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Post Hoc analysis of cardiopulmonary indicators trends among post-operative coronary artery bypass graft patients with normal ventilator weaning response and dysfunctional ventilator weaning response

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Abstract

Objectives: The objectives of this post hoc analysis was to describe the characteristics of cardiopulmonary indicators among patients with normal ventilator weaning response and dysfunctional ventilator weaning response after coronary artery bypass graft surgery, and to find the differences in characteristics of cardiopulmonary indicators between patients with normal ventilator weaning response and dysfunctional ventilator weaning response after coronary artery bypass graft surgery.

Materials and Methods: A post hoc analysis was performed using available data. Descriptive and inferential statistics were used to describe and compare the data. Available data was collected using a retrospective chart audit of the patients who underwent coronary artery bypass graft surgery. All the statistical significance tests were performed as two-tailed tests. A p value of < 0.05 was considered significant.

Results: The results revealed that there are significant differences between patients with normal ventilator weaning response and dysfunctional ventilator weaning response in the trends of cardiopulmonary indicators including respiratory rate, cardiac output, cardiac index, pulmonary artery diastolic pressure, and pulmonary artery systolic pressure during the first eight post-operative hours of coronary artery bypass graft surgery.

Conclusions: Cardiopulmonary indicators may be used to assess the ventilator weaning process following coronary artery bypass graft surgery. The results may have implications to the assessment, planning, providing, evaluating, and coordinating post-operative care for patients undergoing coronary artery bypass graft surgery.

Introduction

Ventilator weaning is an important aspect of critical care nursing for postoperative coronary artery bypass graft (CABG) surgery patients. Determination of optimum cardiopulmonary function is a prerequisite for the weaning process. Restoration and maintenance of normal cardiopulmonary function without injuring the heart and other organs represent the most important goal in the nursing care of postoperative CABG surgery patients. Continuous postoperative cardiopulmonary indicators (CPI) monitoring to prevent postoperative complications in the intensive care unit (ICU) is a known practice. The critical care nurse plays an important role in the prevention of postoperative complications through CPI monitoring. The primary functions of the critical care nurse during the postoperative period are CPI monitoring, hemodynamic stabilization, and assessing weaning readiness of the patient.

Dysfunctional Ventilator Weaning response (DVWR) is a common post-operative complication after CABG surgery (1). Recovery and stabilization of cardiopulmonary function is the major task of postoperative intensive care following surgery. The most important component of the postoperative intensive care services after CABG surgery includes weaning from mechanical ventilation and hemodynamic stabilization. Advances in fast track weaning protocols have decreased the required duration of postoperative mechanical ventilation after CABG surgery from a few days to a few hours (2-3,5). The findings from recent studies reveal that the time limits of Normal Ventilator Weaning Response (NVWR) after CABG surgery vary from one to ten hours (1, 6-25). Most patients are extubated within six to eight hours after surgery. However, 20 to 40% of patients remain intubated twelve hours after surgery. 
due to dysfunctional ventilator weaning response (DVWR) (1, 6-25).

Although the hemodynamic stability is the prerequisite for the initiation of the weaning process, little is known about its association with DVWR. Cardiopulmonary Indicators are the clinical hemodynamic variables measured through invasive and non-invasive monitoring techniques in the ICU. The selected CPI to examine the predictive value in this study are heart rate (HR), mean arterial pressure (MAP), central venous pressure (CVP), cardiac output (CO), respiratory rate (RR), mixed venous oxygen saturation (SVO2), oxygen saturation (SpO2), pulmonary artery diastolic pressure (PAD) and pulmonary artery systolic pressure (PASP). Changes in CPI precede the dysfunctional ventilator weaning response. They can be readily identified through hemodynamic trends by the bedside clinician. In addition, CPI is the sensitive and reliable clinical variable, which may be helpful to foresee the DVWR.

The defining characteristics of DVWR depend upon the severity of the condition. It can be mild, moderate or severe. The majority of the defining characteristics include alteration in hemodynamic clinical data, which can be measured objectively. The signs and symptoms of mild DVWR include slight increased respiratory rate (RR) from the baseline and excessive use of respiratory muscles. The signs and symptoms of moderate DVWR include increase in blood pressure, increase in heart rate, increase in respiratory rate, mild cyanosis, decrease in oxygen saturation from the baseline, and excessive use of accessory muscles for respiration. The signs and symptoms of severe DVWR include deterioration in arterial blood gases, increase in blood pressure, increase in heart rate, and increase in respiratory rate, cyanosis, gasping, altered mental status, and decrease in oxygen saturation (17).

