



Post-Operative Continuous Positive Airway Pressure Therapy Experience in Patients Undergoing Minimal Invasive Multivessel Coronary Artery Bypass Grafting Through Left Anterior Mini-Thoracotomy

Sol Anterior Mini Torakotomi Yoluyla Minimal İnvaziv Çok Damar Koroner Arter Baypas Grefti Yapılan Hastalarda Postoperatif Sürekli Pozitif Hava Yolu Basıncı (CPAP) Tedavisi Deneyimi

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ABSTRACT

Objectives: Minimally invasive coronary bypass surgery may reveal the risk of pulmonary complications that may occur due to single lung ventilation with the aid of a dual lumen endotracheal tube. In our study, we aimed to present the results of post-operative CPAP treatment in this technique as our own clinical experience.

Methods: In our study, a total of 24 patients who underwent minimally invasive multivessel bypass operation with left anterior thoracotomy in our clinic and who were treated with CPAP in the post-operative period were retrospectively analyzed. Sixteen of the patients were male and eight were female. The age ranges were 46–78 years, with a mean age of 61.2±24 years. The patients were evaluated in terms of pulmonary complications such as atelectasis, pleural effusion, pneumonia, partial oxygen pressure decrease, and blunt costodiaphragmatic sinus.

Results: Two of our patients, who had atelectasis areas in the chest X-ray in the early post-operative period, showed improvement with mild blunting of sinus costodiaphragmaticus, without the need for any intervention at the discharge stage after CPAP. Two of our patients with low saturation and partial oxygen pressure achieved sufficient oxygen values in room air after CPAP support. Pleural effusion requiring thoracentesis was not detected in any patient. In general, no different complications were observed. In the post-operative period, our patients were discharged between 5 and 7 days.

ÖZ

Amaç: Minimal invaziv koroner baypas cerrahisi, çift lümenli endotraheal tüp yardımıyla tek akciğer ventilasyonuna bağlı olarak oluşabilecek pulmoner komplikasyon riskini ortaya çıkarabilir. Çalışmada, klinik tecrübe olarak postoperatif sürekli pozitif hava yolu basıncı (CPAP) uygulamasının sonuçlarının sunulması amaçlanmıştır.

Yöntem: Çalışmada, kliniğimizde sol anterior torakotomi ile minimal invaziv çok damarlı baypas operasyonu uygulanan ve postoperatif dönemde CPAP tedavisi uygulanan toplam 24 hasta retrospektif olarak incelendi. Hastaların 16'sı erkek, 8'i kadındı. Yaş aralıkları 46 ile 78 yıl arasında olup ortalama yaş 61,2±24 yıl idi. Hastalar atelektazi, pleval efüzyon, pnömoni, parsiyel oksijen basıncı düşüşü ve künt kostodiyafragmatik sinüs gibi pulmoner komplikasyonlar açısından değerlendirildi.

Bulgular: Ameliyat sonrası erken dönemde akciğer grafisinde atelektazi alanları olan iki hastamızda CPAP sonrası taburculuk aşamasında herhangi bir müdahaleye gerek kalmadan sinüs kostodiyafragmatikusun (SKD) hafif küntleşmesi ile düzelme görüldü. Postoperatif dönemde pnömoni tablosu gelişmedi. Satürasyonu düşük ve parsiyel oksijen basıncı olan iki hastamız CPAP desteği sonrası oda havasında yeterli oksijen değerlerine ulaştı. Hiçbir hastada torasentez gerektiren pleval efüzyon saptanmadı. Genel olarak, farklı bir komplikasyon gözlenmedi. Postoperatif dönemde hastalarımız 5-7 gün arasında taburcu edildi.

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ABSTRACT

Conclusion: However, there are technical difficulties of the method and risks increased by one-lung ventilation. Pulmonary complications, which play an important role in mortality and morbidity, are especially important. In our own clinical experience, we have observed that post-operative CPAP application is beneficial.

