

Predictive value of bedside ultrasound-assessed left ventricular ejection fraction for neurological prognosis in patients after return of spontaneous circulation following in-hospital cardiac arrest: a retrospective cohort study

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Abstract

Background: Poor neurological recovery after in-hospital cardiac arrest (IHCA) may be exacerbated by postresuscitation myocardial dysfunction. However, the predictive value of left ventricular ejection fraction (LVEF) for neurological outcomes remains insufficiently explored.

Methods: This retrospective study included patients with IHCA who achieved return of spontaneous circulation at the Zigong Fourth People's Hospital between 2019 and 2024. Neurological function at discharge was evaluated using the cerebral performance category (CPC) score (favorable: CPC $\leq$ 2; unfavorable: CPC $>$ 2). Multivariable logistic regression, restricted cubic splines, and receiver operating characteristic curves were used to evaluate the predictive performance. The incremental value of LVEF was assessed using net reclassification improvement and integrated discrimination improvement. Decision and calibration curves were used to assess clinical utility.

Results: Of the 179 patients, 31 (17.3%) exhibited favorable neurological outcomes. After adjusting for mechanical ventilation and consciousness levels, LVEF remained an independent predictor of favorable recovery (odds ratio: 1.057; 95% confidence interval [CI]: 1.005–1.112; $P = 0.032$). Restricted cubic splines analysis demonstrated a linear dose–response relation between LVEF and favorable outcomes (P for nonlinearity = 0.984). The integrated model incorporating LVEF, cardiac arrest survival postresuscitation in-hospital, and modified early warning score yielded an area under the curve of 0.869 (95% CI: 0.803–0.935). Bootstrap analysis identified an optimal LVEF threshold of 58% (95% CI: 55%–65%). The addition of LVEF to conventional scoring systems improved both the net reclassification improvement and integrated discrimination improvement ($P < 0.05$), with the decision curve analysis confirming an enhanced net clinical benefit. Calibration curves showed good agreement between the predicted and observed outcomes.

Conclusion: Bedside ultrasonographic assessment of LVEF is an independent linear predictor of neurological recovery in patients with IHCA. Incorporating LVEF into existing clinical frameworks (cardiac arrest survival postresuscitation in-hospital and modified early warning score) enhances the prognostic accuracy and risk stratification, providing objective evidence for early clinical decision-making.

Keywords: In-hospital cardiac arrest, Left ventricular ejection fraction, Neurological prognosis, Point of care ultrasound, Predictive value

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Introduction

In-hospital cardiac arrest (IHCA) is a life-threatening event marked by its abrupt onset, rapid progression, and high likelihood of poor neurological outcomes.^[1,2] Epidemiological data indicate that the incidence of IHCA in the United Kingdom and the United States ranges from 1.6 to 10.16 per 1000 hospital admissions. A 2020 study in China, covering seven regions, reported an incidence of 8.4 per 1000 adult admissions.^[2–4] Despite improvements in resuscitation techniques and post cardiac arrest care, neurological prognosis remains poor, with only 6.7% of IHCA survivors experiencing favorable neurological outcomes at 30 days or upon discharge.^[2,3] Neurological dysfunction is a leading cause of mortality in patients who survive long enough to achieve return of spontaneous circulation (ROSC) and contributes significantly to long-term disability in acute-phase survivors.^[5] Early and accurate assessment of the neurological prognosis is vital for tailoring treatment strategies, optimizing resource allocation, and enhancing communication with patients' families.^[4,6]

