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Impact of early CVP monitoring on 1-year mortality in patients with congestive heart failure in the ICU: a retrospective analysis based on the MIMIC-IV2.2 database

Jiayi Chen[1*†], Shuhao Que[2†], Guangyong Jin[1†], Ying Zhu[1*], Buqing Ma[1*] and Wei Hu[1*]

Abstract

Background Central venous pressure (CVP) monitoring is critical for fluid management in critically ill patients. This study evaluated the impact of CVP monitoring on 1-year mortality in intensive care unit (ICU) patients with congestive heart failure (CHF).

Methods Data from the Medical Information for Critical Care IV (MIMIC-IV) database were analyzed for ICU patients admitted for the first time with a stay > 24 h. Patients were categorized into CVP and no-CVP groups based on CVP measurement. Logistic regression analyses were performed, with propensity score matching (PSM) and overlap weighting (OW) to minimize confounding. Inflection point analysis using logistic regression was conducted in the CVP group. Patients were further stratified into early (≤ 24 h) and late (> 24 h) CVP monitoring groups for additional analysis.

Results Among 4,479 patients, 919 were in the CVP group and 3,560 in the no-CVP group. CVP monitoring was associated with lower 1-year mortality (odds ratio [OR] = 0.75, 95% confidence interval [CI] = 0.62–0.91, $p = 0.003$). Early CVP monitoring (≤ 24 h) independently reduced 1-year mortality (OR = 0.68, 95% CI = 0.47–0.97, $p = 0.032$). Predictors of mortality included the lowest diastolic blood pressure, lowest blood glucose, highest blood chloride, and Acute Physiology Score III (APSIII) score within 24 h of admission.

Background

Acute heart failure (AHF) is a life-threatening clinical syndrome characterized by the rapid onset or worsening of typical heart failure (HF) signs and symptoms that necessitate urgent treatment. Heart failure manifests as dyspnea or fatigue due to impaired ventricular filling or ejection, leading to inadequate oxygen delivery to peripheral organs [1]. With an aging population, the incidence of acute heart failure presenting to emergency rooms is on the rise. In the United States, over 5.7 million people suffer from congestive heart failure annually, and it is projected that by 2030, more than 8 million

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Conclusion Early CVP monitoring significantly improves 1-year survival in ICU patients with congestive heart failure. These findings underscore the value of timely hemodynamic assessments in critical care and warrant further prospective validation in diverse settings.

Keywords Central venous pressure (CVP), Congestive heart failure, Intensive care unit (ICU), 1-year mortality, Retrospective analysis

individuals will have heart failure [2]. Congestive heart failure has a high hospitalization rate and is the leading cause of hospitalization in patients over 65 years of age. Notably, 80–85% of these cases are acute exacerbations of chronic heart failure, also known as acute decompensated heart failure (ADHF) [3].According to the National Heart Failure Audit for England and Wales, the median age of patients discharged with a diagnosis of heart failure was 80 years, with 66% of patients being over 75 years and 30% being over 85 years [4]. Each year, over 1 million people are hospitalized for congestive heart failure, accounting for 1–2% of all hospitalizations, with most patients experiencing recurrent admissions [5]. This condition also places a significant burden on medicare, which spends more than $17 billion annually in the United States. Additionally, the number of patients with asymptomatic left ventricular dysfunction and heart failure is increasing [6].

Congestion is the predominant clinical feature in most patients with acute heart failure (AHF); however, a small percentage of patients present with peripheral hypoperfusion or cardiogenic shock. Hypoperfusion can further compromise organ function, making volume management critical in the care of patients with heart failure. In AHF, damage and dysfunction of target organs (i.e., heart, lungs, kidneys, liver, gut, and brain) are associated with an increased risk of mortality [7]. In an Intensive Care Unit (ICU), it is more common to encounter "wet and warm" patients who have reduced cardiac index (CI), elevated pulmonary capillary wedge pressure (PCWP), and low-to-normal systemic vascular resistance (SVR) [8]. These patients, suffering from "mixed shock" due to inflammatory or infectious reactions, tend to have poorer outcomes and a higher risk of mortality [9]. In such cases, right heart catheterization (RHC) plays a crucial role, as these patients' risks may be underdiagnosed based solely on clinical assessment.However, several studies conducted in the 1990s and early 2000s that investigated the use of pulmonary artery catheters (PAC) indicated detrimental effects, including longer hospital stays, inconsistent data interpretation, and increased mortality, ultimately leading to a significant decline in their use [10].Central venous pressure (CVP), the pressure within the thoracic veins near the right atrium, is an important parameter in critical care medicine. It is used to assess fluid volume status, evaluate cardiac function, and determine the functional status of the right ventricle [11]. Hemodynamic monitoring in critically ill patients often employs CVP to guide fluid resuscitation, pulse-indicating continuous cardiac output monitoring, and pulmonary artery flotation catheterization. CVP is analogous to right ventricular pressure and can serve as a predictor of preload [12].

Given the critical role of CVP in fluid management, this study aims to explore the association between CVP monitoring and 1-year mortality in ICU patients with congestive heart failure. By analyzing a large cohort from the MIMIC-IV database, this study seeks to provide evidence on the timing and impact of CVP monitoring to guide clinical decision-making in critically ill patients.

Methods

Patient selection and data merging

Relevant data were extracted and merged using Navicat Premium (version 15.0.21). Inclusion criteria for this study were: (1) age 18 years or older; (2) ICU stay of more than 24 h; and (3) diagnosis of congestive heart failure during hospitalization.Patients were categorized into two groups based on whether CVP measurements were performed after ICU admission: the CVP group and the no-CVP group. The primary outcome was 1-year mortality. Logistic regression was employed to elucidate the association between CVP measurement and long-term mortality. A total of 4,479 patients met these criteria and were included in the study.

