ORIGINAL RESEARCH

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Management with Guidance of Minimally Invasive Cardiac Output Monitoring (PiCCO®) in Coronary Artery Bypass Surgery and Postoperative Results

Koroner Arter Bypass Cerrahisinde Minimal İnvaziv Kalp Debisi Ölçüm (PICCO®) Kılavuzluğu ile Yönetim ve Postoperatif Sonuçlar

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Abstract

Objective: Our study aimed to assess the correlation between the measured PiCCO® parameters and extubation time and intensive care unit (ICU) length of stay in patients who underwent coronary artery bypass grafting (CABG) surgery and were managed by monitorization of cardiac output and cardiac performance parameters with PiCCO®.

Method: This study was conducted by retrospective analysis data of all 44 patients who underwent CABG surgery during December 2015-March 2016 and were managed through PiCCO® monitorization. The patients' demographic characteristics (age, sex, weight, height, body mass index), American Society of Anesthesiologists physical conditions, comorbidities, ejection fractions, anesthetic management, operative details, hemodynamic data, PiCCO® parameters, extubation times, cardiovascular surgery ICU lengths of stay, requirements for vasoactive agent and blood transfusion, mortality, and morbidity were recorded from patient records and evaluated the correlation between the measured PiCCO® parameters and extubation time and ICU length of stay inpatients.

Results: A significant increase was detected in the parameters of cardiac contractility and performance monitored with PiCCO® in the postoperative period ($p<0.05$). No significant correlation was found between PiCCO® parameters and extubation time and ICU length of stay ($p<0.05$).

Conclusion: Coronary revascularization patients managed with the guidance of PiCCO® showed improved myocardial contractility and cardiac performance and no increase beyond what is anticipated in the extubation time and ICU lengths of stay of the patients. Thus, we believe that optimum volume and hemodynamic targets can be achieved in patients managed through monitorization of cardiac function parameters.

Keywords: Coronary artery bypass surgery, PiCCO®, cardiac output monitoring

Öz

Amaç: Çalışmamızda; koroner arter bypass greftleme cerrahisi (KABG) geçiren ve PİCCO® ile sürekli kalp debisi ve kardiyak performans paremetreleri monitörize edilerek yönetilen hastalarda, ölçülen PİCCO® parametreleri ile ekstübasyon ve yoğun bakım ünitesi (YBÜ) kalış süreleri arasındaki korelasyon değerlendirildi.

Yöntem: Bu çalışma, Aralık 2015-Mart 2016 tarihleri arasında KABG cerrahisi geçiren ve PİCCO® monitorizasyonu ile yönetilen 44 olgunun kayıtlarının retrospektif incelenmesi ile yapıldı. Hastaların demografik özellikleri (yaş, cinsiyet, kilo, boy, vücut kitle indeksi), Amerikan anestezi derneği fiziksel durumları, eşlik eden hastalıklar, ejeksiyon fraksiyonları, anestezi yönetimi, operasyon bilgileri, hemodinamik veriler, PİCCO® paremetreleri, ekstübasyon süreleri, kardiyovasküler cerrahi YBÜ kalış süreleri, vazoaktif ajan ve kan transfüzyonu gereksinimleri, mortalite ve morbidite durumları kaydedildi ve ölçülen PİCCO® parametreleri ile ekstübasyon ve YBÜ kalış süreleri arasındaki korelasyon değerlendirildi.

Bulgular: Postoperatif dönemde PİCCO® ile değerlendirilen kardiyak kontraktilite ve performansı gösteren parametrelerin anlamlı şekilde arttığı tespit edildi ($p<0,05$). PİCCO® parametreleri ile ekstübasyon ve YBÜ kalış süreleri arasında anlamlı korelasyon saptanmadı ($p>0,05$)

Sonuç: PICCO® kılavuzluğu ile yönettiğimiz koroner revaskülarizasyon olgularında, miyokardiyal kontraktilitenin ve kardiyak performansın iyileştiği, hastaların ekstübasyon ve yoğun bakım kalış sürelerinde beklenenin dışında bir uzama olmadığı gösterilmiş olup, kardiyak fonksiyon paremetreleri takip edilerek yönetilen hastalarda optimum volüm ve hemodinamik hedeflerin sağlanabileceğini düşünüyoruz.

