Brief Report

Evaluation of effect of continuous positive airway pressure during cardiopulmonary bypass on cardiac de-airing after open heart surgery in randomized clinical trial

Mojtaba Mansour, Nasim Massodnia, Abolghasem Mirdehghan[1], Hamid Bigdelian[1], Gholamreza Massoumi, Zeinab Rafieipour Alavi[2]

Department of Anaesthesia, Anaesthesiology and Critical Care Research Centre, [1]Department of Cardiac Surgery, Chamran Heart Hospital, [2]Pharmacologist, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Background: Cardiac and pulmonary veins de-airing are of the most important steps during open heart surgery. This study evaluates the effect of continuous positive airway pressure (CPAP) on air trapping in pulmonary veins and on quality of de-airing procedure.

Materials and Methods: This randomized prospective double blind clinical trial conducted on 40 patients. In the control group: During cardiopulmonary bypass (CPB), the ventilator was turned off and adjustable pressure limit (APL) valve was placed in SPONT position. In CPAP group: During CPB, after turning the ventilator off, the flow of oxygen flow was maintained at the rate of 0.5 L/min and the APL valve was placed in MAN position on 20 mbar. During cardiopulmonary bypass (CPB) weaning, the patients were observed for air bubbles in left atrium by using transesophageal echocardiography.

Results: The mean de-airing time after the start of mechanical ventilation in CPAP group ($n = 20$) was significantly lower than the control group ($n = 20$) ($P = 0.0001$).

The mean time of the left atrium air bubbles occupation as mild ($P = 0.004$), moderate ($P = 0.0001$) and severe ($P = 0.015$) grading was significantly lower in CPAP group.

Conclusions: By CPAP at 20 mbar during CPB in open heart surgery, de-airing process can be down in better quality and in significantly shorter time.

Key Words: Cardiopulmonary bypass, continuous positive airway pressure, de-airing, heart surgery

Address for correspondence:
Dr. Gholamreza Massoumi, Chamran Heart Hospital, Isfahan University of Medical Sciences, Isfahan, Iran. E-mail: massoumireza@yahoo.com

Received: 30.04.2013, **Accepted:** 19.11.2013

Access this article online	
Quick Response Code:	Website: www.advbiores.net
	DOI: 10.4103/2277-9175.133280

INTRODUCTION

Cardiac and pulmonary veins de-airing are of the most important steps during open heart surgery.[1,2] The trapped air in heart chambers and pulmonary veins during open heart surgery is expelled in order to prevent air emboli.[3] Air emboli can lead to cardiac arrhythmias, heart failure, cerebral complications and renal and pulmonary failure.[4-6]

How to cite this article: Mansour M, Massodnia N, Mirdehghan A, Bigdelian H, Massoumi G, Alavi ZR. Evaluation of effect of continuous positive airway pressure during cardiopulmonary bypass on cardiac de-airing after open heart surgery in randomized clinical trial. Adv Biomed Res 2014;3:136.

Different techniques of de-airing have been used to both expel the air from heart chambers and prevent air emboli, including: Carbon dioxide insufflations at the site of surgery, rapid shaking of the patient by the surgeon at the end of the surgery, head down position of the patient, venting of heart chambers and ascending aorta.[4,7,8]

Our clinical experiment revealed that in those patients who underwent open heart surgery such as; aorta and/or mitral and/or tricuspid valve replacement, after initial total de-airing of heart chambers and pulmonary veins, air bubbles was observed again in the left atrium through transesophageal echocardiography (TEE) monitoring as the left ventricle (LV) contractions were started during weaning from cardiopulmonary bypass (CPB). This complication is due to trapped air bubbles in pulmonary veins despite primary de-airing.[9,10] This resulted in prolonged weaning time, cardiac arrhythmias and heart failure especially in the right heart.[3]

This study evaluates the effect of continuous positive airway pressure (CPAP) on air trapping in pulmonary veins and on the de-airing procedure. There is no study on the effect of CPAP on the de-airing process. Thus, this study was planned to address the above issue and to assess the application of CPAP in order to reduce the risk of air trapping and the related complications of CPB and air embolization following open cardiac surgery.

MATERIALS AND METHODS

This study was approved ethically and scientifically in Isfahan University of medical sciences research committee. This is a randomized prospective double blind clinical trial conducted on 40 patients (d = 0.2). The study was performed in 2012 in martyr Chamran heart hospital. The inclusion criteria were: (1) Patients candidate for aorta and/or mitral valve with/without tricuspid valve replacement surgery, (2) ejection fraction >40%, (3) patients without history of previous heart surgery, esophageal surgery, dysphasia and odynophagia.

The applied exclusion criterion was: Intra-aortic balloon pump requirement while weaning from CPB.

Patients satisfying inclusion criteria were informed about the whole procedure and signed consent was obtained. Patients were randomly assigned to control and CPAP group (n = 20) through the table of random numbers. Anesthesiologist, the echo cardiographer and statistical analyst were blinded to both groups. Both groups were visited by anesthesiologist and received identical premedication one night prior the surgery. Patients were monitored in the operation room for pulse oximetry, electrocardiogram, invasive blood pressure measuring, temperature, urine output, central venous pressure and capnography. Patients were anesthetized through standard manner in both CPAP and control group. The anesthesia machine was Drager (Fabius). Initial setting for respiratory ventilation was: (1) Tidal volume: 8-10 ml/kg (2) ventilation frequency: 10-12 breath/min (3) maximum ventilation pressure: 25 cm H_2O (4) inspiratory/expiratory ratio: 1:2 (5) positive end expiratory pressure: 5 cm H_2O (6) relative inspiratory pause: 10% (7) fresh gas flow: 100% oxygen. This setting was adjusted to achieve end tidal partial pressure of carbon dioxide about 35-40 mmHg in capnography. The TEE probe was placed in oesophagus and primary echocardiography (midesophageal four chamber view) was performed 10 min after the induction of anesthesia and before administration of heparin. The probe remained in esophagus throughout the whole surgery. After administration of heparin and reaching activated clotting time of over 460 s, cannulation of the ascending aorta and superior and inferior vena cava was performed in all patients. Surgery was performed using pulseless Roller pump. During CPB, the mean arterial pressure was kept between 60 and 90 mmHg, mild hypothermia was used, the hemoglobin concentration was kept over 7 g/dl and PH was controlled using α-stat.