Point-of-care ultrasonography has become an indispensable bedside tool for the management of cardiac arrest.^[7–9] Among its applications, the assessment of left ventricular ejection fraction (LVEF) is a widely used marker of global cardiac systolic function and has been shown to correlate closely with mortality after cardiac arrest.^[10, 11] Nearly two-thirds of patients develop left ventricular systolic dysfunction within 24 hours after ROSC, with mean LVEF values typically ranging between 35% and 45%.^[12] An initial LVEF below 30% within the first 24 hours after ROSC was independently associated with increased in-hospital mortality (odds ratio [OR]: 0.52; 95% confidence interval [CI]: 0.31–0.88; $P = 0.015$).^[11] Within the first 24 hours after ROSC, ischemia–reperfusion injury and other pathophysiological changes, including cerebral injury and myocardial damage, reach their peak.^[5] Postresuscitation left ventricular dysfunction may lead to reduced cardiac output, resulting in impaired cerebral perfusion and aggravation of ischemic–hypoxic brain injury.^[5] Therefore, post-ROSC LVEF may be a useful surrogate marker for assessing neurological prognosis. However, its predictive value in patients with IHCA remains unclear, particularly among the Chinese population.

This study retrospectively analyzed the clinical data of patients with IHCA after ROSC to assess the relation between LVEF and neurological outcomes at discharge. We hypothesized that a high post-ROSC LVEF is linearly associated with improved neurological recovery. The objective of this study was to provide clinically applicable evidence for early neurological prognosis and guide tailored interventions after IHCA recovery.

Materials and methods

Study population

This retrospective study included patients who experienced IHCA and achieved ROSC at the Zigong Fourth People's Hospital between January 1, 2019, and December 31, 2024. The inclusion criteria were as follows: (1) age ≥ 18 years; (2) cardiac arrest occurring in-hospital wards, outpatient departments, health management centers, emergency departments, or ambulances^[13]; (3) diagnosis of cardiac arrest, defined by the absence of heart sounds, loss of large artery pulsation, and sudden onset of impaired consciousness^[1]; and (4) ROSC sustained for at least 20 minutes.^[14] The exclusion criteria were as follows: (1) multiple IHCA events during the same hospitalization, with only the first event included in the analysis; (2) pregnancy; and (3) incomplete data, such as missing bedside echocardiographic assessments, within 24 hours post-ROSC. This study followed the principles of the Declaration of Helsinki, revised in 2013. This study was approved, and written informed consent was waived by the Biomedical Ethics Committee of Zigong Fourth People's Hospital (Approval No. 2020-009, July 20, 2020) owing to the anonymized retrospective nature of the analysis.

Data collection

Clinical data were extracted from the hospital's medical record system and comprised the following: (1) demographic and baseline characteristics, including patient demographics, comorbid conditions before cardiac arrest (such as cardiac disease on admission, sepsis, hypotension, metastatic or hematologic malignancy, liver and kidney dysfunction, and mechanical ventilation status), and the prearrest cerebral performance category (CPC) score; (2) cardiac arrest and resuscitation characteristics, including whether the

cardiac arrest was witnessed, the initial arrest rhythm, the location of the arrest, resuscitation duration, and the implementation of targeted temperature management; (3) post-ROSC status, including level of consciousness and post-ROSC vital signs (heart rate, body temperature, respiratory rate, systolic and diastolic blood pressure); (4) post-ROSC clinical scoring, including cardiac arrest survival postresuscitation in-hospital (CASPRI) score and modified early warning score (MEWS)^[15, 16]; and (5) post-ROSC bedside Doppler echocardiographic assessment performed by experienced echocardiographers within 24 hours post-ROSC using a Mindray M9 device.^[17, 18] All examinations were conducted by board-certified physicians who completed standardized competency training in echocardiography and strictly adhered to established clinical protocols. LVEF was calculated using the modified Simpson method to measure left ventricular volumes, following established guidelines for the echocardiographic assessment of cardiac systolic and diastolic function.^[19] Outcome measures included assessment of neurological function at discharge using the CPC score, with a score of ≤ 2 indicating favorable neurological function and a score > 2 indicating poor neurological function.^[15]