Main exposure factors

Patients were categorized into two groups based on the presence or absence of CVP monitoring: the CVP group (919 patients) and the no-CVP group (3,560 patients).

Inclusion variables

Baseline characteristics were collected within the first 24 h of ICU admission, including age, gender, body weight (kg), severity of disease, and organ dysfunction scores such as Acute Physiology Score III (APSIII), Oxford Acute Severity of Illness Score (OASIS), Logistic Organ Dysfunction System (LODS) score, Sequential Organ Failure Assessment (SOFA) score, and the Glasgow Coma Scale (GCS). Additionally, data on comorbidities, baseline vital signs after admission (maximum, minimum, and mean), biochemical markers within 24 h, and infection markers (maximum, minimum, and mean) were recorded.

Outcome variables

The primary outcome of this study was 1-year mortality, defined as the incidence of death within one year after ICU admission. Secondary outcomes included in-hospital mortality, length of ICU stay, and the incidence of acute kidney injury within 2 and 7 days of ICU admission. To balance covariates and enhance the robustness of the results, a propensity score-based overlap weighting (OW) approach was used. Additionally, the 919 patients with CVP monitoring were analyzed using logistic curve fitting, dividing them into two groups based on the timing of CVP monitoring: within 24 h and beyond 24 h. The differences between these two groups were then compared to assess statistical significance.

Statistical analysis

Descriptive statistics were employed to analyze the characteristics of the study population. Normally distributed continuous variables were expressed as mean ± standard deviation, while non-normally distributed continuous variables were expressed as median (interquartile range). For normally distributed continuous variables, analyses were conducted using Student's t-test; for non-normally distributed continuous variables, the Mann-Whitney U-test was used; and for categorical variables, the chi-square test was applied.

Logistic regression analysis was performed for multivariate regression analysis. Propensity score matching (PSM) and propensity score-based overlap weighting (OW) methods were utilized to balance covariates and ensure result robustness. PSM methods are commonly employed to reduce or eliminate confounding effects in observational data. In this study, the propensity score estimation algorithm was logistic regression, and the matching algorithm was one-to-one matching with a caliper width of 0.10.

For patient data with CVP monitoring, curve fitting was performed using a logistic fit curve, and grouping was determined by inflection point analysis into groups with CVP monitoring within 24 h and beyond 24 h. Univariate and logistic multivariate analyses were subsequently performed.

Statistical analyses were conducted using R statistical software (version 3.6.1) and Stata software (version 15.0). In all analyses, a p-value of less than 0.05 was considered statistically significant.

Results

After reviewing the records of 76,540 ICU patients in the MIMIC-IV database, we included 4,479 patients with congestive heart failure in this study, as illustrated in the flow chart in Fig. 1. The primary outcome was the 1-year mortality rate of patients with congestive heart failure admitted to the ICU. The univariate analysis results are presented in Exhibit 1, and the multivariate logistic regression results are detailed in Table 1. The 1-year mortality rate was significantly lower in the CVP monitoring group compared to the no-CVP monitoring group ($p = 0.003$, OR = 0.75, 95% CI = 0.62–0.91). Additionally, within the CVP monitoring group, mean arterial pressure (MAP-mean), lowest glucose (glucose_min), lowest hematocrit (hematocrit_min), lowest hemoglobin (hemoglobin_min), highest blood chloride (chloride_max), and APSIII, LODS, and OASIS scores were significantly associated with 1-year mortality in critically ill patients with congestive heart failure. The results of the multivariate analysis are depicted in a forest plot (Fig. 2).

Following propensity score matching (PSM) and overlap weighting (OW) analyses, the overall characteristics of the CVP and no-CVP groups remained well balanced (Table 2; Fig. 3). The association between CVP monitoring and 1-year mortality was consistently maintained (Fig. 4). Subgroup analyses further examined the effect of CVP monitoring across different age groups, sexes, and severity scores, including LODS, SOFA, and OASIS. These analyses demonstrated that the beneficial impact of CVP monitoring on 1-year mortality in ICU patients with congestive heart failure persisted across all subgroups (Fig. 5).

For the 919 patients with CVP monitoring, logistic curve fitting (see Fig. 6) divided them into an early CVP monitoring group (≤ 24 h) and a delayed CVP monitoring group (> 24 h), based on whether CVP monitoring was performed within 24 h of ICU admission. The results of the univariate analysis for these two groups are detailed in Supplementary Table 2. Multivariate logistic regression analysis indicated that early CVP monitoring was associated with a reduced 1-year mortality rate (see Fig. 7), with early monitoring independently linked to lower 1-year mortality (OR = 0.68, 95% CI = 0.47–0.97, $p = 0.032$). Additionally, factors such as the lowest diastolic blood pressure (dbp_min), lowest blood glucose (glucose_min), highest blood chloride (chloride_max), APSIII, lowest Glasgow Coma Scale (GCS) score (gcs_min), SOFA, LODS, and OASIS scores were significantly associated with 1-year mortality within 24 h of admission ($p < 0.05$).