Anahtar kelimeler: Koroner arter bypass cerrahisi, PİCCO®, kalp debisi ölçümü

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Introduction

The primary objective in anesthetic management of coronary artery bypass grafting (CABG) surgery is to maintain hemodynamic stability. It has been shown that rates of morbidity and mortality can be decreased in a CABG that is started with hemodynamic stability during induction of anesthesia and ended with stable parameters (1,2,3). It is possible to ensure and maintain hemodynamic stability through targeted treatment. There is strong evidence in Enhanced Recovery After Surgery protocols recommending targeted treatment in CABG (1). The objective in this approach is to ensure that the fluid, blood and vasoactive surgery required for sufficient tissue perfusion is done based on cardiac outflow and associated parameters (1,2).

For target treatment practices today, minimally invasive cardiac outflow monitoring systems (PiCCO®) are used, allowing for assessment of cardiac outflow and cardiac performance parameters based on the principle of transpulmonary thermodilution and pulse contour analysis system (2,3,4).

This retrospective study assessed the correlation between the changes in postoperative PiCCO® parameters and the PiCCO® parameters measured and extubation time and intensive care unit (ICU) length of stay in patients who underwent CABG surgery and were managed by monitorization of cardiac output and cardiac performance parameters with PiCCO®.

Material and Methods

This study was conducted by retrospective analysis of the records of 44 patients who underwent CABG surgery during December 2015-March 2016 and were managed through PiCCO® monitorization, having obtaining approval of the Ethics Board of Health Sciences University, İstanbul Bağcılar Training and Research Hospital (17.03.2016-2016/449).

Patients' preoperative demographic characteristics (age, sex, weight, height, body mass index) as seen from the records, American Society of Anesthesiologists physical conditions, comorbidities as established preoperatively (hypertension, Diabetes Mellitus, hyperlipidemia, previous myocardial infarction, respiratory diseases, cerebrovascular diseases), smoking, ejection fractions, anesthetic management, operative details, hemodynamic data measured, PiCCO® parameters, extubation times, cardiovascular surgery ICU lengths of stay, requirements for vasoactive agent and blood transfusion, mortality, and morbidity were evaluated.

Anesthetic Management

All patients were subjected to anesthetic assessments and submitted informed consent forms. The patients on the operating table underwent routine anesthetic monitorization followed by premedication with 0.5 mg/kg of midazolam (Dormicum®, Roche Ltd, Basel, Switzerland), after which invasive arterial pressure was monitored from the right/left radial artery under local anesthesia. Anesthesia was induced with 0.1 mg/kg^{-1} of midazolam, 5-7 µg/kg^{-1} of fentanyl (Fentanyl® Johnson & Johnson, New Brunswick, NJ, USA) and 0.1 mg/kg^{-1} of vecuronium bromide (Norcuron® Mustafa Nevzat Tıbbi Ürünler Trade Inc., Turkey) and maintained with 1-1.5% Sevoflurane (Sojourn®, Adeka İlaç ve Kimyasal Ürünler San. ve Trade Inc.), 50% O_2-air, and intermittent doses of fentanyl, midazolam, vecuronium and remifentanil (Ultiva®, Glaxo Smith Kline İlaçları San. ve Trade Inc.) 1-1.5 µgkg^{-1} min infusions. After orotracheal intubation, end-tidal CO_2, central venous pressure (CVP-from internal jugular vein), nasopharyngeal temperature and urine flow were monitored; and all patients received 0.3-0.5 µgkg^{-1} min of nitroglycerine infusion.

Five-French sheath was inserted in the femoral artery for cardiac output monitorization, and cardiac function parameters were measured by injecting 15 mL of normal saline at 8°C in the distal lumen of the central venous catheter. The measurements recorded were evaluated at 3 time points, which were immediately after induction of anesthesia (T1), at the end of cardiopulmonary bypass (CPB) (T2), and before transferring the patient to the ICU having closed the sternum (T3). Based on PiCCO® measurements, colloid boluses were administered when volume was needed and vasoactive treatment was performed when necessary. The hemodynamic parameters [heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP)] recorded at the same time points and arterial blood gas analyses were also evaluated. The parameters measured with PiCCO® and the values considered to be the normal range are given in Table 1.

Surgical Management

All patients underwent conventional CABG, and membrane oxygenator (Dideco, Italy) was used for CPB. The pump was primed with 1,000 mL of normal saline, 200 mL of Ringer Lactate, 100 mL of 20% Mannitol, 30 mEq of Sodium Bicarbonate, and 10,000 iu heparin. Moderate systemic

hypothermia (30-32°C), mean blood pressure of 50-70 mmHg and $PaCO_2$ of 30-40 mmHg was maintained with through non-pulsatile flow of 2.0-2.4 L $min^{-1}m^{-2}$ and with by applying alpha-stat strategy for acid-base balance. Myocardial protection was attained with intermittent antegrade or retrograde cold blood cardioplegia or both.