Prevalence and risk factors

Yende reported that 20 to 40% of patients continue to receive Prolonged Mechanical Ventilation (PMV) after undergoing CABG surgery due to DVWR (21). The causes of PMV after CABG surgery are heterogeneous, vary with time, and have a variable impact on the duration of mechanical ventilation required after the patient undergoes CABG surgery. Hypoxemia was found to be the most common cause for PMV for greater than 24 hours (5). Several researchers reported the causes for prolonged ventilation after heart surgery as pulmonary edema (25%), ARDS (5%), excessive bleeding (10%), and tachypnea during weaning trials (16.2%) (20,21). Some research findings reveal that increased age above 70 years is associated with PMV (8,19). In contrast, recent research findings reveal that the outcome of CABG surgery has progressively improved despite increased numbers of elderly patients and worsened preoperative risk profiles over the past few decades, and increased age is not associated with PMV (1,2,7,12).

There are many clinical variables associated with DVWR. Clinical variables such as chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), emergency surgery, and number of grafts are found to be associated with DVWR and PMV (6,7,12,20,21). Some researchers reported that DVWR is associated with the adult respiratory distress syndrome after CABG surgery (6,16,24). Another common complication associated with DVWR following cardiac surgery is deep vein thrombosis. Findings from some studies reveal that 23.6% of patients who required prolonged mechanical ventilation developed deep vein thrombosis despite 100% prophylaxis. Multi organ dysfunction syndrome is also a complication associated with DVWR and PMV.

Furthermore, DVWR is a critical problem as it is associated with ICU mortality following CABG surgery (2,15,22). The mortality related to DVWR is reported as 43% (20,21). The mortality after heart surgery is associated with many complications of DVWR such as acute respiratory distress syndrome, multiorgan dysfunction syndrome, deep vein thrombosis, and ventilator - associated pneumonia. The ICU mortality related to acute respiratory distress syndrome is reported as 15%. The ICU mortality attributable to multiorgan dysfunction syndrome is reported as 19.6%. Another common cause of ICU mortality is ventilator-associated pneumonia. The Institute of Hospital Improvement (2004) Report revealed that ventilator-associated pneumonia is a leading cause of morbidity and mortality in the ICU resulting from DVWR and PMV. The ICU mortality associated with ventilator-associated pneumonia is 30% to 50% (20,21).

The other health care problems resulting from DVWR are increased ICU length of stay and ICU cost (8,15). Providing critical care consumes 30% of the hospital expenses for just 8% of the hospital population (14). Several researchers who focused on studying ICU length of stay and early extubation after cardiac surgery, reported that increased ICU length of stay and ICU cost is directly associated with DVWR and PMV (8,15). Prolonged mechanical ventilation more than 48 hours accounted for 42.8% of the total ICU cost (14).

As a solution to the problem, recent research findings reveal that hemodynamic variables have predictive values in ventilator weaning (14). Many researchers have reported that CPI is associated with ventilator weaning outcomes particularly with PMV. However, no reported study focused on selected CPI, which may be used as predictive indicators for DVWR. Findings from some research reveal that the increase in MPASP and the change in the CO during weaning process are associated with weaning failure. A progressive decrease in SVO2 during the weaning process is reported as associated with weaning failure. Increased respiratory rate during the weaning process is also associated with weaning failure (20). Alteration in cardiac index during weaning has been found to have association with weaning failure (15). Although many researchers have reported the association between CPI and weaning outcomes, there is no reported research using selected CPI for the prediction of DVWR.

Using CPI to predict the DVWR has many advantages such as being sensitive indicators, reliable in detecting the complications beyond the associated co morbidity, helpful in early
diagnosis, and feasible to implement in practice by the nurses in detecting the DVWR and preventing premature trials. Cardiopulmonary indicators are sensitive indicators in identifying complications among cardiac surgery patients.

Weaning is an important aspect of critical care nursing for postoperative CABG surgery patients. Determination of optimum cardiopulmonary function is a prerequisite for the weaning process. Restoration and maintenance of normal cardiopulmonary function without injuring the heart and other organs represent the most important goal in the nursing care of postoperative CABG surgery patients. Continuous postoperative CPI monitoring to prevent postoperative complications in the ICU is a known practice. The critical care nurse plays an important role in the prevention of postoperative complications through CPI monitoring. The primary functions of the critical care nurse during the postoperative period are CPI monitoring, hemodynamic stabilization, and assessing weaning readiness of the patient. Thus, the critical care nurse plays an important role in predicting DVWR through CPI.