Statistical analysis

Continuous variables with a normal distribution are presented as mean $\pm$ standard deviation, and group comparisons were conducted using independent t tests. For data that did not follow a normal distribution, values are expressed as median (interquartile range), and comparisons between groups were made using the Mann–Whitney U test. Categorical variables are expressed as counts (percentages), and group differences were analyzed using the chi-square test or Fisher exact test, as appropriate. Potential confounders were defined as the intersection of variables consistently selected through least absolute shrinkage and selection operator regression, the Boruta algorithm, and the change-in-estimate criterion (defined as $>10\%$ shift in the point estimate). To evaluate the collinearity of the independent variables, the variance inflation factor was calculated. An independent variable with a variance inflation factor > 5 was considered highly collinear. A dose–response relation between LVEF and neurological prognosis was explored using restricted cubic splines (RCS). The diagnostic performance was evaluated by constructing receiver operating characteristic curves and calculating the area under the curve (AUC). The optimal threshold was determined by maximizing the Youden index (sensitivity + specificity – 1). To assess the statistical robustness of the threshold and to account for clinical variability, a 95% CI for the optimal cutoff was calculated, using a bootstrap resampling method. Internal validation was performed by bootstrap resampling (500 repetitions) to assess the stability of the findings.^[20] The incremental predictive value of LVEF over clinical scoring systems was evaluated using the net reclassification improvement (NRI) and integrated discrimination improvement indices, and its clinical utility was further examined using calibration curves and decision curve analysis. All data analyses were performed using R software (version 4.5.2; R Foundation for Statistical Computing, Vienna, Austria), and statistical significance was set at $P < 0.05$.

Results

Clinical baseline characteristics

This study included 179 patients who achieved ROSC (Fig. 1). Among these, 31 patients (17.3%) had favorable neurological outcomes (CPC ≤ 2), whereas 148 patients (82.7%) had

unfavorable outcomes (CPC > 2), as shown in Table 1. The group with unfavorable outcomes had a higher proportion of patients with prearrest sepsis, hypotension, and mechanical ventilation but a lower proportion of patients with cardiac disease on admission. These patients also tended to have higher prearrest CPC scores, and most were treated in the intensive care unit ($P < 0.05$). In contrast, patients with favorable outcomes had lower heart rate, CASPRI score, and MEWS score after ROSC and exhibited higher respiratory rate, systolic blood pressure, ultrasonography duration, and LVEF values ($P < 0.05$). Within the favorable outcome cohort, unresponsiveness was the most prevalent finding (38.71%), followed by alertness (29.03%). Equal proportions of patients were responsive to verbal and painful stimuli (16.13% each). Similarly, most patients in the unfavorable outcome group were unresponsive (77.70%) ($P < 0.05$). The baseline characteristics were not compared between the patients owing to missing data, and the final study cohort is presented in Supplementary Table 1, <https://links.lww.com/ECCM/A118>. No significant systematic differences were observed in baseline conditions between the two groups ($P > 0.05$).

Independent predictors via multivariable logistic regression

To avoid multicollinearity, the CASPRI and MEWS scores were excluded from the initial covariate screening process. Potential confounders were derived from the intersection of variables consistently identified via least absolute shrinkage and selection operator regression, the Boruta algorithm, and the change-in-estimate criterion. This tripartite approach yielded two robust covariates: mechanical ventilation and the level of consciousness (Supplementary Figure 1, <https://links.lww.com/ECCM/A119> and Supplementary Table 2, <https://links.lww.com/ECCM/A120>). As shown in Table 2, after adjusting for these confounders, LVEF remained an independent predictor of favorable neurological outcomes (OR: 1.057; 95% CI: 1.005–1.112; $P = 0.032$).

Nonlinear relation evaluation using RCS

RCS analysis revealed a linear dose–response relation between LVEF and favorable neurological outcomes (P for nonlinearity = 0.984), as shown in Figure 2.