Keywords: Continuous positive airway pressure, mini-thoracotomy, multivessel bypass

ÖZ

Sonuç: Minimal invaziv koroner revaskülarizasyon giderek daha popüler hale gelen bir yöntemdir. Ancak yöntemin teknik zorlukları ve tek akciğer ventilasyonu ile artan riskler vardır. Mortalite ve morbiditede önemli rol oynayan pulmoner komplikasyonlar özellikle önemlidir. Kendi klinik tecrübelemiz olarak postoperatif CPAP uygulamasının faydalı olduğunu gözlemledik.

Anahtar sözcükler: Çok damarlı baypas, mini torakotomi, sürekli pozitif hava yolu basıncı

Introduction

As a minimally invasive method, multi-vessel coronary bypass operations with the thoracotomy technique have become widespread in recent years.^[1] Minimally invasive techniques, especially developed in recent years, can cause complications with different frequencies and rates.^[2] Pulmonary complications are at the forefront of these complications.

In multivessel bypass surgeries performed with thoracotomy, the fact that the left lung is not ventilated for a long time during the operation may cause difficulties in the post-operative process. Post-operative continuous positive airway pressure (CPAP) therapy is used in intensive care units. This method has no active use in minimally invasive coronary bypass surgery with thoracotomy. In our study, we aimed to present the results of CPAP treatment in this technique as our own clinical experience.

Methods

In our study, from May 2021 to August 2021, a total of 24 consecutive patients who underwent minimally invasive on-pump multivessel CABG through the left anterior mini-thoracotomy in the fourth intercostal space, and who were treated with CPAP in the post-operative period were retrospectively analyzed. Ethics committee approval was obtained from Health Sciences University, Umraniye Training and Research Hospital Ethics Committee, dated 30.09.2021 and numbered 2021/276 project/decision.

Minimally invasive on-pump multivessel coronary bypass operation was performed through thoracotomy without selecting patients, except redo patients or porcelain aorta. Preoperatively, all patients were evaluated with computed tomography. Contrast-enhanced CT angiography was performed to ensure that the patient had stenosis in the thoracoabdominal system in terms of peripheral cannulation or whether there was a calcification in the ascending aorta to which cross-clamping was to be applied. In addition, the location of the heart on the tomography, the length of the ascending aorta, and how far to the left of the sternum were evaluated preoperatively. As exclusion criteria, patients

with COPD and previous lung disease and patients with combine valve pathology were excluded from the study.

Patients were pre-medicated with intravenous (iv) midazolam (0.03 mg/kg) before being transferred to the operating room. Next 5 L/min oxygen was given, through a face mask, and peripheral venous access was achieved in the antecubital area. Heart rate was determined by 5-channel electrocardiography, and standard peripheral oxygen saturation and invasive blood pressure monitoring were performed. After local anesthesia with lidocaine 2%, an arterial catheter was placed before anesthesia induction. After anesthesia induction, using 0.05-0.1 mg/kg midazolam, 5-7 µg/kg fentanyl, 0.1 mg/kg rocuronium, and 2-3 mg/kg thiopental, the patients were intubated. Double-lumen endotracheal intubation is performed at all patients with Carlens tube, allowing single-lung ventilation. Tube placement was routinely checked with the help of fiber-optic bronchoscopy after intubation. Following endotracheal intubation, volume controlled mechanical ventilation was started. Tidal volume was set at 8 ml per kilogram of predicted body weight, inspiration/expiration ratio was adjusted 1:2, respiratory rate to 12/min, and fresh gas flow was set at 3 L/min in all patients. Positive end-expiratory pressure of 5 cm H₂O was applied. All patients were ventilated with the same equipment (Draeger, Primus, Draeger Medical AG&Co, Germany). Anesthesia was maintained with 40%/60% O₂/air + desflurane and remifentanyl infusion. The fentanyl dose was limited to a maximum of 20 µg/kg during anesthesia.

