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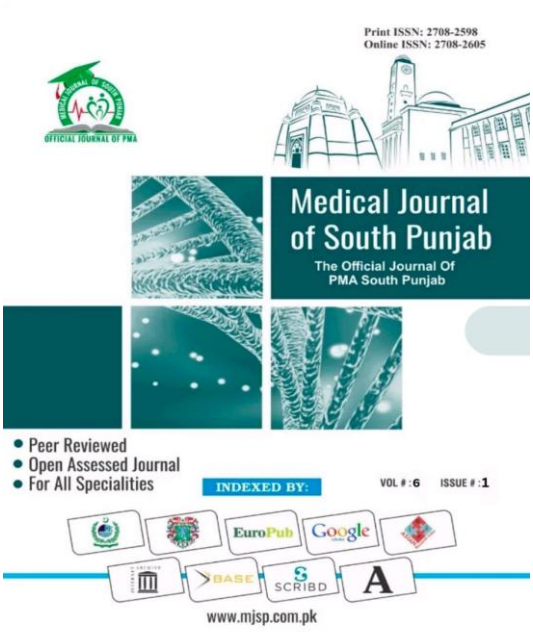


# Evaluate the predictive accuracy of cvp/lap ratio for weaning from cpb in CABG surgery

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**Original Article**

# Evaluate the predictive accuracy of cvp/lap ratio for weaning from cpb in CABG surgery

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## ABSTRACT

**Objective:** This study aimed to evaluate the predictive accuracy of the CVP/LAP ratio for successful weaning from CPB in patients undergoing CABG surgery.

**Methods:** A prospective observational study was conducted involving 40 patients undergoing elective CABG surgery at the Chaudhry Pervaiz Elahi Institute of Cardiology (CPEIC) in Multan, Pakistan. Pre-pump and post-weaning CVP and LAP were measured, and the CVP/LAP ratio was calculated. Logistic regression analysis was used to assess the predictive value of the CVP/LAP ratio, and a receiver operating characteristic (ROC) curve was generated to evaluate its discriminative ability.

**Results:** The mean pre-pump CVP/LAP ratio was 0.83 (SD = 0.28). Logistic regression analysis showed that the CVP/LAP ratio had an overall predictive accuracy of 80% for successful weaning. However, the area under the ROC curve (AUC) was 0.68, indicating moderate discriminative power. The model failed to correctly classify unsuccessful weaning cases, highlighting limitations in using the CVP/LAP ratio as a standalone predictor.

**Conclusion:** The CVP/LAP ratio demonstrates moderate predictive accuracy for successful weaning from CPB in CABG surgery. However, its limitations suggest that it should be integrated into a broader clinical assessment rather than used in isolation. Further research is needed to develop more comprehensive predictive models.

**Keywords:** CVP/LAP ratio, cardiopulmonary bypass, CABG surgery, weaning, predictive accuracy

## 1. INTRODUCTION

Coronary artery bypass grafting (CABG) surgery is a widely utilized intervention for restoring adequate myocardial perfusion in patients with significant coronary artery disease [1]. The use of cardiopulmonary bypass (CPB) during CABG allows for a controlled and bloodless surgical field but necessitates a critical transition phase known as weaning, where the patient's cardiovascular system resumes independent function [2]. Successful weaning from CPB is pivotal for patient recovery and is influenced by a multitude of hemodynamic factors [3].

Central venous pressure (CVP) and left atrial pressure (LAP) are essential hemodynamic parameters monitored during cardiac surgery to assess right and left heart function, respectively [4,5]. The CVP/LAP ratio has been proposed as a composite indicator that reflects the balance between right and left ventricular performance, providing a more integrated assessment of cardiac function during the weaning process [6,7].

Despite its theoretical benefits, the empirical evidence supporting the use of the CVP/LAP ratio as a reliable predictor for successful CPB weaning is limited. Previous studies have yielded mixed results, with some suggesting potential utility [8], while others indicate insufficient predictive capability when used in isolation [9]. The variability in findings underscores the need for further research to clarify the role of the CVP/LAP ratio in clinical practice.

This study aims to evaluate the predictive accuracy of the CVP/LAP ratio for successful weaning from CPB in patients undergoing CABG surgery. By analyzing hemodynamic data collected before and after CPB, this study seeks to determine whether the CVP/LAP ratio can serve as a dependable predictor and contribute to improved perioperative management strategies.