Predictive performance and internal validation via receiver operating characteristic and bootstrap

The ability of the CASPRI score, MEWS score, and LVEF to discriminate neurological outcomes was evaluated individually and in combination. When assessed alone, LVEF demonstrated moderate discriminatory capacity, with an AUC of 0.653 (95% CI: 0.550–0.756). The model integrating all 3 variables showed an AUC of 0.869 (95% CI: 0.803–0.935). Numerically, the AUC values were increased when LVEF was added to the single-score models: the AUC for CASPRI was 0.768 without LVEF and 0.791 with LVEF, and for MEWS, it was 0.730 without LVEF and 0.776 with LVEF (Fig. 3A). A formal statistical comparison of these differences in AUC was not performed owing to the limited sample size.

Internal validation revealed that the optimism values for all models remained low. After bootstrap correction, the combined model (LVEF + CASPRI + MEWS) presented an optimism-corrected AUC of 0.856 (Fig. 3B and Supplementary Table 3, <https://links.lww.com/ECCM/A121>). Bootstrap analysis further identified an optimal LVEF cutoff of 58% (95% CI: 55–65). When the lower bound of this interval (55%) was applied, the sensitivity was high (83.9%), whereas using the upper bound (65%) resulted in a marked improvement in specificity (77.0%) (Supplementary Table 4, <https://links.lww.com/ECCM/A122>).

Clinical performance of predictive models

The addition of LVEF improved the overall NRI and integrated discrimination improvement for both CASPRI and MEWS scores, particularly regarding the NRI for the event group ($P < 0.05$; Table 3). Calibration and decision curve analyses showed a close correspondence between the LVEF-based predictions and the observed clinical outcomes ($P = 0.513$; Supplementary Figure 2, <https://links.lww.com/ECCM/A123>). The decision curve further revealed that incorporating LVEF increased the net clinical benefit of both the CASPRI and MEWS models, with the combined model yielding the greatest overall gain (net benefit = 0.101; Supplementary Figure 3, <https://links.lww.com/ECCM/A124>).

Discussion

In this retrospective study, we examined the association between LVEF, assessed using bedside echocardiography after ROSC, and neurological outcomes at hospital discharge in patients with IHCA. We found that post-ROSC LVEF is an independent predictor of favorable neurological outcomes at discharge, demonstrating a linear dose–response relation with neurological prognosis. Moreover, the incorporation of LVEF into the existing clinical risk scores improved the discriminatory performance of the predictive models. These results suggest that early assessment of LVEF after ROSC may provide incremental prognostic information and has potential clinical utility for neurological outcome stratification in patients with IHCA.

Previous studies have consistently highlighted the significant correlation between LVEF and cardiac arrest outcomes. In a large multicenter retrospective study involving 950 patients with out-of-hospital cardiac arrest, those with a prearrest LVEF > 60% had a markedly higher likelihood of survival to hospital discharge (OR: 5.46; 95% CI: 3.09–9.66; $P < 0.001$).^[21]

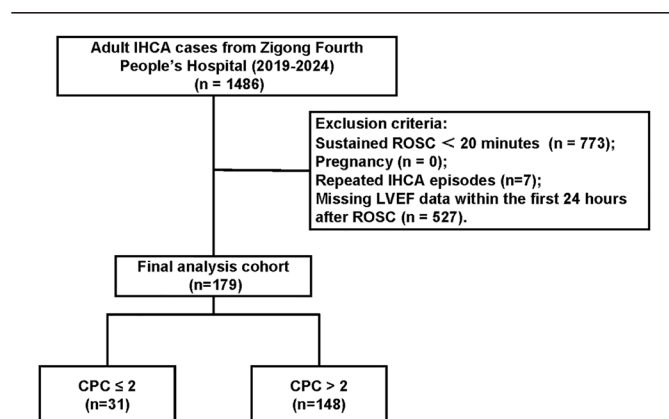


Figure 1. Flowchart of study patient selection. IHCA, in-hospital cardiac arrest; LVEF, left ventricular ejection fraction; ROSC, return of spontaneous circulation.