Patients were positioned in the supine position by placing soft gel bags under the left half of the chest. The left anterior mini-thoracotomy was performed through a 5-6 cm skin incision, usually in the 4th intercostal space, depending on the level of the aorta, the location of the apex of the heart, and the size of the heart, previously evaluated on CT angiography. Single-lung ventilation was initiated and the left thoracic artery was identified ready for harvesting. A special rib retractor (Delacroix-Chevalier, Paris, France) was used for the left internal mammary artery (LIMA) harvesting. Suitable sites for cannulation were exposed with a small incision of about 2-3 cm (femoral artery and femoral vein).

Vessels were cannulated with 19F-21F arterial cannula (Medtronic DLP, Grand Rapids, Mich) and 24-26F venous cannula (Medtronic DLP, Grand Rapids, Mich). For other anastomoses, saphenous veins were harvested endoscopically with Vasoview Hemopro 2 Endoscopic Vein Harvesting system (MAQUET Medical Systems, Wayne, NJ), during LIMA harvesting. The distance between the aorta and the pulmonary vein was dissected with the help of cautery and encircled with 10 mm tape.

A long antegrade cardioplegia cannula (MiAR™ Cannulae, Medtronic, USA) was inserted by pulling the aorta to the left with the help of the tape. The Chitwood DeBakey Clamp (Scanlan® International Inc., Saint Paul, Minnesota, USA) was inserted through the anterior axillary line of the second intercostal space to clamp the aorta. With the help of saphenous vein graft, anastomoses are controlled by giving antegrade blood cardioplegia after each anastomosis and regional feeding was performed (Fig. 1). After the distal anastomoses were completed, the Chitwood® clamp was opened and the heart beats. A slight traction was applied to the aorta by placing a side-biting Kemp on the ascending aorta. Standard technique of running 6_0 polypropylene sutures and standard coronary instruments were used for proximal anastomosis. After the operation was completed, the double-lumen Carlens tubes were replaced with single-lumen tubes in all patients, and the patient was taken to the intensive care unit.

All patients were extubated the same day after the operation (mean ventilation time= 6.9 ± 3.1). In the post-operative period, the decision to extubate was taken by anesthesiologist and cardiovascular surgeon. In addition, clinical characteristics of each patient were taken into account including arterial blood gas results, mechanical ventilator parameters, hemodynamic stability, degree of consciousness, body temperature, and drainage that requiring red blood cell transfusion.

The patients were routinely applied CPAP therapy at 12 h intervals starting from the post-operative 1st day. The first session was started in the morning after the operation and each session lasted approximately 30 min. PEEP was 5 cm H₂O and support with 10 cm H₂O in CPAP treatment. The patients were evaluated in terms of pulmonary complications such as atelectasis, pleural effusion, pneumonia, partial oxygen pressure decrease, and blunt costodiaphragmatic sinus. Oxygen saturation, partial oxygen pressure, partial carbon dioxide pressure, and arterial pH were recorded by daily blood gas monitoring of the patients. Moreover, atelectasis was followed up with daily telegraphy follow-up of the patients.

Pre-operative general demographic data of the patients (age, gender, and body weight), comorbidities (hypertension, diabetes mellitus, peripheral artery disease, and hy-