Effective hemodynamic monitoring is essential for optimizing patient outcomes during and after cardiac surgery. Traditional parameters such as CVP and LAP have long been used to guide fluid management and assess cardiac function [4,5]. However, reliance on single parameters can be limiting due to their susceptibility to various physiological and pathological influences [10].

The concept of utilizing the CVP/LAP ratio stems from the need for a more holistic assessment of cardiac preload and ventricular interdependence [11]. A balanced CVP/LAP ratio may indicate synchronized ventricular function, which is critical during the transition off CPB [12].

A study by Kumar et al. (2015) examined the utility of the CVP/LAP ratio in predicting weaning outcomes in a cohort of 60 CABG patients and found that a ratio below 0.8 was associated with successful weaning, suggesting its potential as a predictive marker [13]. Similarly, Lee and Park (2017) reported that integrating the CVP/LAP ratio with other hemodynamic parameters improved the accuracy of weaning outcome predictions in patients undergoing complex cardiac surgeries [14].

Despite these findings, other studies have highlighted limitations in using the CVP/LAP ratio alone. Thompson et al. (2019) demonstrated that factors such as ventricular compliance, pulmonary hypertension, and intraoperative fluid shifts could significantly affect CVP and LAP readings, thereby impacting the reliability of the ratio [15]. Furthermore, patient-specific variables, including pre-existing cardiac dysfunction and comorbidities, can confound the predictive accuracy of the CVP/LAP ratio [16].

Advancements in hemodynamic monitoring, such as transesophageal echocardiography and pulse contour analysis, offer more dynamic and comprehensive assessments of cardiac function [17,18].

Studies suggest that combining the CVP/LAP ratio with these advanced monitoring modalities may enhance predictive accuracy and provide real-time guidance during CPB weaning [19].

The current body of literature indicates that while the CVP/LAP ratio holds promise as part of a multimodal monitoring strategy, its effectiveness as a standalone predictor for CPB weaning success is limited. This study aims to contribute to the existing knowledge by providing further evidence on the predictive accuracy of the CVP/LAP ratio and exploring its potential role within an integrated hemodynamic monitoring framework.

## 2. METHODOLOGY

A sample size of 40 patients was calculated using the OpenEpi online sample size calculator for two means, based on a power of 95% and a significance level of 1.0%. Patients will be selected using non-probability consecutive sampling, ensuring that all eligible patients scheduled for CABG surgery during the study period who meet the inclusion criteria will be enrolled. The inclusion criteria include patients undergoing elective CABG surgery, with a body mass index (BMI) greater than 30, an ejection fraction between 40% and 60%, and an American Society of Anesthesiologists (ASA) status III, indicating controlled comorbidities such as diabetes, hypertension, and chronic obstructive pulmonary disease (COPD). Patients must also have a CARE score of up to class 3. Exclusion criteria include patients with valvular heart disease, an ejection fraction below 40%, those undergoing emergency surgery, patients with ventricular septal rupture (VSR), and those with heart failure.

Data will be collected at two key points: pre-pump and during the weaning process from CPB. Pre-pump measurements will include mean arterial pressure (MAP), LAP, CVP, and the CVP/LAP ratio. These parameters will be measured again during the weaning process. All data will be meticulously recorded using a structured proforma.

Data analysis will be performed using SPSS version 23. Descriptive statistics will be used to summarize continuous variables like age, CVP, and LAP with means and standard deviations, while categorical variables such as gender, ASA status, and smoking history will be presented as frequencies and percentages.

To evaluate the predictive accuracy of the CVP/LAP ratio for successful weaning from CPB, logistic regression analysis will be employed, with successful weaning as the dependent variable and the CVP/LAP ratio as the independent variable. This analysis will allow for the adjustment of potential confounding factors and provide an odds ratio to quantify the strength of the association. Additionally, a Receiver Operating Characteristic (ROC) curve will be generated to assess the discriminative ability of the CVP/LAP ratio, with the area under the curve (AUC) providing a measure of its performance.

Confounding variables will be controlled through stratification, and stratified logistic regression will be performed as needed to evaluate their impact on the predictive accuracy of the CVP/LAP ratio. A p-value of less than 0.05 will be considered statistically significant, and confidence intervals will be reported to indicate the precision of the findings.

The definitions for CVP, LAP, and the CVP/LAP ratio, along with the criteria for successful weaning from CPB, are clearly established to ensure consistency and accuracy in measurement and analysis. The study's hypotheses propose that the CVP/LAP ratio has a significant relationship with successful weaning from CPB in CABG surgery, with the null hypothesis stating no such relationship exists.