Table 1
Baseline Characteristics

Variables	Total (n = 179)	Unfavorable Outcomes (n = 148)	Favorable Outcomes (n = 31)	P
Baseline characteristics				
Age (yr)	72 (61, 81)	73 (60, 81)	71 (64, 74)	0.192
Gender				0.791
Male	102 (56.98)	85(57.43)	17(54.84)	
Female	77 (43.02)	63(42.57)	14(45.16)	
Prearrest comorbidities and conditions				
Cardiac disease on admission (%)	64 (35.75)	42 (28.38)	22 (70.97)	<0.001
Sepsis (%)	35 (19.55)	34 (22.97)	1 (3.23)	0.012
Hypotension (%)	58 (32.40)	55 (37.16)	3 (9.68)	0.003
Metastatic or hematologic malignancy (%)	11 (6.15)	11 (7.43)	0 (0.00)	0.248
Liver dysfunction (%)	20 (11.17)	16 (10.81)	4 (12.90)	0.982
Renal dysfunction (%)	37 (20.67)	34 (22.97)	3 (9.68)	0.096
Mechanical ventilation (%)	137 (76.54)	125 (84.46)	12 (38.71)	<0.001
Prearrest CPC Score	3 (1,4)	3 (1,4)	1 (1,2)	<0.001
Cardiac arrest and resuscitation characteristics				
Witnessed cardiac arrest (%)	168 (93.85)	140 (94.59)	28 (90.32)	0.625
Initial arrest rhythm (%)				0.104
Ventricular fibrillation	22 (12.29)	14 (9.46)	8 (25.81)	
Ventricular tachycardia	2 (1.12)	2 (1.35)	0 (0.00)	
Pulseless electrical activity	80 (44.69)	67 (45.27)	13 (41.94)	
Asystole	75 (41.90)	65 (43.92)	10 (32.26)	
Location of event (%)				0.004
Nonmonitoring area	61 (34.08)	45 (30.41)	16 (51.61)	
Monitoring area (eg, resuscitation room)	29 (16.20)	21 (14.19)	8 (25.81)	
Intensive care unit	89 (49.72)	82 (55.41)	7 (22.58)	
Resuscitation time (min)	15 (6, 25)	15 (7,25)	18 (5.5,26)	0.877
Implementation of TTM (%)	16 (8.94)	12 (8.11)	4 (12.90)	0.614
Post-ROSC status				
Consciousness level (%)				<0.001
Alert	12 (6.70)	3 (2.03)	9 (29.03)	
Responsive to verbal stimuli	9 (5.03)	4 (2.70)	5 (16.13)	
Responsive to pain	31 (17.32)	26 (17.57)	5 (16.13)	
Unresponsive	127 (70.95)	115 (77.70)	12 (38.71)	
Heart rate (bpm)	108.99 ± 34.16	112.14 ± 33.32	93.97 ± 34.62	0.007
Temperature (°C)	36.3 (36, 36.5)	36.3 (36, 36.5)	36.4 (36.0, 36.5)	0.500
Respiratory rate (bpm)	16 (15, 18)	15 (15, 18)	18 (17, 19)	<0.001
Systolic blood pressure (mm Hg)	103 (84.5, 129.5)	101.5 (83.5, 126.3)	115 (101.5, 146)	0.015
Diastolic blood pressure (mm Hg)	60 (44.5, 74)	60 (42, 73.3)	63 (54.5, 74)	0.157
Post-ROSC clinical scores and ultrasound parameters				
CASPRI score	27 (23, 30)	27 (24,31)	22 (17,26)	<0.001
MEWS score	6 (5, 7)	6 (5,7)	4 (2,6)	<0.001
LVEF (%)	58 (50.5, 64.5)	58.0 (49.7,63.0)	62.0 (57.5,65.5)	0.007
Ultrasound Time (h)	5.35 (2.34, 15.21)	4.61 (2.21, 12.53)	13.15 (5.68, 20.00)	0.002

Data are presented as mean ± standard deviation, median (interquartile range), or n (%).

CASPRI, cardiac arrest survival postresuscitation in-hospital; CPC, cerebral performance category; LVEF, left ventricular ejection fraction; MEWS, modified early warning score; ROSC, return of spontaneous circulation; TTM, targeted temperature management.