Statistical Analysis

Number Cruncher Statistical System 2007 Statistical Software (Utah, USA) package program was used for statistical analyses. When evaluating the data, in addition to descriptive statistical methods (mean, standard deviation), we used repeated measures analysis of variance for multiple groups, Newman-Keuls multiple comparison test to compare subgroups, independent t-test to compare two groups, and Pearson's correlation test among the variables. The results were evaluated according to significance level of $p<0.05$.

Results

Four patients were excluded from this retrospective study due to missing information on the records kept. Demographic characteristics of the 40 patients evaluated are given in Table 2.

All patients underwent isolated CABG under cardiopulmonary perfusion, and no intra-operative complications were experienced. Whereas 12 patients with hematocrit level of 20-25% and hemoglobin of 7-8 gr/dL required erythrocyte transfusion, no patient required vasoactive agent administration. The operative details of the patients are given in Table 3.

Based on the patients' PiCCO® data recorded at the 3 time points, whereas the mean values of the parameters such as CVP associated with the volume status and right ventricular performance, and CO, CI, Cardiac Function Index (CFI), and global ejection fraction (GEF) indicating cardiac performance and sufficiency were found to be statistically significantly higher at the end of CPB (T2) and before transferring the patient to the ICU having closed the sternum (T3) when compared to immediately after induction of anesthesia (T1) ($p=0.0001$), no significant difference was found between the time points T2 and T3. While no significant difference was revealed by the measurements of the dP_{max}, which is another parameter associated with cardiac contractility and systolic pressure increase, the dP_{max} was found to be higher at the time points T2 and T3 than at T1 (Table 4).

Table 1. Parameters measured and evaluated

CO	3-5 L/min/m^2
CI	3-5 L/min/m^2
CFI	4.5-6.5 L/min
GEF	25-35%
GEDI	680-800 mL/m^2
GEDV	-
EVLW	3-7 mL/kg
EVLWI	-
PVPI	1-3
SVR	1700-2400/dyncm/ H_2O
SVRI	-
SVV	<10%
PPV	<10%
dP_{max}	-

CO: Cardiac output, CI: Cardiac index, CFI: Cardiac function index, GEF: Global ejection fraction, GEDI: Global end-diastolic index, GEDV: Global end-diastolic volüme, EVLW: Extravascular lung water, EVLWI: Extravascular lung water index, PVPI: Pulmonary vascular permeability index, SVR: Systemic vascular resistance, SVRI: Systemic vascular resistance index, SVV: Stroke volume variation, PPV: Pulse pressure variation, dP_{max}: Systolic pressure increase

Table 2. Demographic characteristics and comorbidities of the patients

Parameters	Number of patients n=40 (%)	Mean ± SD (minimum-maximum)
Gender		
Male	30 (75%)	-
Female	10 (25%)	-
Age (year)	-	58.73±10.62 (33-79)
Height (cm)	-	166.9±8.54 (145-183)
Weight (kg)	-	73.85±10.17 (56-96)
BMI (kg/m^2)	-	26.48±3.01 (20.2-33.3)
EF%	-	57.5±5.32 (36-62)
ASA		
II	30 (75%)	-
III	10 (25%)	-
NYHA III	40 (100%)	-
CANADA II	40 (100%)	-
HT	25 (62.5%)	-
COPD	1 (2.5%)	-
DM	23 (57.5%)	-
Stent	7 (17.5%)	-
MI	17 (42.5%)	-
Hypercholesterolemia	15 (37.5%)	-
Smoking	19 (47.5%)	-

EF: Ejection fraction, ASA: American Society of Anesthesiologists, NYHA: New York Heart Association, CANADA: Canadian Cardiovascular Society Grading for Angina Pectoris, HT: Hypertension, COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus, MI: Myocardial infraction, BMI: Body mass index, SD: Standard deviation

While Systemic vascular resistance (SVR) and Systemic vascular resistance index (SVRI) associated with afterload were found to be significantly high at the time point T1 compared to T2 and T3 (p=0.0001), no significant difference was found between the time points T2 and T3 (Table 4).