Although the fast track weaning protocols driven early extubation has economic implications, it is imperative to consider that there are a considerable number of postoperative CABG patients are at risk of developing DVWR. Weaning from mechanical ventilation involves a significant amount of stress to physiological systems and increased risk of postoperative silent myocardial ischemia. Prediction of DVWR could help in preventing post-operative complications after CABG surgery.

The purposes of this post hoc analysis were to:
1. Describe the characteristics of CPI trends among patients with NVWR and DVWR after CABG surgery.
2. Find the differences in characteristics of cardiopulmonary indicators trends between patients with NVWR and DVWR after CABG surgery.

Materials and Methods

A post hoc analysis was performed using available data. Descriptive and inferential statistics were used to describe and compare the data. Available data was collected using a retrospective chart audit of the patients who underwent CABG surgery. After the IRB approval, a purposive sampling strategy was used to select the electronic medical records of 300 (100 Cases DVWR; 200 control NVWR) patients who underwent CABG surgery (On- pump) from the EPF system. Data was retrieved using operational definitions and data abstraction form.

Operational Definitions

Cardiopulmonary indicators (CPI): Cardiopulmonary indicators are defined as the selected hemodynamic variables recorded postoperatively in the cardio vascular intensive care unit (CVICU) after CABG surgery. Within this study CPI include HR, MAP, CVP, CO, RR, SVO2, SpO2, PAD and PASP which are retrieved from the electronic patient file (EPF) of postoperative CABG patients. Electronic patient file is an electronic medical record of the patients in which the individual patient’s information, clinical data, treatments and outcome are recorded and maintained by the study hospital. A definition for each of these indicators follows.

Heart rate (HR): The actual numeric value of heartbeat recorded by the Spacelab cardiac monitor and electronically transferred to the patient’s vital sign computer charting. It is retrieved from the nursing assessment page of EPF.

Mean arterial blood pressure (MAP): The actual numeric value of the MAP recorded by Spacelab cardiac monitor through the arterial line and electronically transferred to the patient’s vital sign computer charting. It is retrieved from the nursing assessment page of the EPF.

Central venous pressure (CVP): The actual numeric value of CVP recorded through the pulmonary artery catheter by the Spacelab cardiac monitor and electronically transferred to the patient’s vital sign computer charting. It is retrieved from the nursing assessment page of EPF.

Cardiac output (CO): The actual numeric value of cardiac output recorded through the pulmonary catheter by the Edward lifescience SVO2 monitor and entered into the nursing assessment page; it is retrieved from the nursing assessment page of the EPF.

Respiratory rate (RR): The actual numeric value of the patients’ total ventilator rate per minute recorded by the ventilator and entered into the nursing assessment page; it is retrieved from the nursing assessment page of the EPF.

Mixed venous oxygen saturation (SVO2): The actual numeric value of SVO2 recorded through the pulmonary artery catheter by the Edward lifescience SVO2 monitor and entered into the nursing assessment page; it is retrieved from the nursing assessment page of the EPF.

Oxygen saturation (SpO2): The actual numeric value of the SpO2 recorded by the Spacelab cardiac monitor through a Nellcor pulse oxymetry probe and electronically transferred to the patient’s vital sign computer charting. It is retrieved from the nursing assessment page of the EPF.

Pulmonary artery diastolic pressure (PAD): The actual numeric value of PAD recorded through the pulmonary artery catheter by the Spacelab cardiac monitor and electronically transferred to the patient’s vital sign computer charting. It is retrieved from the nursing assessment page of the EPF.

Pulmonary artery systolic pressure (PASP): The actual numeric value of PASP recorded through the pulmonary artery catheter by the Spacelab cardiac monitor and electronically transferred using operational definitions and data abstraction form.
transferred to the patient’s vital sign computer charting. It is retrieved from the nursing assessment page of the EPF.

Dysfunctional ventilator weaning response (DVWR): DVWR is operationally defined as the condition in which the patient remains on the ventilator > 8 hours after surgery. It is identified as the ventilator setting charted after 8 hours of surgery in the nursing assessment and nursing notes pages of the EPF.