Additionally, another single-center study demonstrated that combining pre-ROSC heart failure stage with LVEF for stratification could effectively predict both neurological outcomes and in-hospital survival in patients with IHCA ($P < 0.05$).^[22] In the present study, we identified a similar relation between LVEF and neurological outcomes in patients with IHCA. One potential explanation for this association is that myocardial dysfunction after cardiac arrest leads to decreased cardiac output, which, in turn, reduces cerebral perfusion, ultimately hindering neurological recovery.^[5, 23, 24] Our findings are consistent

Table 2
Multivariable Logistic Regression Analysis

Variables	Model I		Model II	
	OR (95% CI)	P	OR (95% CI)	P
LVEF	1.061 (1.015–1.108)	0.008	1.057 (1.005–1.112)	0.032

Model I, unadjusted; Model II, adjusted for mechanical ventilation and consciousness level.

CI, confidence interval; LVEF, left ventricular ejection fraction; OR, odds ratio.

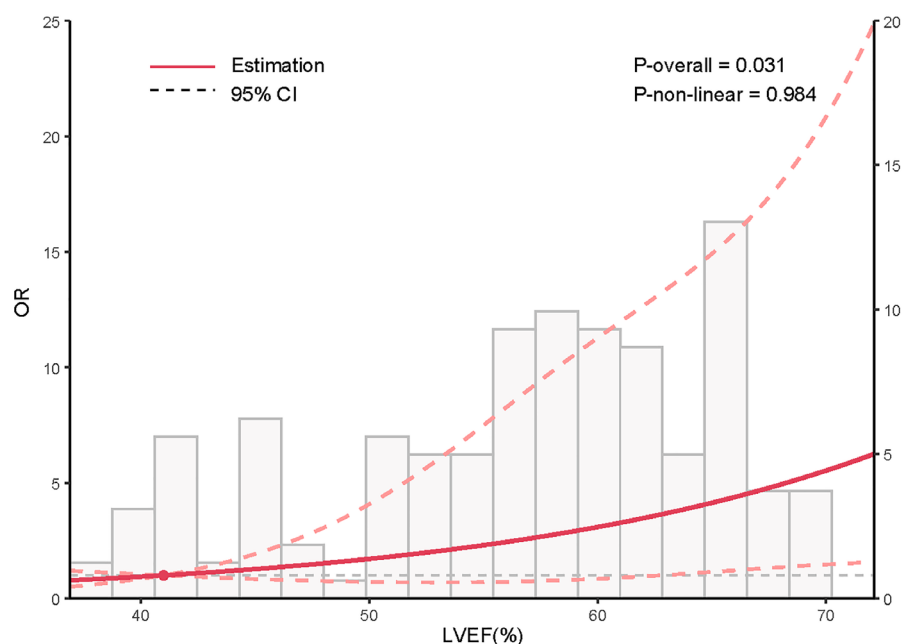


Figure 2. RCS analysis of LVEF and favorable neurological outcomes in patients with IHCA. CI, confidence interval; IHCA, in-hospital cardiac arrest; LVEF, left ventricular ejection fraction; OR, odds ratio; RCS, restricted cubic splines.

