Journal of Cardiovascular Disease Research

Journal of Cardiovascular Disease Research, 12 (1)
ISSN: 0975-3583, 0976-2833
10.31838/jcdr.2021.12.01.07

Evaluation of the relationship between pump duration and arterial blood gases in patients undergoing on-pump CABG

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Received: 22 September 2020; Accepted: 2 January 2021; Published: 14 March 2021

Abstract

Introduction: Arterial blood gas (ABG) is one of the most important laboratory tests to determine the pH status, oxygen, and carbon dioxide levels of the blood and bicarbonate levels. This test also helps to record the lactate, hemoglobin, and electrolyte levels. Evaluating the changes in these levels can play a critical role in determining the relationship with the various organ co plications. Hence, this study aimed to investigate the relationship between pump duration and arterial blood gases in patients undergoing on-pump coronary artery bypass graft (CABG).

Material and Methods: A responsible resident recorded the exact time of the pump time, patients' cross-clamping, and questionnaires during the surgery. Arterial blood samples were collected from all patients in the following instances: before and 45 min after anesthesia, after cardiopulmonary pump removal, one-hour postadmission to the intensive care unit (ICU), one and six hours after extubating, and 3 days after admission to open heart ICU. The ABG parameters including partial pressure of oxygen, partial pressure of carbon-di-oxide (PCO_2), pH, and bicarbonate was also measured each time. Finally, the relationship between pump time and ABG parameters was assessed using the obtained data and designed questionnaire. Data were analyzed using the IBM *SPSS* Statistics *V*22.0 software.

Results: ABG parameters in the two pump time groups were not statistically significant before anesthesia, during surgery, ICU admission time, one hour after open heart ICU admission, and one hour after extubating the patient ($P > 0.05$). PCO_2 in the long pump time group decreased relatively six hours and three days after admission to the open-heart ICU, and patients showed some degree of respiratory alkalosis ($P = 0.04$).

Conclusion: Our findings show that preoperative and postoperative ABG analysis is ca pivotal factor in CABG patients, and its correct interpretation aids in successful management of postoperative complications.

Keywords: arterial blood gases; open heart surgery; pump time

Introduction

Coronary artery bypass graft (CABG) surgery is the treatment of choice for many patients. Over 1 million coronary artery bypass graft surgeries are performed annually worldwide[1] and are one of the most common surgeries to increase and improve the survival and quality of the life of a patient.[2] Patients undergoing coronary artery bypass graft are at risk for respiratory complications.[3] The respiratory complication is the most common postoperative complication that plays a critical role in the frequency of patient's disability and mortality and increases hospital expenditures. Arterial hypoxemia is one of the main pulmonary complications after coronary artery bypass grafting and is reported to be seen in all patients post coronary artery bypass grafting.[4] Despite many advances in anesthesia,[5]

cardiopulmonary pump,[6] as well as preoperative and postoperative care,[7] there is still no significant relationship between advances in technology and the reduction of respiratory complications.[8] In the postoperative care of patients with *heart disease*, respiratory complications have a special place.[9] In cardiopulmonary surgery, impaired lung function matters in mortality.[10,11] In these operations, stopping the pump reduces the risk in patients.[12] When compared with cardiopulmonary bypass (CPB), the discontinuation of the pump during coronary artery bypass graft surgery was not associated with an increased risk of death and myocardial infarction,and it enhanced postoperative pulmonary function was observed.[13] The requirement of respiratory support is necessary when impaired arterial blood oxygenation and changes in carbon dioxide pressure occur, which leads to increased intubation time in patients.[14] So far, all studies have only compared the two types of on-pump and off-pump surgery, but to date no study has examined the relationship between pump duration and arterial blood gases. Therefore, the present study aimed to investigate the relationship between pump duration and arterial blood gases in CABG surgery.

Materials and methods

This cross-sectional observational study included CABG patients referred to Amir Al-Momenin Hospital in Arak, Iran, from early summer 2017 to early summer 2018. The sampling method in this design was convenience sampling.

