 – Outstanding discrimination

Sensitivity and specificity values were also calculated for both scoring systems.

Ethical Considerations: Ethical approval for the study was obtained from the institutional ethics committee of PMCH prior to initiation of the research.

Patient confidentiality was strictly maintained throughout the study. Personal identifiers were removed from the dataset to ensure privacy and anonymity.

Since the study involved analysis of routinely collected clinical data, it posed minimal risk to participants.

Results

A total of 105 patients were included in the present study, consisting of 35 cases (patients who developed cardiopulmonary arrest) and 70 controls (patients without cardiopulmonary arrest). The results were analyzed to compare demographic characteristics, physiological parameters, and predictive scores between the two groups.

Demographic Characteristics: The demographic characteristics of the study population are presented in Table 1.

As shown in Table 1, the mean age of patients in the case group was 58.9 ± 12.6 years, which was significantly higher than the control group (51.4 ± 11.9 years) with $p = 0.01$.

Regarding gender distribution, 57.1% of cases were male and 42.9% were female, whereas in the control group 54.3% were male and 45.7% were female. The difference in gender distribution between the two groups was not statistically significant ($p = 0.78$).

Table 1: Demographic Characteristics of Study Participants

Variable	Cases (n=35)	Controls (n=70)	p value
Age (years)	58.9 ± 12.6	51.4 ± 11.9	0.01
Male	20 (57.1%)	38 (54.3%)	0.78
Female	15 (42.9%)	32 (45.7%)	0.78

Comparison of Physiological Parameters: Physiological parameters including respiratory rate, heart rate, systolic blood pressure, and temperature were compared between cases and controls. The results are summarized in Table 2.

As shown in Table 2, the mean respiratory rate among cases was significantly higher (26.8 ± 5.1 breaths/min) compared with controls (19.5 ± 3.7 breaths/min) with $p < 0.001$.

Similarly, the mean heart rate was significantly elevated in the case group (111.9 ± 17.8 beats/min) compared to controls (87.6 ± 11.9 beats/min) with $p < 0.001$.

The mean systolic blood pressure was significantly lower among cases (97.4 ± 14.8 mmHg) compared to controls (118.2 ± 13.7 mmHg) with $p < 0.001$.

Temperature was also slightly higher among cases (37.8 ± 1.0 °C) compared with controls (37.2 ± 0.9 °C), and the difference was statistically significant ($p = 0.02$).

These findings indicate that abnormal vital signs were significantly associated with patients who experienced cardiopulmonary arrest.

Table 2: Comparison of Physiological Parameters Between Cases and Controls

Parameter	Cases (Mean ± SD)	Controls (Mean ± SD)	p value
Respiratory Rate (breaths/min)	26.8 ± 5.1	19.5 ± 3.7	<0.001
Heart Rate (beats/min)	111.9 ± 17.8	87.6 ± 11.9	<0.001
Systolic BP (mmHg)	97.4 ± 14.8	118.2 ± 13.7	<0.001
Temperature (°C)	37.8 ± 1.0	37.2 ± 0.9	0.02

Comparison of MEWS and CART Scores: The comparison of Modified Early Warning Score (MEWS) and Cardiac Arrest Risk Triage (CART) score between the two groups is shown in Table 3.

As demonstrated in Table 3, the mean MEWS score among cases was 6.2 ± 1.9, which was significantly higher compared with controls (3.1 ± 1.4) with $p < 0.001$.

Similarly, the mean CART score among cases was 17.6 ± 5.2, which was markedly higher than controls (9.1 ± 3.7) with $p < 0.001$.

These results indicate that both scoring systems were significantly associated with cardiopulmonary arrest; however, CART score showed a greater difference between cases and controls.

Table 3: Comparison of MEWS and CART Scores

Score	Cases (Mean ± SD)	Controls (Mean ± SD)	p value
MEWS	6.2 ± 1.9	3.1 ± 1.4	<0.001
CART	17.6 ± 5.2	9.1 ± 3.7	<0.001

Diagnostic Performance of MEWS and CART Scores: The diagnostic performance of MEWS and CART scores in predicting cardiopulmonary arrest was evaluated using sensitivity, specificity, and area under the receiver operating characteristic curve (AUC). The results are presented in Table 4.

As shown in Table 4, the MEWS score demonstrated a sensitivity of 74% and specificity of 69%, with an AUC of 0.78.

In comparison, the CART score demonstrated higher sensitivity (87%) and specificity (82%), with a higher AUC of 0.89.

These findings indicate that the CART score had superior predictive performance compared to MEWS for identifying patients at risk of cardiopulmonary arrest.

Table 4: Diagnostic Performance of MEWS and CART Scores

Score	Sensitivity	Specificity	AUC
MEWS	74%	69%	0.78
CART	87%	82%	0.89

Logistic Regression Analysis: Logistic regression analysis was performed to determine the association between MEWS score, CART score, and the risk of cardiopulmonary arrest. The results are summarized in Table 5.

As shown in Table 5, both MEWS and CART scores were significantly associated with cardiopulmonary arrest.

The odds ratio for MEWS was 1.72 (95% CI: 1.24–2.36, $p = 0.003$), indicating that an increase in MEWS score significantly increased the risk of cardiopulmonary arrest.