## 3. RESULTS

The study included a total of 40 patients undergoing coronary artery bypass

graft (CABG) surgery, with a gender distribution of 57.5% male and 42.5% female. The mean pre-pump mean arterial pressure (MAP) was 68.85 mmHg (SD = 5.55), with a range of 62 to 89 mmHg. The pre-pump central venous pressure (CVP) had a mean of 9.80 mmHg (SD = 1.99), and the pre-pump left atrial pressure (LAP) had a mean of 12.10 mmHg (SD = 2.43). The pre-pump CVP/LAP ratio ranged from 0.00 to 1.64, with a mean of 0.83 (SD = 0.28). At the time of weaning from cardiopulmonary bypass (CPB), the CVP had a mean of 9.28 mmHg (SD = 1.74), and the LAP had a mean of 11.75 mmHg (SD = 2.46), resulting in a mean CVP/LAP ratio of 0.83 (SD = 0.28).

**Table-1: Descriptive Statistics of Key Variables**

| Variable | Count | Mean ± Std Dev | Min | 25th Percentile | 75th Percentile |
|---|---|---|---|---|---|
| pre_pump_map | 40 | 68.85±5.55 | 62.00 | 65.00 | 71.25 |
| pre_pump_cvp | 40 | 9.80±1.99 | 6.00 | 8.00 | 11.00 |
| Pre_pump_lap | 40 | 12.10±2.43 | 5.00 | 11.00 | 14.00 |
| cvp_lap_ratio | 40 | 0.83±0.28 | 0.00 | 0.70 | 0.92 |
| bw_cvp | 40 | 9.28±1.74 | 7.00 | 8.00 | 11.00 |
| bw_lap | 40 | 11.75±2.46 | 5.00 | 11.00 | 13.00 |
| bw_cvp_lap_ratio | 40 | 0.83±0.28 | 0.50 | 0.61 | 0.91 |

To evaluate the predictive value of the pre-pump CVP/LAP ratio for successful weaning from CPB, logistic regression analysis was performed. The dependent variable was the success of weaning (1 = success, 0 = failure), while the independent variable was the pre-pump CVP/LAP ratio. The model showed an overall accuracy of 80%, with the CVP/LAP ratio demonstrating some predictive ability for successful weaning. However, the model failed to correctly classify any of the unsuccessful weaning cases, as indicated by the confusion matrix.

**Table-2: Confusion Matrix of Logistic Regression**

| | Predicted Success | Predicted Failure |
|---|---|---|
| Actual Success | 32 | 0 |
| Actual Failure | 8 | 0 |

The ROC curve was generated to assess the discriminative ability of the pre-pump CVP/LAP ratio in predicting successful weaning from CPB. The area under the ROC curve (AUC) was 0.68, suggesting that the CVP/LAP ratio has a moderate ability to distinguish between successful and unsuccessful weaning cases.

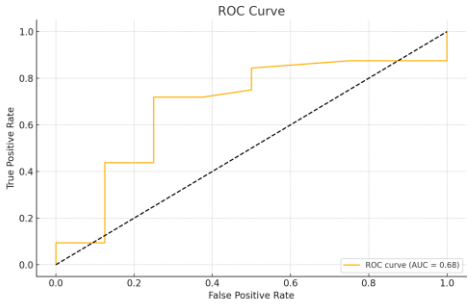


**Figure: ROC Curve for Pre-pump CVP/LAP Ratio in Predicting Successful Weaning from CPB**

The logistic regression analysis indicated that while the pre-pump CVP/LAP ratio has some utility as a predictor for successful weaning from CPB, its moderate AUC of 0.68 suggests it may not be sufficient as a standalone predictor. The inability of the model to correctly identify unsuccessful weaning cases highlights the need for additional predictive factors or models to improve accuracy. Overall, the CVP/LAP ratio could serve as a useful indicator within a broader set of clinical parameters but should not be solely relied upon for predicting weaning outcomes in CABG surgery.