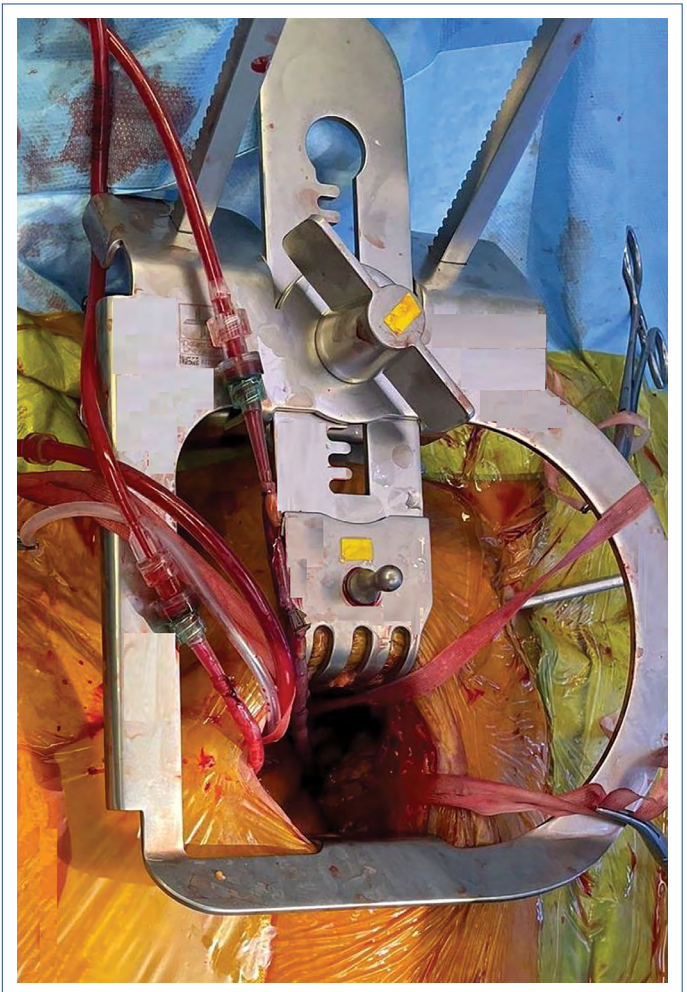


Figure 1. Anastomoses are controlled by giving antegrade blood cardioplegia with saphenous vein graft after each anastomosis.

perlipidemia), intraoperative variables (cardiopulmonary bypass times and cross-clamp times), post-operative ventilation times, the amount of transfusion, length of stay in the ICU, hospital mortality, and mean blood gas values and vital signs were analyzed retrospectively.

Results

A total of 24 consecutive patients who underwent minimally invasive on-pump multivessel CABG through the left anterior mini-thoracotomy between May 2021 and August 2021 were included in our study. Sixteen of the patients were male and eight were female. The age ranges were 46-78 years, with a mean age of 61.2 ± 24 years. Patient's demographic data are presented in Table 1. Mean age of patients was 61.2 ± 24 years. Males were predominant ($n=16$).

The patients included in our study were selected among patients who underwent isolated minimally invasive on-pump multivessel CABG, and patients who underwent additional cardiac surgery were not included in our study. All

Table 1. Demographic characteristics of the patients

Characteristics	Values (total patients, n=24)	
	n	%
Male	16	
Female	8	
Age (Mean±SD)		61.2±24
Smoker	14	58.3
Hypertension	11	45.8
Diabetes mellitus	13	54.1
Hyperlipidemia	15	62
PAD	1	0.5
CVA	1	0.5
BMI >30	1	0.8

BMI: Body mass index.

intraoperative and post-operative data were collected and evaluated in Table 2. CPB time was 154.5±22.4 min, and aortic cross-clamp time was 89.1±14.3 min.

Our average hospital stay was 5.2±0.6 days with mean ICU stay 1.2±0.5 days. Two of our patients, who had atelectasis areas in the chest X-ray in the early post-operative period, showed improvement with mild blunting of sinus costodiaphragmaticus (SCD), without the need for any intervention at the discharge stage after CPAP. No pneumonia developed in the post-operative period. Two of our patients with low saturation (<90%) and partial oxygen pressure (<80 mmHg) achieved sufficient partial values in room air after CPAP support. Pleural effusion requiring thoracentesis was not detected in any patient.

On discharge day; mean PaO₂ was 99±14.3 mmHg, PaCO₂ was 33±2.2, and mean saturation O₂ was 94±3.3 % (Table 3). The increase in PaO₂ and saturation values and the decrease in PaCO₂ values toward the day of discharge in patients receiving CPAP treatment are shown in Figure 2.