Discussion

Heart failure (HF) affects approximately 1–2% of the population in Western countries, with an annual incidence nearing 5–10 per 10,000 people [13]. It is the leading cause of cardiovascular disease-related hospitalization in individuals over 65 years of age [2, 14]. Central venous pressure (CVP) measurement is a critical component of hemodynamic monitoring, particularly in cardiovascular medicine and cardiac surgery ICUs [15]. CVP

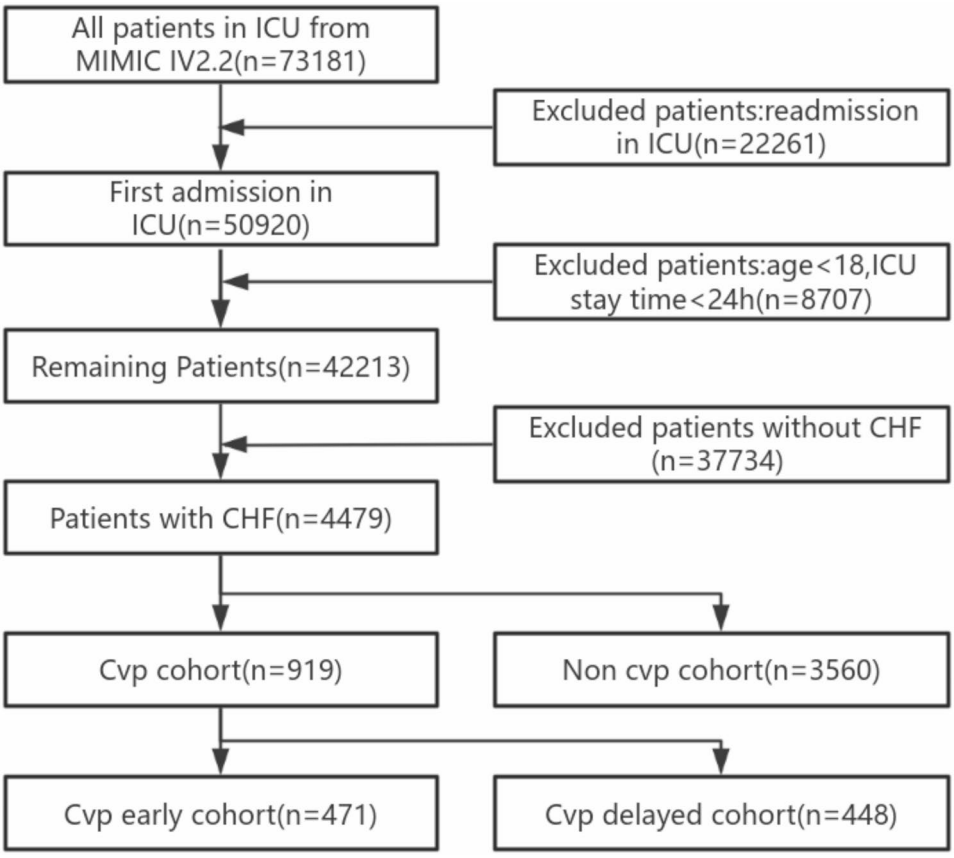

Fig. 1 Flowchart of the study cohort. Abbreviations: ICU: Intensive Care Unit, MIMIC-IV: Medical Information Mart for Intensive Care-IV, CVP: Central Venous Pressure, CHF: Congestive Heart Failure. The grouping criteria for the CVP early cohort and CVP delayed cohort were based on whether CVP measurement was performed within 24 h

Table 1 Multifactorial logistic regression analysis of 1-year mortality in CVP and no CVP groups

Variable	crude.OR(95%CI)	crude.*P* value	adj.OR(95%CI)	adj.*P* value
CVP cohort	0.7 (0.61 ~ 0.81)	< 0.001	0.75 (0.62 ~ 0.91)	0.003
Age	1.04 (1.04 ~ 1.05)	< 0.001	1.03 (1.03 ~ 1.04)	< 0.001
Gender male	0.88 (0.78 ~ 0.99)	0.03	1.23 (1.06 ~ 1.43)	0.007
MBP mean	0.97 (0.96 ~ 0.98)	< 0.001	0.97 (0.94 ~ 1)	0.021
Glucose min	1 (1 ~ 1.01)	< 0.001	1 (1 ~ 1)	0.023
Hematocrit min	0.99 (0.98 ~ 1)	0.019	1.16 (1.11 ~ 1.21)	< 0.001
Hemoglobin min	0.92 (0.9 ~ 0.95)	< 0.001	0.63 (0.55 ~ 0.72)	< 0.001
Chloride max	0.97 (0.96 ~ 0.98)	< 0.001	0.97 (0.94 ~ 1)	0.047
APSIII	1.03 (1.03 ~ 1.03)	< 0.001	1.02 (1.01 ~ 1.03)	< 0.001
LODS	1.18 (1.16 ~ 1.2)	< 0.001	1.05 (1 ~ 1.1)	0.031
OASIS	1.05 (1.05 ~ 1.06)	< 0.001	1.02 (1 ~ 1.03)	0.007
Weight(kg)	0.99 (0.98 ~ 0.99)	< 0.001	0.99 (0.99 ~ 0.99)	< 0.001

Abbreviations: CVP: Central Venous Pressure; MBP: Mean Blood Pressure; APSIII: Acute Physiology Score III; LODS: Logistic Organ Dysfunction System; OASIS: Oxford Acute Severity of Illness Score

reflects right heart filling pressure and function, serving as a crucial indicator of cardiovascular status [16].