However, the CART score showed a stronger association, with an odds ratio of 2.41 (95% CI: 1.60–3.64, $p < 0.001$).

This suggests that CART score was a stronger independent predictor of cardiopulmonary arrest compared with MEWS.

Table 5: Logistic Regression Analysis for Prediction of Cardiopulmonary Arrest

Variable	Odds Ratio	95% Confidence Interval	p value
MEWS	1.72	1.24 – 2.36	0.003
CART	2.41	1.60 – 3.64	<0.001

ROC Curve Analysis: Receiver Operating Characteristic (ROC) curve analysis was performed to compare the predictive accuracy of MEWS and CART scores for cardiopulmonary arrest.

As illustrated in Figure 1, the CART score demonstrated a larger area under the ROC curve compared to MEWS, indicating better discrimination ability.

The area under the ROC curve for CART score was 0.89, while the AUC for MEWS score was 0.78. This difference indicates that CART score had superior predictive accuracy for cardiopulmonary arrest in the study population.

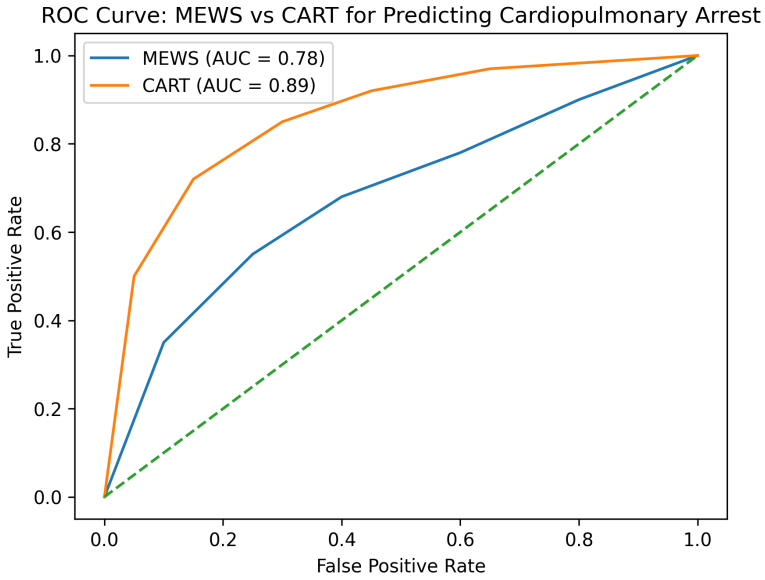

Figure 1: ROC Curve Comparing Predictive Performance of MEWS and CART Scores

Summary of Findings

Overall, the results of the present study demonstrated that:

- Patients who developed cardiopulmonary arrest had significantly abnormal vital signs compared with controls.
- Both MEWS and CART scores were significantly higher among cases.
- CART score demonstrated higher sensitivity, specificity, and predictive accuracy than MEWS.
- Logistic regression analysis showed that CART score was a stronger independent predictor of cardiopulmonary arrest.

These findings suggest that CART score may be a more reliable tool for early identification of patients at risk of cardiopulmonary arrest in hospital wards.

Discussion

Early detection of physiological deterioration remains a major priority in improving hospital patient safety. In the present study, both MEWS and CART scores were effective predictors of cardiopulmonary arrest; however, CART score demonstrated significantly better predictive performance.

Previous studies have reported that abnormal vital signs often precede cardiac arrest by several hours, providing an opportunity for early intervention [15]. Early warning scoring systems help clinicians recognize these abnormalities and respond promptly [16].

In this study, respiratory rate and heart rate were significantly higher among patients who developed cardiopulmonary arrest. Similar findings have been reported in earlier studies emphasizing the importance of respiratory rate as a sensitive indicator of clinical deterioration [17].

The mean MEWS score among cases was significantly higher than controls. These results are consistent with studies demonstrating that elevated MEWS values are associated with increased risk of ICU admission and mortality [18].

However, MEWS has been criticized for limited sensitivity in predicting cardiac arrest events [19]. In our study, MEWS showed moderate predictive accuracy with an AUC of 0.78.

The CART score demonstrated superior predictive performance with an AUC of 0.89. Similar results were reported in previous investigations comparing CART with traditional early warning scores [20].

One advantage of CART score is its focus on fewer but more predictive variables that are strongly associated with cardiac arrest [21]. This targeted approach may improve predictive accuracy in hospital wards.

Our findings also showed that CART score had higher sensitivity and specificity compared with MEWS. This observation aligns with earlier studies suggesting that CART may provide more reliable prediction of cardiopulmonary arrest [22].

Early identification of high-risk patients enables timely clinical interventions and may prevent deterioration requiring intensive care [23].

In resource-limited hospital settings, simple bedside scoring systems such as CART can be particularly valuable for improving patient monitoring [24].

Overall, the results of this study support the implementation of CART score as an effective tool

for predicting cardiopulmonary arrest among hospitalized patients [25].

Conclusion

Both Modified Early Warning Score and Cardiac Arrest Risk Triage score are useful tools for detecting early clinical deterioration. However, the CART score demonstrated superior predictive ability for cardiopulmonary arrest in this study. Implementation of CART scoring in hospital wards may improve early recognition of high-risk patients and enhance patient safety.

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