We had three patients who developed atrial fibrillation postoperatively, and rhythm restoration was achieved in all of them with medical treatment. No post-operative myocardial infarcts were observed in any of the patients. There was no revision for post-operative bleeding. There was one case of seroma in the inguinal region, and it was treated with puncture. There was no hospital mortality. In general, no different complications were observed. In the post-operative period, our patients were discharged between 5 and 7 days.

Discussion

Surgical developments in cardiovascular surgery continue to increase in recent years. Minimally invasive approaches come to the fore in the treatment of coronary artery disease,

Table 2. Intraoperative and post-operative data

Characteristics	Value
X-Klemp (min)	89.1±14.3
CPB (min)	154.5±22.4
Blood transfusion (unit)	1.6±0.9
Ventilation time, mean±SD (hours)	6.9±3.1
ICU length of stay (day)	1.2±0.5
Hospital length of stay (day)	5.2±0.6

ICU: Cardiopulmonary bypass.

Table 3. Mean blood gas values and vital signs on discharge day

Characteristics	Value, mean (SD)
PaO ₂ (mmHg)	99 (14.3)
Arterial (pH)	7.38 (0.04)
PaCO ₂ (mmHg)	33 (2.2)
Mean arterial blood pressure, mean (SD) (mmHg)	82 (9.3)
Heart rate (min)	92 (11.2)
Saturation O ₂ (%)	94 (3.3)

which is common in the world. The thoracotomy method, in which the sternum is not cut and has better cosmetic results, has become popular in coronary surgery. However, in addition to its advantages, some complications may occur in the post-operative period depending on the technique. Pulmonary complications are among the most common complications, which can cause serious morbidity and mortality.^[3]

The multivessel coronary bypass technique with thoracotomy requires a long learning curve. Even for surgeons with sufficient experience and skill, some complications may be inevitable. Rodriguez et al.^[4] in their study, they stated that this method can be applied as safely and successfully as the conventional method in selected patients. However, the operation itself carries risks that may cause comorbidity per bacillus. We aimed to bring the benefits of CPAP treatment to the literature to minimize the pulmonary complications, which are at the beginning of these risks.

The main advantage of this technique over other minimally invasive coronary surgery techniques is that all distal anastomoses are still performed in a cardioplegic heart and bloodless anastomosis site. When appropriately positioned with the aid of tapes, surgeons use the same coronary instruments and the same anastomosis skills and tie all knots with their fingers as in traditional CABG with the sternotomy approach. It is an undeniable fact that the operating area is narrow, but with certain maneuvers, an excellent exposure can be achieved in a narrow space. The target coronary anastomosis area can be reached within the reach of conventional surgical instruments. However, the lack of

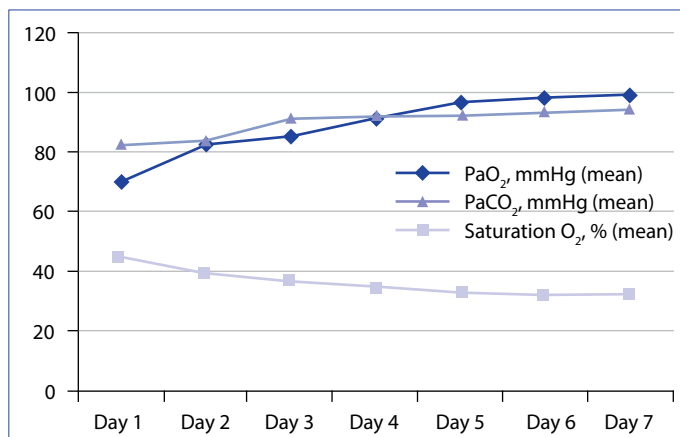


Figure 2. Mean blood gas parameter changes during the post-operative period.