In this study, we found a significant association between CVP monitoring and 1-year mortality in patients with congestive heart failure, with those undergoing CVP monitoring demonstrating a lower 1-year mortality rate compared to those who did not receive CVP monitoring. Our findings also indicated a correlation between minimum hemoglobin levels at 24 h post-ICU admission and long-term prognosis (1-year mortality). These results remained consistent after applying propensity score matching. Additionally, subgroup analysis revealed that early CVP monitoring (≤ 24 h)

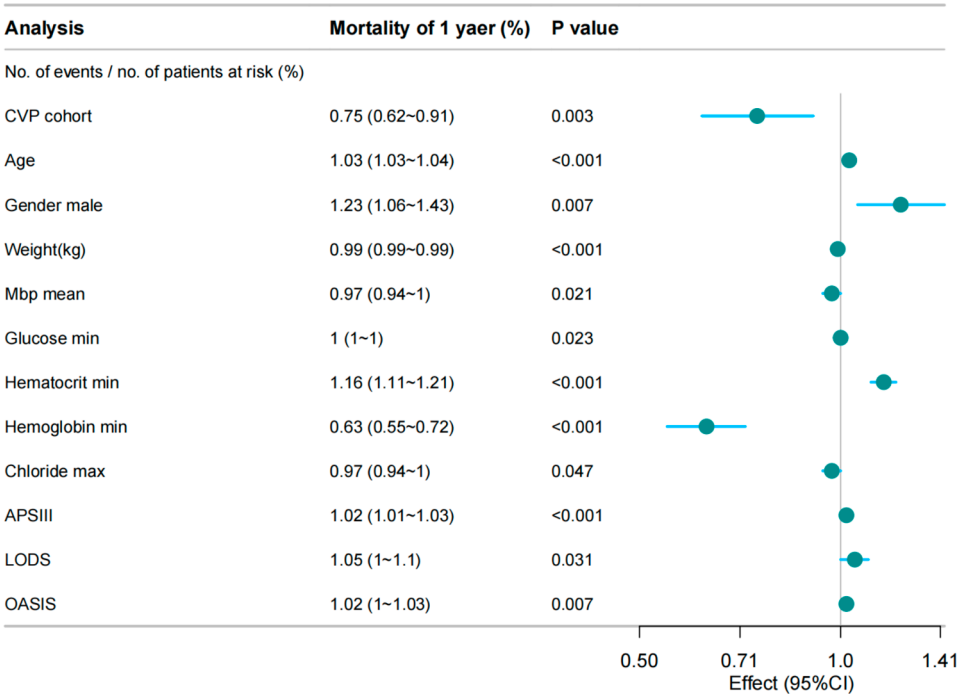

Fig. 2 Forest plot of multifactorial logistic regression analysis of 1-year mortality in the CVP group and the group without CVP. Abbreviations: CVP: Central Venous Pressure; APSIII: Acute Physiology Score III; LODS: Logistic Organ Dysfunction System; OASIS: Oxford Acute Severity of Illness Score

Table 2 Propensity score matching (PSM) outcomes

Item1	Item2	OR(95%CI)	*P* value
Unmatched.crude	CVP early: 1 vs. 0	0.36 (0.27 ~ 0.47)	< 0.001
Multivariable.adjusted	CVP early: 1 vs. 0	0.69 (0.48 ~ 0.99)	0.044
PropensityScore.adjusted	CVP early: 1 vs. 0	0.77 (0.55 ~ 1.06)	0.111
PropensityScore.Matched	CVP early: 1 vs. 0	0.87 (0.61 ~ 1.25)	0.463
Weighted.IPTW	CVP early: 1 vs. 0	1.02 (0.79 ~ 1.31)	0.877
Weighted.SMRW	CVP early: 1 vs. 0	0.57 (0.43 ~ 0.75)	< 0.001
Weighted.PA	CVP early: 1 vs. 0	0.75 (0.53 ~ 1.08)	0.121
Weighted.Ow	CVP early: 1 vs. 0	0.77 (0.5 ~ 1.19)	0.233

The variable"CVP early: 1 vs. 0"indicates the comparison between patients who received early CVP monitoring (within 24 h of ICU admission) and those who did not. The following statistical methods were applied:

Unmatched crude: The raw, unadjusted comparison

Multivariable adjusted: Adjusted for potential confounders

Propensity Score adjusted: Adjusted using propensity score weighting

Propensity Score Matched: Matched on propensity scores

Weighted IPTW (Inverse Probability of Treatment Weighting): Weighting based on the inverse probability of treatment

Weighted SMRW (Standardized Mortality Ratio Weighting): Weighting based on the standardized mortality ratio

Weighted PA (Propensity Score Adjustment): Adjustment using propensity score weights

Weighted OW (Overlap Weighting): Weighting using overlap propensity score methodology

was associated with a reduced 1-year mortality rate in patients with heart failure.

A review of national and international literature indicates that volume overload is a primary cause of heart failure decompensation and that CVP measurement is crucial in the management of heart failure, guiding prognosis effectively [17]. This aligns with our findings. Furthermore, CVP provides valuable information about cardiac output (CO), and when combined with CO, it offers insights into cardiac function and venous return adequacy [18]. Studies have shown that CVP monitoring can reduce renal impairment, and elevated CVP in critically ill patients with multiple comorbidities is linked to an increased risk of acute kidney injury (AKI) [19]. Optimal CVP management should be individualized, with a goal to maintain it at a low level to prevent AKI in the intensive care setting [20]. This is likely due to a cycle where impaired renal function leads to fluid retention,