Inclusion criteria were: (1) Candidate for CABG or coronary surgery; (2) Aged between 40 to 80 years; (3) ASA class II and III; (4) All on-*pump* CABG candidate patients.

Exclusion criteria were: (1) History of the lung, chronic, and metabolic diseases; (2) Dissatisfaction to take part in the study; (3) ASA class four; (4) Addiction to drugs and smoking; (5) Candidate patients for simultaneous coronary and valvular surgery; (6) All patients who are candidates for valvular surgery; (7) All pump-off CABG candidate patients.

Procedure

Informed consent was obtained from patients included in the study. The medications administered to the patients before the surgery included oxaspam at the night, 3–5 mg of morphine and 15–25 mg of promethazine on the day of surgery, and 3–5 cc of crystalloid per kilogram of body weight. The patients were connected to a complete monitoring including electrocardiogram, heart rate, and oxygen pressure during the surgery.

Patients were prepared to receive arterial line after taking 1–2 cc of sufentanil. The arterial line was implanted from the radial region of the non-dominant hand using a 20-gauge needle, after which patients were given 5–10 mg/kg of sufentanil, 0.1 mg/kg of midazolam, and 12–15 mg of pancuronium. Maintenance drugs including sedatives, narcotics, benzodiazepines, and anesthetics (propofol) were administered after implantation of a central venous catheter. The patients were placed on a cardiopulmonary pump for surgery post performing a sternotomy and releasing the left internal mammary artery. The grafts were removed from the cardiopulmonary pump after the operation based on the condition and stability of the patient. Later, all the patients were admitted to the intensive care unit (ICU) with stable intubation status and hemodynamics. A responsible resident recorded the exact time of the pump time, patients' cross-clamping, and questionnaires during the surgery.

Arterial blood samples were taken from all patients before and 45 minutes after anesthesia, after being removed from the cardiopulmonary pump, one hour after entering the ICU, 1 and 6 hours after leaving the endotracheal tube, and three days after entering open heart ICU. ABG parameters that included partial pressure of oxygen (PO_2), partial pressure of carbon-di-oxide (PCO_2), pH, and bicarbonate (HCO_3) were also measured each time. Finally, the relationship between pump duration and ABG parameters of patients was calculated using the obtained data and a questionnaire.

Data Analysis

The data obtained from the questionnaire were statistically analyzed using T-, Fisher-, and Chi-square tests and expressed in statistical tables and graphs using IBM *SPSS Statistics V22*.0.

Ethical Considerations

The university and the research centers approved the study post understanding the purpose of the

study. Every research unit gave written consent for participation. The patient's information was kept confidential by the project manager. In all stages of the research, the declaration of *Helsinki* and the ethical principles of *research ethics committees* of the University of Medical Sciences were considered.

Results

The study included 200 patients which consisted of males (65.7%) and females (34.3%). The mean age of patients was 67.8 ±3.6 years. The mean pump time in the short- and long pump time group was 97.8±8.6 and 116.3±9.9 min, respectively, and the mean pump time in all patients was 107.05 min. Table 1 shows ABG parameters before anesthesia in patients. There was no statistically significant difference between the two pump time groups (P > 0.05) in terms of pump duration.

Comparison of arterial blood gas (ABG) parameters during surgery is listed in Table 2. Our findings showed no statistically significant difference between ABG parameters during surgery in the two groups in terms of pump duration (P > 0.05).

Arterial blood gas parameters in candidate patients with coronary artery bypass graft admitted to an open-heart ICU are shown in Table 3 based on the pump time. ABG parameters in the two groups were not significantly different in terms of pump time (P > 0.05).

Arterial blood gas parameters one hour after entering the open-heart ICU in patients with CABG patients were examined separately by pump time (Table 4). ABG parameters one hour after entering the open-heart ICU were not statistically significant in the two groups in terms of pump duration (P> 0.05).

Arterial blood gas parameters one hour after extubation of the patient with coronary artery bypass graft based on pump time are summarized in Table 5. There was no statistically significant difference between the two groups in terms of pump duration (P > 0.05).