Normal ventilator weaning Response (NVWR): Normal ventilator weaning response is operationally defined as the condition in which the patient is extubated and placed on either a binausal cannula or an aerosol facemask before 8 hours after surgery. It is the first charted time of BiNasal cannula (BNC) or aerosol facemask (AFM) oxygen after surgery, which is recorded in nursing assessment and nursing notes pages of the EPF.

Statistical Analysis

Statistical analysis was performed using a SAS statistical analysis software program. Descriptive statistics were performed on all variables, including demographic and comorbid data. All the statistical significance tests were performed as two-tailed tests. A p value of < 0.05 was considered significant.

Results and Discussion

Description of CPI trends comparison between cases and control

The descriptive trends of CPI means are displayed from Figure 1 to Figure 10. The differences in the mean of CPI were established by performing an unpaired t-test comparing the hourly mean of CPI in cases and control.

The result of comparing heart rate trends revealed that there were no significant differences in the hourly mean heart rate between cases and control except at the first hour, when there was a significant differences (p = 0.05) in mean heart rate between cases and control.

Comparison of hourly trends mean of MAP revealed no significant differences between cases and control except at the fifth hour, when there was a significant difference (p = 0.01) in the mean MAP.

The comparison of CVP trends revealed that there were no significant differences between cases and control in the hourly mean CVP of first, second, fourth, fifth, sixth, and eleventh hours. However, there was a significant difference between cases and control in the mean CVP at the third hour (p = 0.05), the seventh hour (p = 0.004), the eighth hour (p = 0.01), the ninth hour (p < 0.0001), the tenth hour (p = 0.05), and the twelfth hour (p = 0.001).

Comparison of RR trends revealed no significant difference in the mean RR between cases and control at the first hour. However, there was a significant difference between cases and controls in mean RR at all the times.

Comparison of the hourly means of SPO2 in cases and control revealed no significant difference in the hourly mean of SPO2 between cases and control except in the fourth, fifth, and sixth hour.

The comparison result of CO revealed that there is significant difference in the hourly mean of CO between cases and controls except in ninth, tenth, and eleventh hour.

The comparison result of CI revealed significant difference in the hourly mean of CI between cases and controls in the first, fifth, sixth, eighth and twelfth hour.

The comparison result of PAD revealed that there is significant difference in the hourly mean of PAD between cases and controls in all the hours except the first and eighth hour. The trend reveals that the mean PAD pressure is same for cases and controls during the first hour. However, the mean PAD pressure for the cases remains higher than control throughout eight hours, while the mean PAD of controls decreases during the third, fourth, fifth, and sixth hours, followed by a plateau at the seventh and eighth hour.

The trend reveals that the mean PASP in patients with DVWR (Cases) is higher than in the patients with NVWR (control) for the first three hours. There is a gradual increase in PASP in the patients with NVWR from the fourth hour and it remains higher than in the cases from the fourth to the eighth hour.

The comparison result of SVO2 revealed no significant difference between cases and controls in the hourly mean of SVO2 in all the hours except the eleventh and twelfth hours.

Differences in the characteristics of CPI

The second purpose of this analysis was to find the differences in the characteristics of the CPI in patients with DVWR (cases) and NVWR (control) after CABG surgery. To answer the above research purpose, the researcher first found the differences in study clinical variables by comparing the frequencies and proportions of the clinical variables of cases and controls through chi-square test. A preplanned comparison of clinical variables was performed in this analysis, which included the study variables such as COPD, CHF, and renal failure.

Based on the descriptive findings the researcher performed a post hoc analysis, which included the comparison of the demographic variables and clinical variables such as age, sex, BSA, and number of grafts between cases and control. Although age has no significant differences, sex was included in the analysis as a covariate acknowledging the maturation effect of age in the CPI. Sex was included as a covariate in the post hoc analysis considering the occurrence of increased proportion of frequency distribution of female sex in the cases. Although BSA is not a study variable, it was included in the analysis as a covariate considering the effect of BSA in the CPI. Number of grafts were included as a covariate in the post hoc analysis because of it’s effect on the postoperative
Figures

1. The mean heart rate (HR) trend
2. The mean mean arterial blood pressure (MAP) trend
3. The mean central venous pressure (CVP) trend
4. The mean respiratory rate (RR) trend
5. The mean oxygen saturation (SpO2) trend
6. The mean cardiac output (CO) trend
7. The mean cardiac index (CI) trend
8. The mean pulmonary artery diastolic pressure (PAD) trend
9. The mean pulmonary artery systolic pressure (PASP) trend
10. The mean mixed venous oxygen saturation (SVO2) trend
recovery and acuity of the patient.