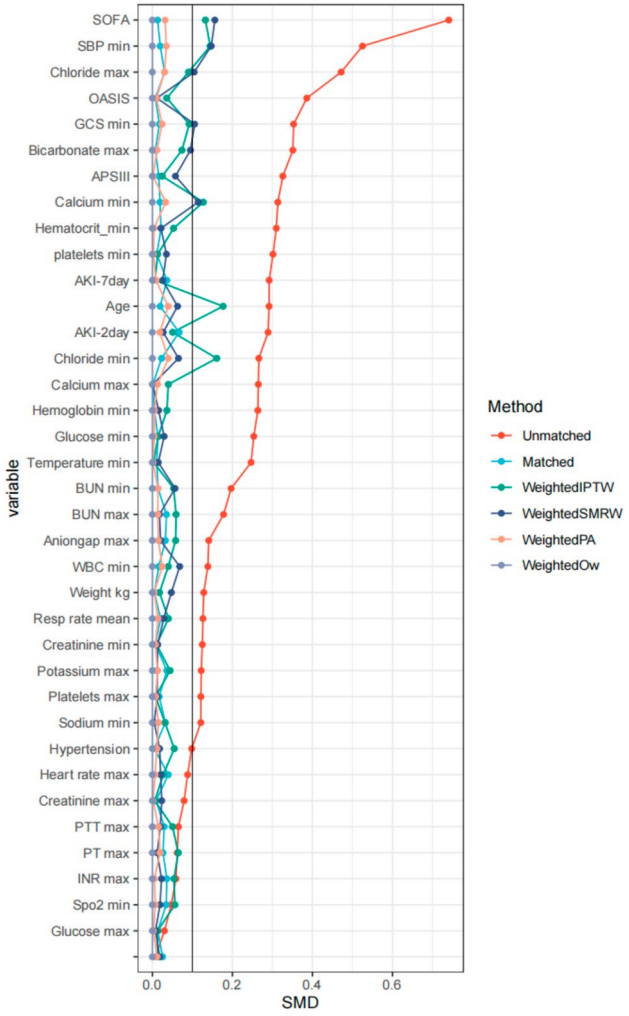

Fig. 3 A graph showing the covariate balance of the matching balance effect between CVP and no-CVP groups. Propensity score MW, Propensity score matching weight; Propensity score OW, Propensity score overlap weight

further elevating CVP, or decreased cardiac output from heart failure results in impaired renal function [21]. Elevated CVP can cause renal congestion [22]. In our study, there was a statistically significant difference in the incidence of 2-day and 7-day AKI between patients with and without CVP monitoring, although this did not translate into a difference in 1-year mortality.

One study investigated hemodynamic parameters of patients undergoing Impella LV-MCS across 28 global prospective catheter ventricular assist device (cVAD) study centers in the United States. The study found that increased age, decreased left ventricular ejection fraction (LVEF), elevated central venous pressure (CVP), and the need for mechanical ventilation were significantly associated with higher mortality [23, 24]. Right ventricular preload dysfunction, both systolic and diastolic, can lead to volume mismanagement, resulting in increased preload and elevated CVP. Elevated preoperative CVP (>10–14 mmHg, as reported in various studies) is consistently linked to right heart failure following left ventricular assist device (LVAD) implantation [17].

Retrospective studies have highlighted that acute kidney injury (AKI) following cardiac surgery is often associated with reduced arterial perfusion, with a two-fold increase in the risk of AKI observed when postoperative CVP exceeds 14 mmHg (OR = 1.99, 95% CI 1.16–3.40) [25]. Growing evidence underscores the significant role of central venous pressure (CVP) in precipitating acute kidney dysfunction in both cardiology and surgery. Elevated CVP has been identified as an independent factor influencing mortality, with higher initial CVP early in the ICU course after cardiac surgery correlating with poorer patient prognosis [14]. In a study conducted in a teaching hospital in Boston, Massachusetts, among 12,778 patients, 2,338 (18%) presented with peripheral edema. Additionally, among patients with CVP measured within 6 h of ICU admission, those in the highest quartile of CVP (>13 cm H2O) faced a 35% higher risk of hospital death compared to those in the lowest quartile (≤7 cm H2O) (95% CI = 1.05–1.75, $p = 0.02$) [26].

All of these findings suggest that excessively high central venous pressure (CVP) is associated with a poor prognosis, reinforcing our results. However, the differential diagnosis and management of elevated CVP should be approached on an individual basis. Elevated CVP can result from several factors, including excessive intravascular volume, cardiac systolic and diastolic dysfunction, increased vascular resistance, and elevated intrathoracic pressure. It reflects a complex interplay of factors such as volume status, right ventricular function, hemodynamic support, respiratory function, and surgical interventions [19].

There are several approaches to volume management and the assessment of hemodynamic status in patients with heart failure [27–29]. Many patients with severe heart failure require vasoactive drugs or a combination of drugs upon admission, and deep venous cannulation can facilitate rapid drug administration, improving the timeliness of resuscitation in critically ill patients. In a retrospective analysis of patients with cardiogenic shock, norepinephrine remains the recommended first-line vasopressor [30]. Norepinephrine administration is confined to deep veins, thus it is advisable to prefer the internal jugular vein for cannulation and to monitor CVP as early as possible. Currently, biomarkers such as BNP and NT-proBNP, and cardiac ultrasound to monitor the width of the inferior vena cava, are also used for volume management. However, blood test results for these biomarkers take time and are not readily available on a daily basis. Additionally, cardiac ultrasound results can vary due to the variability among doctors in