Arterial blood gas parameters were evaluated separately in time pump 6 hours after admission to open heart ICU (Table 6). According to PCO_2 results, a statistically significant difference was found between the two groups 6 hours after admission to open heart ICU (P = 0.04). PCO_2 in the long pump time group were relatively reduced and patients progressed somewhat to respiratory alkalosis.

Comparison of arterial blood gas parameters three days after entering the open-heart ICU is

Table 1 Comparison of arterial blood gas (ABG) parameters before anesthesia.

ABG parameters	Short pump time group	Long pump time group	P-value
pH	1.3 ± 7.45	2.2 ± 7.46	0.6
PCO_2	1.05 ± 30.3	1.9 ± 31.1	0.4
HCO_3	1.8 ± 23.6	2.1 ± 24.3	0.4
PO_2	3.8 ± 91.5	4.3 ± 90.8	0.4

PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

Table 2 Comparison of arterial blood gas parameters during surgery, by pump time.

ABG parameters	Short pump time group	Long pump time group	P-value
PH	1.9 ± 7.48	2.3 ± 7.49	0.7
PCO_2	3.2 ± 34.5	2.9 ± 33.2	0.6
HCO_3	2.7 ± 26.6	3.1± 25.7	0.4
PO_2	8.9 ±236.2	9.3 ± 238.4	0.4

PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

Table 3 Comparison of arterial blood gas parameters at open heart ICU entry, by pump time.

ABG parameters	Short pump time group	long pump time group	P-value
PH	2.3 ± 7.41	3.8 ± 7.39	0.3
PCO_2	2.7 ± 31.6	3.2 ± 31.4	0.4
HCO_3	3.1 ±21.3	2.7 ± 20.8	0.6
PO_2	10.9± 202.3	9.8± 200.9	0.4

PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

Table 4 Arterial blood gas (ABG) parameters one hour after entering the open-heart ICU.

ABG parameters	Short pump time group	long pump time group	P-value
PH	1.9 ± 7.38	2.2 ± 7.33	0.6
PCO_2	2.9 ± 33.9	3.1 ± 32.7	0.4
HCO_3	2.1 ± 20.1	2.7 ± 19.8	0.6
PO_2	9.8 ± 147.5	8.7± 144.6	0.4

ICU, intensive care unit; PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

Table 5 Comparison of arterial blood gas (ABG) parameters one hour after patient extubation based on the pump duration.

ABG parameters	Short pump time group	Long pump time group	P-value
PH	1.9 ± 7.42	2.1 ± 7.46	0.6
PCO_2	2.7 ± 36.1	3.2 ± 35.4	0.4
HCO_3	2.9 ± 24.1	3.3 ± 23.7	0.6
PO_2	11.1 ± 123.4	9.9 ± 125.1	0.4

PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

Table 6 Comparison of arterial blood gas (ABG) parameters 6 hours after admission to the open-heart ICU.

ABG parameters	Short pump time group	Long pump time group	P-value
PH	2.1 ± 7.42	1.9 ± 7.48	0.4
PCO_2	3.9 ± 35.8	2.7 ± 32.1	0.04*
HCO_3	2.7±23.7	3.6 ± 22.8	0.4
PO_2	9.4 ± 138.6	9.8 ± 140.7	=0.4

ICU, intensive care unit; PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

Table 7 Comparison of arterial blood gas parameters three days after admission to open heart ICU.

ABG parameters	Short pump time group	Long pump time group	P-value
PH	1.9 ± 7.48	2.2 ± 7.51	=0.2
PCO_2	2.3 ±32.9	2.7 ± 29.5	0.04*
HCO_3	2.8 ± 25.4	1.8 ± 23.8	0.3
PO_2	9.8 ±148.8	10.1 ± 147.6	0.4

ICU, intensive care unit; PCO_2, partial pressure of carbon-di-oxide; PO_2, partial pressure of oxygen; HCO_3, bicarbonate.

shown in Table 7. According to PCO_2 results, statistically significant difference was observed between the two in terms of pump duration (P = 0.04). PCO_2 in the long pump time group was relatively reduced and patients progressed somewhat toward respiratory alkalosis.