A test of the hypothesis was performed with $H_0$: $P$ (cases) = $P$ (controls) versus $H_1$: $P$ (cases) ≠ $P$ (controls). The results of the chi-square test revealed no significant difference in the demographic variables such as BSA, number of grafts, and renal failure among cases and controls. However, there was a significant difference in the prevalence of COPD ($p < 0.0001$) and CHF ($p = 0.0003$) among cases and controls. In addition, there was a significant difference ($p = 0.01$) in sex when comparing cases and controls. Further, Age groups showed a significant ($p = 0.05$) difference between cases and controls.

Next, differences in the characteristics of CPI between DVWR (cases) and NVWR (controls) were demonstrated with a consideration of all the possible significant antecedences as covariates; the analysis was accomplished through an ANOVA for a repeated-measures model based design using the PROC MIXED procedure of SAS. The covariates included in this analysis included age, sex, BSA, number of grafts, COPD, CHF, and renal failure.

The first eight repeated mean measures were generated for CPI values in eight hourly time points for cases and controls. The comparison of group means was performed using ANOVA for repeated measures through Mixed procedure (PROC MIXED). This procedure was selected because it is specifically designed for mixed effects models. In addition, PROC MIXED procedure is selected to accommodate the following considerations in analysis.

The first consideration was that this research data contained a considerable amount of missing data. To address this issue the PROC MIXED repeated measure ANOVA was selected as it handles missing data and applies multiple comparison procedures to both between and within subjects’ factors. Unlike other programs, the PROC MIXED handles all of the technical details itself through likelihood based estimation method. Further, it knows the proper way to construct its test statistics that account for the fixed and random nature of the study factors. In addition, it provides many important, unique features such as provision for a larger class of covariance structures and a better mechanism of handling missing data through estimates of covariance by restricted maximum likelihood computations and comparisons.

The next consideration was to control for the effects of covariates on the outcome variable. As this research, study involves multiple covariates, controlling for their effect was mandatory while addressing this research question. Assessing the nature of this study data, CPI may be influenced by the effect of various covariates such as age, sex, COPD, CHF, renal failure, BSA, and number of grafts. With repeated measures analysis of variance, measurements made on the same subject are likely to be more similar than measurements made on different individuals. That is, repeated measures are correlated. For an analysis to be valid, the co-variances among repeated measures must be modeled properly. The PROC MIXED ANOVA for repeated measures computes LSMEANS which are averaged across repeated measures and whose standard errors reflect the appropriate covariance structure. The covariance structure used in this study is compound symmetry (CS), which implies that the correlations between all pairs of measures are the same. This process is accomplished through the PROC MIXED repeated measures ANOVA program, in order to have control the effects of repeated measures arising from different sets of conditions, such as the response to different conditions.

The methods implemented in the PROC MIXED were based on an assumption of normally distributed residuals, independent, constant variances across groups. The PROC MIXED uses a restricted maximum likelihood-based estimation routine (REML) based on normal distribution theory and therefore does not compute nor display sums of squares as observed with PROC GLM.

A null and alternative hypothesis was formulated as $H_0$: All means are equal vs At least one means is different with alpha of 0.05. The Restricted maximum likelihood-based estimation routine (REML) uses a weighted average of the individual sample variances. The results are presented in the ANOVA...
The ANOVA table shows no significant differences in the means of heart rate between DVWR (Cases) and NVWR (Controls) groups. However, there is a significant (p = 0.0005) difference in the effect of time on the heart rate means between cases and controls. Age had a significant (p = 0.008) effect on HR. In contrast, covariates such as sex, BSA, CHF, COPD, Renal failure, and Number of grafts did not have a significant effect on the heart rate means of cases and controls.

The ANOVA table shows no significant differences in the group means of MAP between DVWR (Cases) and NVWR (Controls) groups. However, there are significant differences in the effect of age (p = 0.0028) and sex (p = 0.0012) on the group means of MAP between cases and controls. Covariates such as BSA, CHF, COPD, Renal failure, and Number of grafts did not have a significant effect on the group means of MAP cases and controls.

The ANOVA table shows no significant differences in the group means of CVP between DVWR (Cases) and NVWR (Control) groups. However, there is a significant (p < 0.0001) difference in the effect of time on the group means of CVP between cases and controls. Covariates such as age, sex, CHF, COPD, Renal failure, and number of grafts did not have a significant effect on the heart rate means of cases and controls. There is also a significant (p = 0.044) effect of BSA on the group means of CVP.