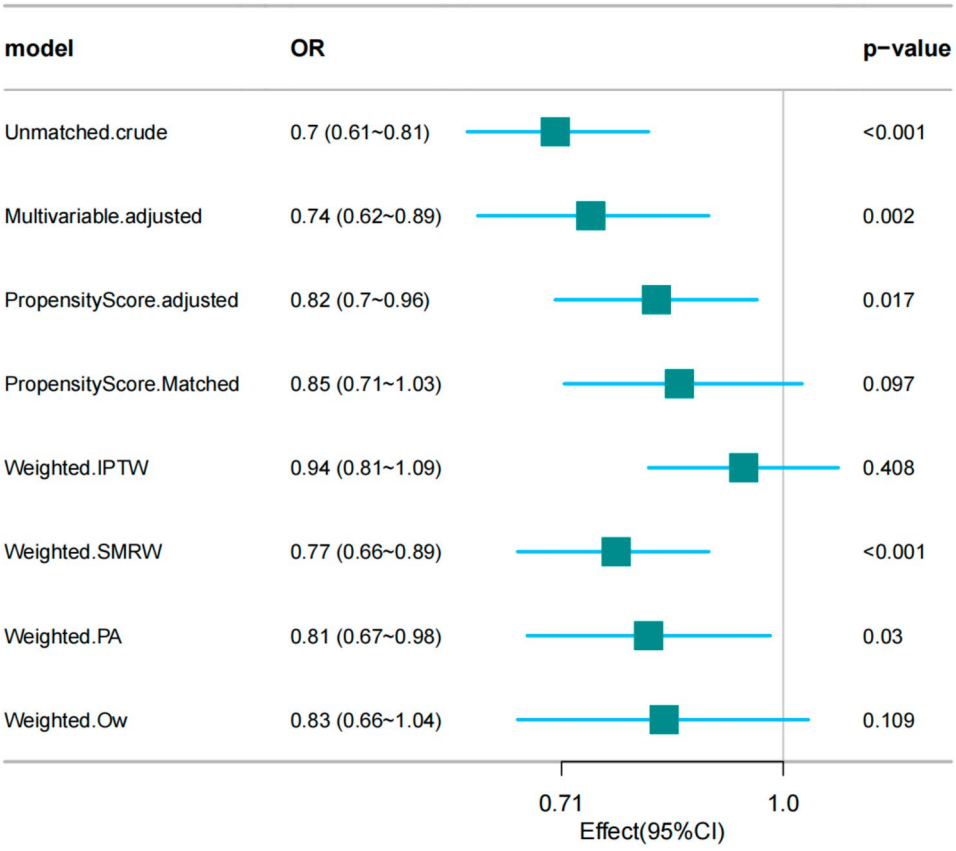

Fig. 4 Association between CVP measurement and 1-year mortality. The odds ratios and 95% confidence intervals (error bars) in the cohorts were calculated dependent on the method of covariate adjustment. Propensity score MW, Propensity score matching weight; Propensity score OW, Propensity score overlap weight

obtaining consistent cross-sections, making CVP monitoring a valuable and timely tool for managing critically ill patients.

In our study, the lowest hemoglobin level recorded after ICU admission was associated with 1-year mortality. Further analysis revealed that the lowest diastolic blood pressure (DBP_min), the lowest blood glucose (glucose_min), the highest blood chloride (chloride_max), as well as the APSIII, lowest Glasgow Coma Scale (GCS_min), SOFA, LODS, and OASIS scores were all significantly associated with 1-year mortality within 24 h of admission ($p < 0.05$). Specifically, DBP_min and glucose_min were negatively correlated with 1-year mortality, indicating that lower levels of these parameters were associated with better outcomes. Conversely, higher APSIII, lower GCS_min, SOFA, LODS, and OASIS scores were positively correlated with 1-year mortality, reflecting greater disease severity and increased mortality risk [31–34].Diastolic blood pressure results from the interplay between left ventricular mechanical work and the arterial system, depending on factors such as stroke volume (SV), forward blood flow, aortic stiffness, vessel size, and wave reflection [35]. Functional indices of left ventricular (LV) diastolic function have been found to be negatively correlated with elevated diastolic blood pressure, though not with systolic blood pressure [36]. Low diastolic blood pressure can diminish coronary perfusion pressure, leading to additional myocardial injury and exacerbating LV dysfunction [37]. A diastolic blood pressure drop below 70 mmHg may impair cardiac perfusion and negatively impact cardiovascular outcomes [38].

Our study also identified hyperchloremia as an independent risk factor for poor prognosis. Variations in serum chloride concentration, independent of sodium and bicarbonate levels, have been linked to increased risks of acute kidney injury (AKI), morbidity, and mortality [39]. Studies have suggested that chloride, rather than sodium, may contribute more substantially to poor survival outcomes associated with hyponatremia in heart failure patients [40]. While the exact mechanisms connecting renal function parameters and serum electrolyte fluctuations to adverse clinical outcomes warrant further investigation, our findings indicate that hyperchloremia should be avoided in heart failure patients whenever possible.