Table 3. Operative details

Parameters	Number of patients n=40 (%)	Mean ± SD (minimum-maximum)
Aortic cross clamp time (min)	-	54.3±18.16 (19-96)
Total pump time (min)	-	94.13±27.45 (40-155)
Pump crystalloid (mL)	-	1,450±349.36 (700-2,000)
Pump colloid (mL)	-	405.56±128.56 (150-500)
Anesthesia crystalloid (mL)	-	1,130±475.82 (400-1,500)
Anesthesia colloid (mL)	-	662.5±237.17 (500-1,000)
Preoperative total fluid (mL)	-	3,265±631.97 (2,400-4,600)
Diuresis (mL)	-	941.75±191.35 (500-1,340)
Pump balance (mL)	-	+723.5±288.49 (140-1,500)
Total balance (mL)	-	+1,255.25±411.87 (400-1,950)
Blood products used		
Erythrocyte suspension	12 (30%)	-
Fresh frozen plasma	0	-
Whole blood/unit	0	-

SD: Standard deviation

No significant difference was found at any of the time points in the measurements of GEDV and GEDI associated with the end-diastolic volume status (p=0.07, p=0.124), and the values measured were within the normal range. Stroke volume variation (SVV) and pulse pressure variation (PPV) values also associated with the volume status was found to be significantly lower at the time point T1 than T2 and T3 (p=0.0001) (Table 4).

Whereas no significant difference was found in all measurements of Extravascular Lung Water Index and extravascular lung water (EVLW) associated with pulmonary edema (p=0.990, p=0.438), pulmonary vascular permeability index (PVPI) measurements indicating pulmonary vascular permeability were within normal range but significantly higher at T2 and T3 than at T1 (p=0.002).

Whereas the other hemodynamic parameters monitored (SAP, DAP and MAP) were found to be significantly higher when measured at the time point T1 compared to T2 and T3, the HR value was found to be lower (Table 5). However, all the values measured were within the normal range.

The hemoglobin and hematocrit levels monitored via arterial blood gas were found to be significantly lower at T2 when compared to time points T1 and T3. No significant difference was observed in the lactate levels in any of the three time points, but an increase was observed at the time points T2 and T3 (Table 5).

Table 4. PiCCO® parameters measured at three time points

Parameters	T1	T2	T3	p*
CO	3.47±0.73*	4.3±1.28	4.37±1.1	**0.0001**
CI	1.9±0.4*	2.37±0.69	2.41±0.57	**0.0001**
CFI	3.56±0.95*	4.22±1.12	4.35±1	**0.0001**
GEF	20.93±3.77*	23.98±4.85	25.13±5.32	**0.0001**
CVP	8.63±3.72*	9.33±3.32	10.53±3.61	**0.0001**
dP_{max}	730.53±413.51	777.6±390.93	789.43±381.5	0.203
SVR	1640.98±608.19*	1220.23±390.09	1235.23±489.33	**0.0001**
SVRI	2965.08±1087.3*	2219.75±681.27	2243.45±850.24	**0.0001**
GEDI	593.7±121.55	545.78±135.71	578±186.6	0.124
GEDV	1053.75±233.87	969.55±222.9	1015.33±239.29	0.07
PVPI	2.25±0.83*	2.57±0.86	2.63±0.83	**0.002**
ELWI	7.75±2.18	7.77±1.61	7.73±2.1	0.990
EVLW	555.43±196.43	548.28±130.83	529±146.01	0.438
PPV	8.63±2.46*	11.08±3.9	11.8±4.69	**0.0001**
SVV	12.05±4.83*	13.8±4.27	15.1±4.77	**0.0001**

CO: Cardiac output, CI: Cardiac index, CFI: Cardiac function index, GEF: Global ejection fraction, GEDI: Global end-diastolic index, GEDV: Global end-diastolic volume, EVLW: Extravascular lung water, EVLWI: Extravascular lung water index, PVPI: Pulmonary vascular permeability index, SVR: Systemic vascular resistance, SVRI: Systemic vascular resistance index, SVV: Stroke volume variation, PPV: Pulse pressure variation, dP_{max}: Systolic pressure increase, CVP: Cardioventricular pacing

While the mean extubation time of patients was found to be 9.6±3.57 (0-21) hours and their mean ICU length of stay was found to be 4±5.86 (2-39) days in the postoperative period, no significant relationship was seen having examined the correlation between the PiCCO® parameters measured, the extubation times and the ICU lengths of stay.