Discussion

ABG is one of the most important laboratory tests to determine pH, oxygen, blood carbon dioxide, and bicarbonate levels. Lactate, hemoglobin, and electrolytes can also be obtained from this test. Testing the changes in these items can be important steps in determining their relationship with the complications of different organs.[14] Therefore, this study aimed to investigate the relationship between pump duration and arterial blood gases in candidate patients for *pump-on* CABG.

In this study, the prevalence of male patients was 65.7% and female patients were 34.3%. The mean age of patients was 67.8 ± 3.6 years. The mean pump duration in all patients was 107.05 min. Our findings revealed that the ABG parameters in the two pump time groups were not statistically significant before anesthesia, during surgery, and at the time of admission to the open-heart ICU, one hour after admission, and one hour after extubating (P > 0.05). PCO_2 had a statistically significant difference between the two pump time groups 6 hours and 3 days after admission to the open-heart ICU (P = 0.04). PCO_2 in the long pump time group was relatively low and patients switched to respiratory alkalosis to some extent.

It can be concluded that PCO_2 in the long pump time group was relatively reduced 6 hours and 3 days after entering the open-heart ICU and patients went to respiratory alkalosis to some extent and long pump time caused respiratory alkalosis 6 hours and 3 days after admission to the open-heart ICU. The study of Paramanik et al.[15] in 2017 was performed to evaluate arterial blood gases and serum electrolytes in patients undergoing CABG surgery, where there was a significant decrease in PaO_2 on days 5 and 9 after surgery (P = 0.0001). $PaC0_2$ had no significant changes before and one day after surgery. But there was a statistically significant difference in days 5 and 9, where its amount had decreased. Serum potassium, hemoglobin, and hematocrit were found to be statistically significant before and after surgery on days 1 and 5. Their results were in line with our study when our findings revealed that PCO_2 in the long pump time group was relatively reduced 6 hours and 3 days after admission to the open-heart ICU, and patients were somewhat prone to respiratory alkalosis.

Another study evaluated lung function in both off- and on-pump on 40 patients (20 patients undergoing CABG using on-pump and off-pump CABG, respectively) submitted to coronary artery surgery. All patients underwent spirometry assessments, and pre- (6 min) and post-operative walk test (5 days) were also considered for patients. Preoperative, postinduction, and post CABG have also been also. No statistically significant difference was found between PO_2 and PCO_2 in the two groups. Lung function was not statistically

different between the two groups but was lower in the on-pump group.[16] This study was also in line with our study.

In 2003, Ozkul et al.[17] Conducted a study comparing daily pulmonary functions between off-pump coronary operation and off-pump coronary operation. Eighty patients were included in each group. ABG and pulmonary function tests were performed before and daily after surgery. There was no statistically significant difference between the two groups before surgery. Pulmonary function of maximal voluntary ventilation (MVV) was higher in the on-pump group and partial arterial oxygen pressure was lower. Hematocrit (P = 0.004) and forced expiratory volume (FEV) (P = 0.049) values during postoperative first day and partial arterial oxygen pressure (P = 0.011) and hematocrit (P = 0.011) values in third day were found to be lower in on-pump group. Pulmonary function and ABG were not different in the two groups. In our study, a long pump time caused respiratory alkalosis at 6 hours and 3 days after admission to the open-heart ICU.

Based on the information presented here, it can be said that PCO_2 in the long pump time group was reduced relatively 6 hours and 3 days after entering the open-heart ICU, and patients showed some respiratory alkalosis. The long pump time caused respiratory alkalosis within 6 hours and 3 days after admission to the open-heart ICU. It is recommended to use a short pump time according to the patient's condition, if possible.

Conclusion

Our findings show that preoperative and postoperative ABG analysis is an important factor in patients undergoing CABG and its correct interpretation can manage postoperative complications.

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