The ANOVA table shows a significant (p < 0.001) differences in the group means of RR between DVWR (Cases) and NVWR (Controls). In addition there is a significant (p < 0.0001) difference in the effect of time on the group means of RR. Further there are significant (p = 0.0086) difference in the effect of number of grafts and BSA (p = 0.0028) on the group means of RR. Covariates such as Age, Sex, CHF, COPD, Renal failure did not have a significant effect on the group means of respiratory rate. The ANOV A table shows a significant (p = 0.054) difference in the group means of SPO2 between DVWR (Cases) and NVWR (Controls). In addition, there are significant differences in the effect of covariates such as Age (p = 0.042), BSA (p = 0.0034), Renal failure (p = 0.019), and Number of grafts (p =0.057) on the group means of SPO2. However, covariates such as sex, CHF, and COPD, did not have a significant effect on the group mean SPO2 of cases and controls.

The ANOVA table shows that there is a significant (p = 0.03) differences in the group means of CO between DVWR (Cases) and NVWR (Control) groups. In addition, covariates such as Age (p = 0.015), Sex (p <0.0001), and BSA (p = 0.0001) have a significant effect on the group means of CO. Other covariates such as CHF, COPD, Renal failure, and Number of grafts did not have a significant effect on the group means of CO.

The ANOVA table shows a significant ( p = 0.03) differences in the group means of CI between DVWR (Cases) and NVWR (Control) groups. In addition, covariates such as Age ( p = 0.016), Sex ( p <0.0001), and BSA ( p = 0.0001) have a significant effect on the group means of CI. Other covariates such as CHF, COPD, Renal failure, and Number of grafts did not have a significant effect on the group means of CI.

The ANOVA table shows a significant (p = 0.0012) differences in the group means of PAD between DVWR (Cases) and NVWR (Controls) groups. In addition there is also a significant effect (p = 0.011) of time on the group means of PAD. Age also had a significant effect on PAD (p = 0.04). In contrast, covariates such as sex, BSA, CHF, COPD, Renal failure, and number of grafts did not have significant effect on the group means of PAD in cases and controls.

The ANOVA table shows no significant differences in the group means of PASP between DVWR (Cases) and NVWR (Control) groups. However, there are significant effects of covariates such as BSA (p = 0.0059), CHF (p = 0.0034), and Number of grafts (p < 0.05) on the group means of PASP. Covariates such as Age, Sex, COPD, and Renal failure did not have a significant effect on the group means of PASP in cases and controls.

The ANOVA table shows no significant difference in the group means of SVO2 between DVWR (Cases) and NVWR (Control). In addition, there is no significant effect of time on the group means of SVO2 in cases and controls. Covariates such as Age, Sex, BSA, CHF, COPD, Renal failure, and Number of grafts did not have a significant effect on the group means of SVO2 in cases and controls.

These analysis findings also revealed that there are significant differences between cases and controls in the characteristics of certain CPI such as RR, SPO2, CO, CI, and PAD after CABG surgery. There was a significant (p < 0.001) difference in the group means of RR between DVWR (Cases) and NVWR (Control). There was also a significant (p = 0.054) difference in the group means of SPO2 between DVWR (Cases) and NVWR (Control) groups noted. In addition, there was a significant (p = 0.03) difference in the group means of CO between DVWR (Cases) and NVWR (Control) groups. Further, there is a significant (p = 0.03) difference in the group means of CI between DVWR (Cases) and NVWR (Control) groups. Furthermore, there was a significant (p = 0.0012) difference in the group means of PAD between DVWR (Cases) and NVWR (Control) groups. These analysis findings also revealed that there are no significant differences between cases and controls in the characteristics of certain CPI such as HR, MAP, CVP, PASP, and SVO2 after CABG surgery. In addition, the findings revealed that Covariate COPD did not have any effect on the characteristics of CPI among cases and controls after CABG surgery, however, COPD as comorbidity showed significant predictability to DVWR. This finding may be attributed to the small sample size used in this study, which may not be adequate to demonstrate the significance of this finding, which may warrant for future replication studies with larger sample size to further validate the findings. These results may have implications in the areas of education, practice, and research related to assessment, planning, providing, evaluating, and coordinating post-operative care for patients undergoing CABG surgery. Findings are limited to the population of the
study subjects. Future studies need to be done using prospective designs to increase the applicability of the findings.

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