In the postoperative period, we detected morbidities such as pleural effusion in two (5%), pericardial effusion in one (2.5%), pneumonia in one (2.5%), pneumothorax in one (2.5%), bleeding revision in one (2.5%), acute renal failure in one (2.5), and delirium in two (5%) out of 40 patients, as well as mortality in one (2.5%) patient due to multiorgan dysfunction.

Discussion

In cardiac surgery, postoperative sufficient cardiac outflow and performance are targeted. Thus, it is necessary to ensure optimal fluid balance and support the patient with vasoactive treatment when needed. Adverse events include hypovolemia and hypervolemia. However, increased vascular permeability due to non-pulsatile flow and systemic inflammatory response syndrome associated with CPB, decreased sensitivity of certain parameters used to evaluate the volume status such as CVP and pulmonary capillary wedge pressure complicate the management of fluid and vasoactive treatment (5,6). In such cases, there is a fine line between low cardiac output status associated with hypovolemia and diffuse tissue edema due to fluid load. A targeted treatment approach adopted for hemodynamic management provides for optimal use of intravenous fluids and vasoactive support, allowing for optimization of cardiac output and improving postoperative survival (5,6,7).

In a study of hemodynamic management performed with target values of GEDV> 640 mL/m^2, CI> 2.5 mL/min/m^2 and MAP >70 mmHg and based on clinic evaluation criteria in coronary artery surgery patients whose cardiac outflows were measured, it was shown that larger amounts of colloid infusion were administered in the targeted treatment group to attain optimum values, but lower doses and shorter times of inotropic support were required and the mechanical ventilation time and ICU length of stay were shortened (8). In our study, optimal interventions were made targeting optimal values of cardiac volume, contractility and performance indicators such as CVP, GEDV, GEDI, CO, CI, CFI, GEF, and dP_{max} in 40 patients who were monitored only via PiCCO®. It was found out that there was no significant difference in the values of GEDI and GEDV that indicate end-diastolic cardiac volume and volume status across the three measurement time points, and the patients received 662.5±237.17 mL of colloid infusion after CPB for volume support. Cardiac performance parameters such as CO, CI, CFI, GEF and dP_{max} were found to be significantly higher after coronary revascularization (T2 and T3) than before the operation (T1) (Table 4). As such, it could be considered that optimum volume status was achieved and the patients benefited from the coronary revascularization. In addition, good preoperative ventricular function of the patients (ejection fraction 57.5±5.32%) included in our study is an important factor that has an effect on ensuring good postoperative myocardial contractility parameters.

The key parameters to take into consideration when administering volume infusion for sufficient cardiac outflow are EVLW and PVPI. Increased EVLW and PVPI are associated with edema and also known as predictors of mortality (9). EVLW values are important in terms of guiding fluid treatment, providing highly valuable information on preload and lung water. In our study, it was observed that there was no statistically significant difference between the EWLI and EVLW values recorded at the three measurement time points and the values were close to the physiological range. PVPI, which is considered to have an important role when determining the direction to pulmonary edema that indicates pulmonary vascular

Table 5. Hemodynamic data, Hct, Hb and lactate values measured at three time points

Parameters	T1	T2	T3	p
HR	69.85±14.67*	80.13±16.42	81.7±16.37	**0.0001**
SAP	106.78±23.12*	97.4±15.78	99.43±14	**0.008**
DAP	61.65±14.49*	54.85±10.26	56.78±12.71	**0.002**
MAP	77.48±17.68*	69.05±11.04	70.83±13.49	**0.002**
Hct	33.95±4.25	25.78±3.39*	28.55±2.36	**0.0001**
Hb	11.36±1.51	8.51±1.15*	9.47±0.88	**0.0001**
Lactate	1.34±0.57	1.49±0.53	1.6±0.53	0.055

HR: Heart rate, SAP: Systolic arterial pressure, DAP: Diastolic arterial pressure, MAP: Mean arterial pressure, Hct: Hematocrit, Hb: Hemoglobin

permeability, was found to be within the normal range at the time points T2 and T3 but was higher than at T1. It could be considered that such increase was due to the increased vascular permeability as a result of systemic inflammatory response that occurred due to extracorporeal circulation (Table 4). In the fluid infusion management performed by monitoring cardiac function parameters via PiCCO® monitorization, significantly increased values of CO, CFI and GEF compared to preoperative values, in spite of GEDI being a little bit below the normal range, allowed for maintaining MAP at 70 mmg, which is of importance to supplying the heart, and stable hemodynamic conditions were attained by preventing increased EWLW and PVPI that might result in respiratory complications. Furthermore, the lactate concentration, which is considered as an indicator of hypoperfusion, staying below the value of 2 mmol/L throughout the operation and at the end of the operation might indicate that sufficient tissue perfusion was achieved (Table 5).