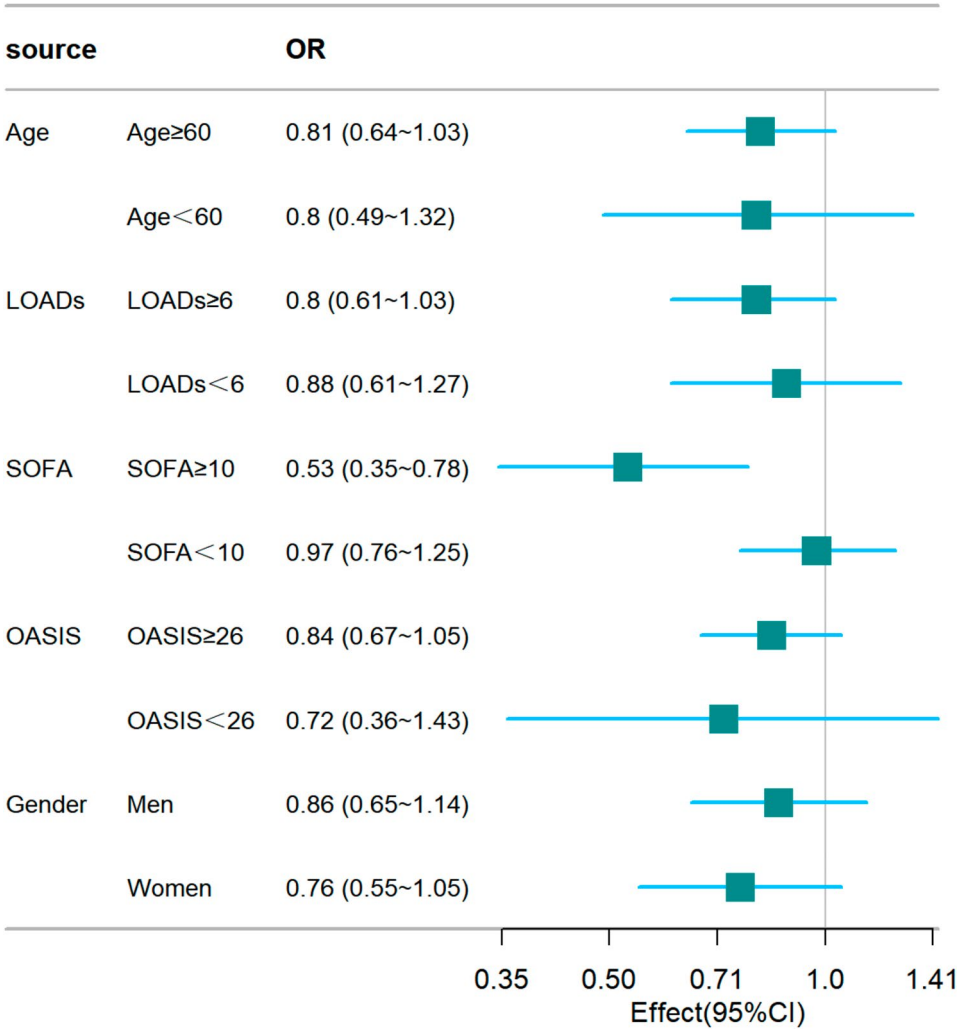

Fig. 5 Subgroup analysis showed the relationship between CVP measurement and 1-year mortality in different subgroups. The model was adjusted by age, gender, weight, apsiii, gcs min, SOFA, LODs, OASIS, wbc max, creatinine max. Abbreviations: LODS: Logistic Organ Dysfunction System; SOFA: Sequential Organ Failure Assessment; OASIS: Oxford Acute Severity of Illness Score

Our study also found that the lowest blood glucose level within 24 h of ICU admission was a risk factor for 1-year mortality in patients with severe heart failure. A review of the literature reveals that an international study retrospectively analyzed adult patients with type 2 diabetes mellitus and found that severe hypoglycemia requiring medical intervention was associated with a 68% higher relative risk of heart failure compared to those who did not experience such events (HR 1.68; 95% CI, 1.06–2.66). Additionally, severe hypoglycemia requiring assistance was linked to a 49% increased relative risk of heart failure (HR 1.49; 95% CI, 1.01–2.21) [41].Another study investigated the impact of hypoglycemic episodes during hospitalization for heart failure in patients with type 2 diabetes mellitus (T2DM) and found that patients with both T2DM and hypoglycemia had a 2.58-fold higher risk of all-cause mortality. In contrast, patients with T2DM but without hypoglycemia had a 1.32-fold higher risk of mortality [42].

Various studies have suggested a potential link between blood glucose levels and heart failure, though the underlying mechanisms require further investigation. It is widely accepted that hypoglycemia can increase myocardial electrical vulnerability and contribute to vascular thrombosis. Hypoglycemia triggers inflammation, abnormal platelet function, and activation of the fibrinolytic system, as well as induces oxidative stress and endothelial dysfunction [14, 30].All of these factors may contribute to the progression of atherosclerosis. Evidence indicates that in patients with type 2 diabetes mellitus, sudden glucose fluctuations can induce oxidative stress and enhance endothelial apoptosis more significantly than sustained hyperglycemia. These fluctuations may lead to coronary artery injury through mechanisms such as arrhythmias, prolonged cardiac repolarization, and

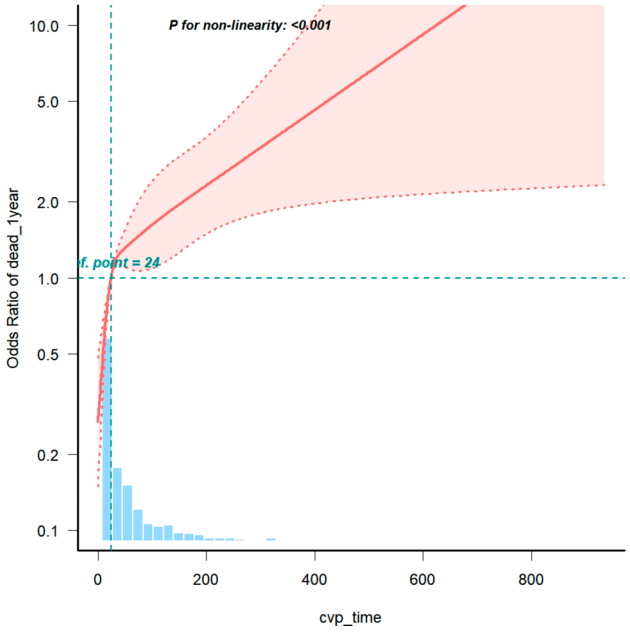

Fig. 6 Logistic fitting curve. Divided into CVP early cohort and CVP delayed cohort using 24 h as a division

hypoglycemia-associated autonomic failure [43]. Therefore, we recommend that ICU patients with heart failure undergo rigorous blood glucose monitoring and be vigilant for episodes of hypoglycemia.