ventilation of the left lung during the operation increases the risk of atelectasis in the post-operative period. Dual endotracheal tube is indispensable for operation. The lung should not be ventilated when performing coronary anastomoses during and after harvesting LIMA from the left thorax. There may be micro- and macro-atelectasis that occur during this process. Prolonging the operation process or treating the tissues harshly increases this risk. This situation may affect many parameters in the post-operative period. Especially in chest X-ray follow-ups, increased density in the left hemithorax, flattening of the sinus costodiaphragmaticus, accumulation of hematoma in the hemithorax spaces that are not fully expanded, or causing effusion may adversely affect the patient. This situation, which appeared to be mechanical problems before, may cause deterioration of oxygenation of the patient. A decrease in the partial pressure of oxygen, an increase in the partial pressure of carbon dioxide, or a decrease in oxygen saturation may occur.

Impaired patient oxygenation may result in tissue perfusion impairment, which indirectly leads to cardiac compression.^[5] To combat this situation in the post-operative period, medical treatment approaches and inhaler treatments are generally tried to support the patient. However, these treatments may not always be sufficient. To minimize pulmonary complications in the approach with the left anterior thoracotomy, we applied CPAP treatment postoperatively to our case series. We have determined that this technique, which is a simple method, contributes to the benefit and speed of recovery provided to the patients.

The main purpose of minimally invasive methods in surgery is to provide rapid recovery, comfort, and a good cosmetic result by minimally traumatizing the patient. We also stated that we applied the endoscopic vein harvesting (EVH) technique in all our cases. We think that EVH is an indispensable component of this surgery.^[6] Leg infection

was not observed in any of the female, diabetic or obese patients. It is very important in terms of patient preference as it reduces surgical morbidity and is cosmetic. While obtaining these advantages, it is necessary not to ignore the other increased risks that arise. The CPAP we apply in the post-operative period contributes to reducing the amount of atelectasis, pleural effusion, hematoma, and even drainage that may occur or have occurred.

In patients with severe chronic obstructive pulmonary disease, CPB is not a contraindication for this technique as most of the procedure is performed, but a more sensitive approach may be required to control hemostasis at the end of the procedure if the patient cannot tolerate one-lung ventilation.^[7] In addition, COPD patients receive effective respiratory physiotherapy and are mobilized early, since both the pain is less in the early post-operative period and there is no problem with bone stabilization. For this patient group, CPAP treatment may be needed in the post-operative period and the treatment will have serious benefits. Furthermore, in patients with severe kyphoscoliosis, vertebral fusion due to ankylosing spondylitis, or pectus excavatum and carinatum, surgery can be safely performed with post-operative CPAP therapy planning.

Another group of patients for whom the benefit of CPAP therapy may be greater is obese patients.^[8] BMI; in cardiac surgery, it is not in the group preferred by surgeons because of the risk of perioperative mortality and morbidity. We observed that the early mobilization we observed in the post-operative period and the comfort in the mobilization capacity of the patient contributed to the patient's recovery. Again in this patient group, CPAP treatment support in the post-operative period is an important issue that should be kept in mind.

Considering all the pulmonary complications that may develop in the post-operative period, the improvement of atelectasis and blunt SCD in two patients with CPAP, no post-operative pneumonia, and no effusion and no need for thoracentesis are a success. The rapid improvement of blood gas parameters with CPAP support also shows that this method is beneficial in two patients with low saturation (<90%) and partial oxygen pressure (<80 mmHg) decrease in the early post-operative period.

Minimal methods are becoming more common in cardiac surgery.^[9] The fact that the technique is new and more challenging than conventional methods makes it difficult for surgeons to adopt it. In addition, reducing the complications that may occur will contribute to the spread and success of the technique. We presented the results of CPAP treatment in this technique as our own clinical experience. Therefore, we recommend that surgeons who perform multivessel bypass surgery with thoracotomy keep this method in mind as a curettage.

Disclosures

Ethics Committee Approval: The study was approved by The İstanbul University of Health Sciences Ümraniye Training and Research Hospital Clinical Research Ethics Committee (Date: 30/09/2021, No: 2021/276).

Informed Consent: Written informed consent was obtained from all patients.

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