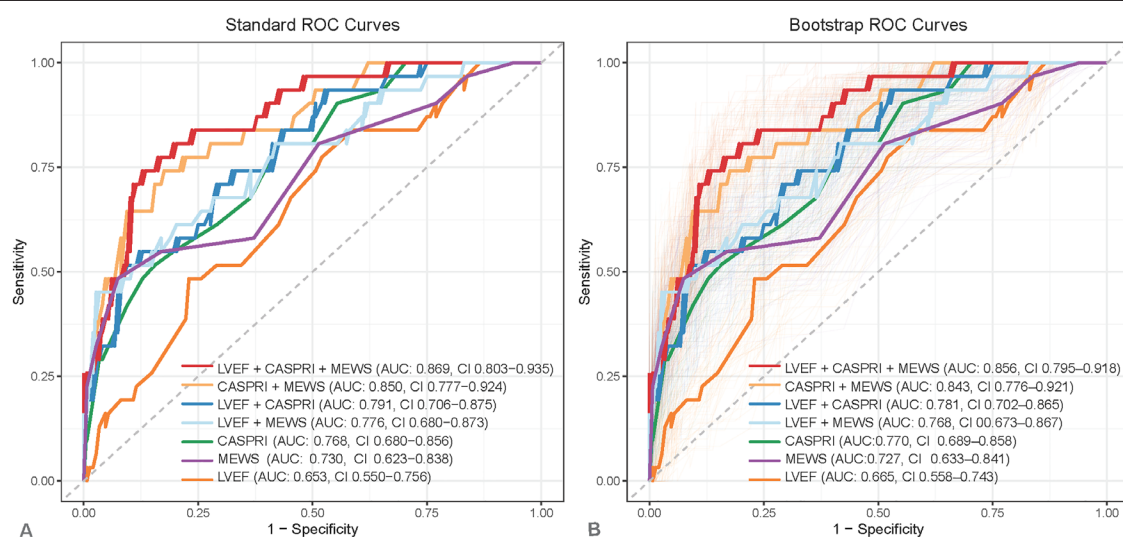


Figure 3. ROC curves and bootstrap validation. (A) Standard ROC curves. (B) Bootstrap ROC curves. AUC, area under the curve; CASPRI, cardiac arrest survival postresuscitation in-hospital; CI, confidence interval; LVEF, left ventricular ejection fraction; MEWS, modified early warning score; ROC, receiver operating characteristic.

with those of a single-center retrospective study involving 2466 patients with IHCA, which showed that in patients with heart failure, a prearrest LVEF $\geq 50\%$ was independently linked to more favorable neurological recovery (OR: 1.90; 95% CI: 1.00–3.61; $P = 0.05$).^[22] This study identified an optimal LVEF range of 55%–65%. Within this interval, a comprehensive evaluation of neurological outcomes in patients with IHCA should include additional clinical parameters. When the LVEF exceeds 65%, its specificity (77.0%) suggests a stronger potential to predict favorable neurological recovery during hospitalization.

The CASPRI score, a well-established tool for predicting neurological outcomes in patients with IHCA, incorporates 11

variables, including age and initial arrest rhythm.^[25] A retrospective study of 168 patients with IHCA found a strong correlation between lower CASPRI scores and favorable neurological outcomes at discharge, with an AUC of 0.77 (95% CI: 0.68–0.85, $P < 0.01$).^[26] This result is similar to the AUC of 0.768 (95% CI: 0.680–0.856) observed in our study. The MEWS score is widely used in clinical settings to assess illness severity and has gained increasing recognition as an early warning tool for IHCA.^[16, 27] In a cohort of 1230 critically ill patients, the admission MEWS score and LVEF were identified as independent risk factors for the occurrence of IHCA ($P < 0.05$).^[28] In our study, when combined with LVEF, the model showed an AUC

Table 3
NRI and IDI Analyses

Variables	NRI (95% CI)			IDI (95% CI)
	NRI (total)	NRI (Events)	NRI (Nonevents)	
LVEF + CASPRI + MEWS vs. CASPRI + MEWS	0.500 (0.143–0.858)*	0.419 (0.099–0.738)*	0.081 (–0.079 to 0.241)	0.029 (0.001–0.057)*
LVEF + CASPRI vs. CASPRI	0.449 (0.083–0.816)*	0.354 (0.025–0.684)*	0.094 (–0.065 to 0.255)	0.038 (0.006–0.071)*
LVEF + MEWS vs. MEWS	0.446 (0.089–0.804)*	0.419 (0.099–0.738)*	0.027 (–0.134 to 0.188)	0.044 (0.012–0.077)*

Asterisks indicate statistical significance (* $P < 0.05$).