Limitations

This study may have been influenced by the cessation of positive pressure mechanical ventilation, as normal CVP responses typically decrease during spontaneous breathing trials (SBT) in patients with normal cardiac function, absence of fluid overload, or significant inspiratory effort [44]. Additionally, the variability in CVP measurement techniques in clinical practice may have introduced information bias, affecting the consistency and reliability of the results.Moreover, as a retrospective study, several limitations are inherent: Selection Bias: Patients receiving CVP monitoring may represent a subgroup with more severe conditions or those admitted to high-performance ICUs, potentially limiting the generalizability of our findings. Propensity score matching and overlap weighting were applied to mitigate this bias, but unmeasured confounders remain a possibility.Survivor Bias: Patients who did not survive the early critical period (e.g., within 24 h) were excluded, possibly underestimating the immediate risks associated with CVP monitoring.Confounding Bias: Despite adjusting for key variables such as APSIII score, blood pressure, blood glucose, and chloride levels, the influence of unmeasured factors (e.g., adherence to therapeutic interventions) cannot be completely ruled out. Information Bias: Variations in CVP measurement protocols and potential inaccuracies in data collection may have impacted the precision of our findings.To address these limitations and validate our findings.These studies will include:1.Standardized CVP Monitoring Protocols:

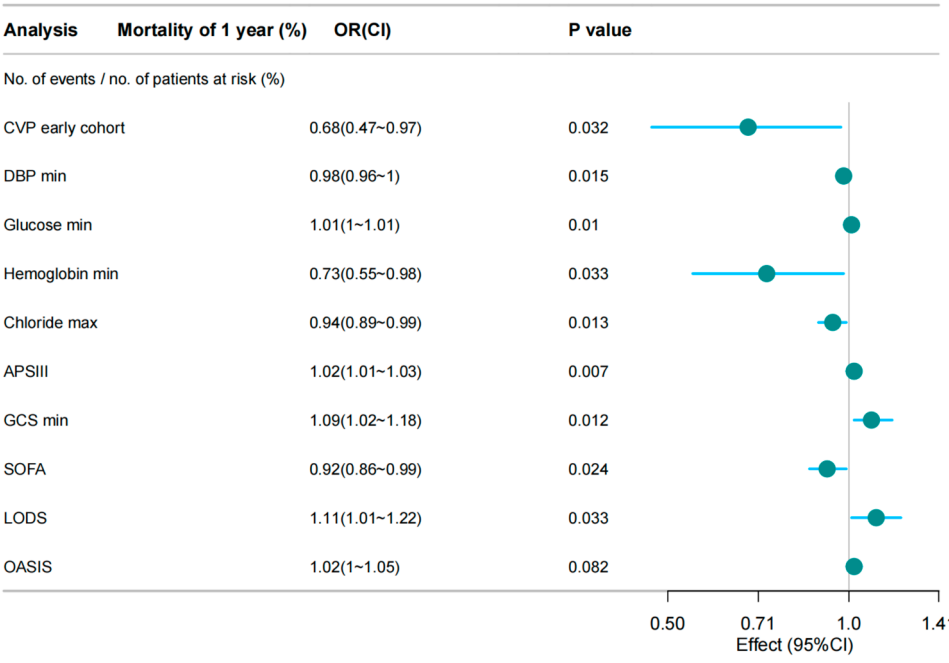

Fig. 7 Logistic multivariate analysis of CVP early cohort and CVP delayed cohort. Abbreviations: CVP: Central Venous Pressure; DBP: Diastolic Blood Pressure; APSIII: Acute Physiology Score III; GCS: Glasgow Coma Scale; SOFA: Sequential Organ Failure Assessment; LODS: Logistic Organ Dysfunction System; OASIS: Oxford Acute Severity of Illness Score

Implementing uniform protocols for CVP measurement to minimize variability and ensure consistency across clinical practices.2.Comprehensive Data Collection: Collecting detailed clinical, emodynamic, and outcome data from diverse ICU populations to enhance the generalizability of our findings.3.Focused Subgroup Analyses: Evaluating the differential effects of CVP monitoring in specific subpopulations, such as patients with heart failure, sepsis, or varying illness severities.4.Longitudinal Outcome Assessment: Investigating the long-term effects of early CVP monitoring, including its impact on mortality, weaning success, and quality of life after ICU discharge.These studies will aim to further evaluate the impact of early CVP monitoring on ICU patient prognosis, including its effects during and after weaning from mechanical ventilation.

Conclusion

Early monitoring of central venous pressure (CVP) in patients with heart failure can offer significant improvements in long-term prognosis. Our findings suggest that initiating CVP monitoring within 24 h of ICU admission is associated with a notable reduction in 1-year mortality, as compared to delayed monitoring. However, it is important to acknowledge the inherent limitations of our retrospective study, such as potential selection bias, survivor bias, and confounding variables. Given these limitations, we recommend that future prospective studies validate our findings and explore the benefits of early CVP monitoring across different subpopulations, including those with varying severity of heart failure. Based on our results, we propose that CVP monitoring be implemented within the first 24 h of ICU admission for patients with congestive heart failure, particularly those requiring deep venous cannulation, with a preference for using the internal jugular vein.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12872-025-04602-1.

Supplementary Material 1

Supplementary Material 2

Author contributions

Guangyong Jin and Shuohao Que performed the data processing and statistical analysis, Jiayi Chen drafted the manuscript, and Ying zhu, Buqing Ma and Wei Hu reviewed and organized the paper.

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Data availability

All data generated or analyzed during this study are included in this published article. Given that the research data involve sensitive information, there may be privacy and ethical concerns, so the datasets generated and/or analyzed in this study are not publicly available but may be obtained from the corresponding author upon reasonable request. Data supporting the findings of this study are available from the MIMIC database, though access to these data is restricted; they were obtained under license for this study and are therefore not publicly accessible. However, in accordance with the usage policies of the MIMIC-IV public database, access to MIMIC data requires completion of a specified ethics certification. If you wish to view the original data, please visit the MIMIC-IV database page (https://physionet.org/content/mimiciv/2.2/) and follow the instructions to obtain the necessary access permissions.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent to publish

Not applicable.

Clinical trial number

Not applicable.

Competing interests

The authors declare no competing interests.

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