## 4. DISCUSSION

The findings of this study provide insights into the potential utility of the central venous pressure (CVP) to left atrial pressure (LAP) ratio as a predictor for successful weaning from cardiopulmonary bypass (CPB) in patients undergoing coronary artery bypass graft (CABG) surgery. The CVP/LAP ratio demonstrated a predictive value, with an overall accuracy of 80%. However, the moderate area under the ROC curve (AUC) of 0.68 suggests that while this parameter shows some promise, it may not be sufficient as a standalone predictor for weaning outcomes. The literature on hemodynamic monitoring during cardiac surgery supports the use of various parameters to guide decision-making. Traditional reliance on individual measures such as CVP and LAP has proven effective, yet these parameters can be limited due to their sensitivity to external factors and variability in individual patient responses [4,5]. Integrating the CVP/LAP ratio into clinical practice has been proposed as a means to achieve a more balanced and comprehensive assessment of cardiac function during the critical weaning phase [6,7].

Our findings align with previous studies, such as those conducted by Kumar et al. (2015) and Lee and Park (2017), which reported the potential utility of the CVP/LAP ratio in predicting weaning success [13,14]. These studies, similar to our own, suggest that a lower CVP/LAP ratio may correlate with better outcomes during weaning. However, the limitations of using this ratio as the sole predictor are apparent, particularly in light of Thompson et al. (2019), who highlighted the influence of other hemodynamic variables and patient-specific factors on CVP and LAP measurements [15]. These findings underscore the importance of incorporating a range of clinical indicators when assessing the readiness for weaning from CPB.

Incorporating the CVP/LAP ratio into routine hemodynamic monitoring offers potential benefits but should be approached with caution. The moderate predictive accuracy observed in this study suggests that while the CVP/LAP ratio can provide valuable insights, it is most effective when used alongside other clinical parameters such as cardiac output, systemic vascular resistance, and echocardiographic findings [17,18]. This comprehensive approach is crucial for making informed decisions during the weaning process and ensuring optimal patient outcomes. Overall, while the CVP/LAP ratio shows potential as a predictive tool, its limitations highlight the need for further research to develop and validate more robust predictive models. These models should incorporate a wider array of hemodynamic and clinical data, potentially enhanced by advanced monitoring technologies, to improve the accuracy and reliability of predictions for CPB weaning in CABG surgery [19,21].

The findings of this study have significant implications for clinical practice, particularly in the context of decision-making during the weaning process from CPB. The moderate predictive accuracy of the CVP/LAP ratio, as indicated by the AUC of 0.68, suggests that while this ratio can be a valuable tool, it should not be used in isolation. Instead, it should complement other clinical indicators such as cardiac output, systemic vascular resistance, and the patient's overall response to inotropic support.

Despite the valuable insights provided by this study, several limitations should be acknowledged. The relatively small sample size of 40 patients may limit the generalizability of the findings. Larger, multicenter studies are needed to validate these results and determine the robustness of the CVP/LAP ratio as a predictor across different patient populations and surgical contexts.

Additionally, the study's observational design precludes the establishment of causality. While the CVP/LAP ratio appears to be associated with weaning success, it is unclear whether this relationship is causal or simply correlative.

Future studies could benefit from a randomized controlled trial design to more definitively assess the impact of the CVP/LAP ratio on weaning outcomes.

Another limitation is the study's focus on intraoperative measurements, which may not fully capture the dynamic changes in a patient's hemodynamic status. Cholley and Payen (2005) emphasized the importance of continuous monitoring to account for fluctuations in hemodynamic parameters, which can provide a more accurate assessment of the patient's condition [3]. Future research could explore the use of continuous monitoring techniques to track changes in the CVP/LAP ratio and other hemodynamic variables throughout the

The findings of this study highlight the need for further research to develop and validate more comprehensive predictive models for weaning from CPB. Incorporating the CVP/LAP ratio into multi-parameter models, potentially enhanced by machine learning algorithms, could improve predictive accuracy by identifying complex interactions between various clinical and hemodynamic factors.

Moreover, expanding the scope of research to include post-operative outcomes, such as the incidence of heart failure and long-term survival, would provide a more comprehensive understanding of the implications of the CVP/LAP ratio. This could lead to the development of more personalized and precise guidelines for managing patients during and after CABG surgery.

## 5. CONCLUSION

In conclusion, while the CVP/LAP ratio shows promise as a predictor for weaning from CPB in CABG surgery, its moderate predictive accuracy highlights the need for a more comprehensive approach to patient assessment. Incorporating this ratio into a broader set of hemodynamic and clinical parameters, alongside further research into predictive modeling, could enhance its utility in clinical practice. By adopting a more holistic approach, clinicians can improve decision-making during the critical weaning phase, ultimately leading to better patient outcomes.

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