Inotropic and vasopressor therapy used to improve cardiac functions in cardiovascular surgery are emphasized as the cornerstone of hemodynamic therapy. However, it was shown to increase myocardial oxygen consumption, cause arrythmias and disrupt microcirculation (10,11,12). It is certainly inevitable to use it in case of left ventricular dysfunction and low cardiac output. In our study, inotropic or vasopressor support was not needed as sufficient cardiac function and hemodynamic parameters were achieved.

In our study, the SVR and SVRI values indicating the postoperative vasomotor tonus were found to be significantly lower than preoperative values but within the normal range. It could be considered that such decrease might be attributable to vasodilating effect of anesthesia, infusion of nitroglycerin at 0.3-0.5 µgr/kg/min throughout the clinical routine operation and extracorporeal circulation that result in vasodilatation by activating the systemic inflammatory response. In addition, vasopressor support was not considered since elevated SVR and SVRI values that result in decreased CO by increasing the afterload are an adverse event.

Conventional monitoring parameters SAP, DAP, MAP and HR values were found to be significantly low at the end of the operation and CVP value was found to be high. However, no intervention was made since hemodynamic stability was maintained with such values (Table 5).

In our study, when we analyzed the SVV and PPV values, which are dynamic measurement parameters recently used to evaluate the intravascular volume response in particularly non-cardiac surgeries, we found that the postoperative values were significantly higher than the preoperative values and the targeted normal ranges could not be provided.

However, we believe this increase that reflects a deficit of volume does not affect the hemodynamic parameters as it is minimal. Furthermore, a study conducted by using the PPV target values as a basis in cardiac surgery reported that volume application based on PPV values did not affect the patient results, could be highly limited in improving the results, and transient thermal changes associated with CPB might result in abnormal arterial pressure gradients, decreasing the reliability of PPV and SVV values (13,14).

Several studies showed that targeted fluid and vasoactive therapy protocols conducted on the basis of minimally invasive monitorization shortened the mechanical ventilation time and hospital and ICU lengths of stay as compared to patients managed on the basis of conventional monitoring parameters (15,16,17,18).

In our study, a control group was not created to compare treatment protocols. Evaluation of cardiac function parameters of the patients measured with PiCCO® at three time points, extubation times and ICU lengths of stay did not reveal a statistical relationship. However, there was no increase beyond what was anticipated in the extubation time and ICU lengths of stay of the patients.

During the ICU monitoring, we detected mortality due to multiorgan dysfunction in one out of 40 patients, and morbidity due to pleural effusion in two patients, pericardial effusion in one patient, acute renal failure in one patient, and bleeding revision in patient. As our study evaluated a small homogenous group of patients and lacked a control group, although it is not possible to make a definitive comment on the causes of the mortality and morbidities developed, these are complications that might be anticipated after a cardiovascular surgery.

Conclusion

Intraoperative and postoperative hemodynamic disorders attributable to complex causes in cardiac surgeries render hemodynamic management difficult. Minimally invasive methods that allow for immediate and close monitorization of cardiac function parameters in hemodynamic management and targeted therapy practices are recommended for better patient results. Although it had a limitation, worked on a small number of patients

and lacked a control group, our study on the coronary revascularization patients managed with the guidance of PiCCO® measurement parameters showed improved myocardial contractility and cardiac performance and no increase beyond what was anticipated in the extubation time and ICU lengths of stay of the patients. Therefore, we believe optimum volume and hemodynamic targets can be achieved in the patients managed through monitorization of cardiac function parameters.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from the Ethics Board of Health Sciences University, İstanbul Bağcılar Training and Research Hospital (17.03.2016-2016/449).

Informed Consent: All patients were subjected to anesthetic assessments and submitted informed consent forms.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: F.G.Ö., A.S., K.E., Design: F.G.Ö., S.D., G.B., Data Collection or Processing: A.Ö., G.B., S.D., Analysis or Interpretation: F.G.Ö., A.S., K.E., Literature Search: G.B., A.Ö., F.G.Ö., S.D., Writing: G.B., F.G.Ö., K.E.

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