CASPRI, cardiac arrest survival postresuscitation in-hospital; CI, confidence interval; IDI, integrated discrimination improvement; LVEF, left ventricular ejection fraction; MEWS, modified early warning score; NRI, net reclassification improvement.

of 0.776 (95% CI: 0.680–0.873). The integrated model incorporating LVEF, CASPRI, and MEWS presented an AUC of 0.869 (95% CI: 0.803–0.935), supporting the observed contribution of LVEF within this combined assessment framework. Moreover, we observed that incorporating LVEF conferred both incremental predictive value and net clinical benefit. This advantage is likely attributable to LVEF being a key indicator of myocardial function after ROSC, thereby providing a more comprehensive assessment of global cardiac performance, which, in turn, refines neurological outcome prediction.

Compared with other prognostic tools, bedside ultrasound monitoring of LVEF provides several key advantages. It is non-invasive, portable, and readily accessible, making it an effective method for predicting neurological outcomes in patients after ROSC.^[7, 29] Although electroencephalography is essential for evaluating brain injury and neurological prognosis after cardiac arrest, its application in routine practice is often restricted owing to its limited availability, particularly in primary care and smaller hospitals.^[30, 31] Serum biomarkers, including neuron-specific enolase, neurofilament light chain protein, and S-100 β , produced by glial cells, show potential in predicting post-ROSC neurological recovery. However, these biomarkers are not suitable for early and rapid assessments.^[32–34] Diffusion-weighted imaging has been employed to predict neurological outcomes after ROSC; however, the requirement for patients to leave the intensive care unit limits its feasibility for bedside monitoring.^[35]

Limitations

This study had several limitations. First, the retrospective, single-center design involving exclusively Chinese patients may limit the generalizability and introduce selection bias. Second, neurological outcomes were assessed only at discharge without long-term follow-up (eg, 3–6 months CPC). Third, the broad 24-hour window for post-ROSC LVEF assessment may have introduced a measurement bias. Fourth, the absence of dynamic LVEF monitoring precludes evaluation of the impact of temporal changes on prognosis. Fifth, the retrospective nature and involvement of multiple operators precluded a systematic interobserver variability assessment, potentially introducing measurement bias despite the use of standardized protocols by board-certified physicians. In addition, the small sample of favorable outcomes ($n = 31$) increased the risk of model overfitting. Furthermore, owing to sample size limitations, no formal statistical significance test (eg, DeLong test) was conducted for the AUC differences. Finally, the proposed pathophysiological link between reduced LVEF, impaired cerebral perfusion, and neurological injury remains indirect, although it is biologically plausible. Future prospective interventional studies focusing on patients with reduced LVEF

are needed to clarify the causal relation and determine whether improving cardiac function can translate into better neurological outcomes.

Conclusion

In conclusion, early bedside ultrasonographic assessment of LVEF serves as an independent predictor of neurological recovery after ROSC in patients with IHCA. A high LVEF was associated with improved neurological outcomes. Further prospective studies are required to validate its predictive value and to explore whether interventions based on LVEF can enhance neurological recovery in this critically ill cohort.

Conflict of interest statement

The authors declare no conflict of interest.

Author contributions

Zhong Z, Luo C, and Xu P contributed to study design; Gao X, Huang X, Ren Y, and Chen Y contributed to data acquisition; Zhong Z, Gao X, and Xu P contributed to statistical analysis; Zhong Z and Luo C contributed to data interpretation; Zhong Z and Xu P contributed to manuscript drafting; Luo C and Xu P contributed to manuscript revision. All authors made substantial intellectual contributions to the conceptualization and design of the study, data acquisition and analysis, and the drafting and critical revision of the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of this work.

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Ethical approval of studies and informed consent

The study followed the principles of the Declaration of Helsinki as revised in 2013. This study was approved, and written informed consent was waived by the Biomedical Ethics Committee of Zigong

Fourth People's Hospital (Approval No. 2020-009, July 20, 2020) owing to the anonymized retrospective nature of the analysis.

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