Control group

During the surgery and CPB, the ventilator (Drager, Fabius) was turned off and the flow of fresh air was totally ceased and adjustable pressure limit (APL) valve was placed in SPONT position.

CPAP group

During CPB, after turning the ventilator off, the flow of oxygen flow was maintained at the rate of 0.5 L/min and the APL valve was placed in MAN position on 20 mbar (20 hectopascal, 15 mmHg).

During the surgery

The vent catheter was placed in right upper pulmonary vein in order to keep the surgical site free of blood.

After completion of the surgery, de-airing procedure and weaning from CPB was started under TEE monitoring if the serum potassium level was less than 6 mmol/dl, normothermic state was established, the arterial blood gas was normal and no cardiac arrhythmia was detected. The lungs were ventilated. The Vent catheter was placed in LV apex and aortic root and primary de-airing of these areas was performed. The aortic clamp was released afterwards.

The patient was placed in the head down position, venous return of CPB was gradually reduced by the surgeon, the cardiac chambers were gradually filled and cardiac ejection was begun. The patient was continually observed for air emboli in left atrium using TEE and de-airing was continued if needed. De-airing procedure was continued until the left atrium was free from air emboli.

For the 1st time for evaluation of severity of air bubbles occupation in the left atrium we purpose new classification into 3 grades on TEE:

Mild: If air bubbles occupied less than 25% of the left atrium area.

Moderate: If air bubbles occupied 25-50% of the left atrium area.

Severe: If air bubbles occupied more than 50% of the left atrium area.

During the survey, the patient demographic data was recorded in a check list as well as duration of de-airing after starting mechanical ventilation of lungs, duration of de-airing after cardiac ejection and duration of the left atrium air bubble occupation graded as mild, moderate, severe in the left atrium.

After weaning from CPB and hemodynamic stability, the heparin was reversed with protamine at 1:1.5 ratio of the initial heparin dose. After completion of the surgical procedure, the patients were transferred to intensive care unit under monitoring.

The data was analyzed by SPSS softwar version 17, using Chi-square for categorical variables and *t*-test for numerical variables. $P < 0.05$ was considered to be statically significant.

RESULTS

There were no significant differences in demographic parameters in both groups [Table 1]. None of the patients were excluded from the survey during the study and all were included [Figure 1].

The mean de-airing time after the start of mechanical ventilation in CPAP group was significantly lower than the control group ($P = 0.0001$) [Table 2].

The mean de-airing time after the start cardiac ejection in CPAP group was significantly lower compared with the control group ($P = 0.0001$) [Table 2].

The mean air bubble occupation time in the left atrium with mild ($P = 0.004$), moderate ($P = 0.0001$) and severe ($P = 0.015$) grading was significantly lower in CPAP group [Table 2].

DISCUSSION

Despite the standard de-airing techniques in open heart surgery, the air will enter the left atrium from pulmonary veins as the heart is allowed to contract.[9-11] We decided to evaluate the effect of CPAP on the amount of trapped air in pulmonary veins and de-airing quality.

Our study demonstrated that positive pressure in alveoli and follow this in pulmonary veins during open heart surgery will significantly decrease the amount of trapped air in pulmonary veins, leading to better de-airing in a short time.

In a study conducted by Faleh Al-Rashidi *et al*. in 2009,[3] 20 patients were assigned to control group (10 patients: Pleural cavities unopened, dead space ventilation during CPB) and CPAP group (10 patients: Pleural cavities open, ventilator disconnected during CPB, staged perfusion, and ventilation of lungs during de-airing) and the quality of de-airing was evaluated.

Table 1: Comparison of demographic parameters between two groups

Demographic parameters	CPAP group	Control group	*P* value
Number of patients	20	20	
Pre-operative LVEF%	45.5±6.9	46.7±7.3	0.58
Age (year)	46.4±14.3	45.4±11.2	0.4
Weight (kg)	63.4±8.1	65.7±11.8	0.2
Sex			
Male	9	12	0.2
Female	11	8	

LVEF: Left ventricular ejection fraction, CPAP: Continuous positive airway pressure

Table 2: Comparison of various stage of the de-airing process between two groups

Durations of LA air bubble occupation and de-airing process	CPAP group minute (mean±SD)	Control group minute (mean±SD)	*P* value
Duration of severe grade of LA air bubble occupation	1.4±2.25	5.4±4.87	0.003
Duration of moderate grade of LA air bubble occupation	1.8±1.53	5.2±4.18	0.002
Duration of mild grade of LA air bubble occupation	5.3±4.0	9.5±5.25	0.008
De-airing time after the start of mechanical ventilation	10.8±4.5	21.1±10.01	<0/0001
De-airing time after the start of cardiac ejection	4.6±3.3	12.6±8.0	<0/0001

SD: Standard deviation, LA: Left atrium, CPAP: Continuous positive airway pressure

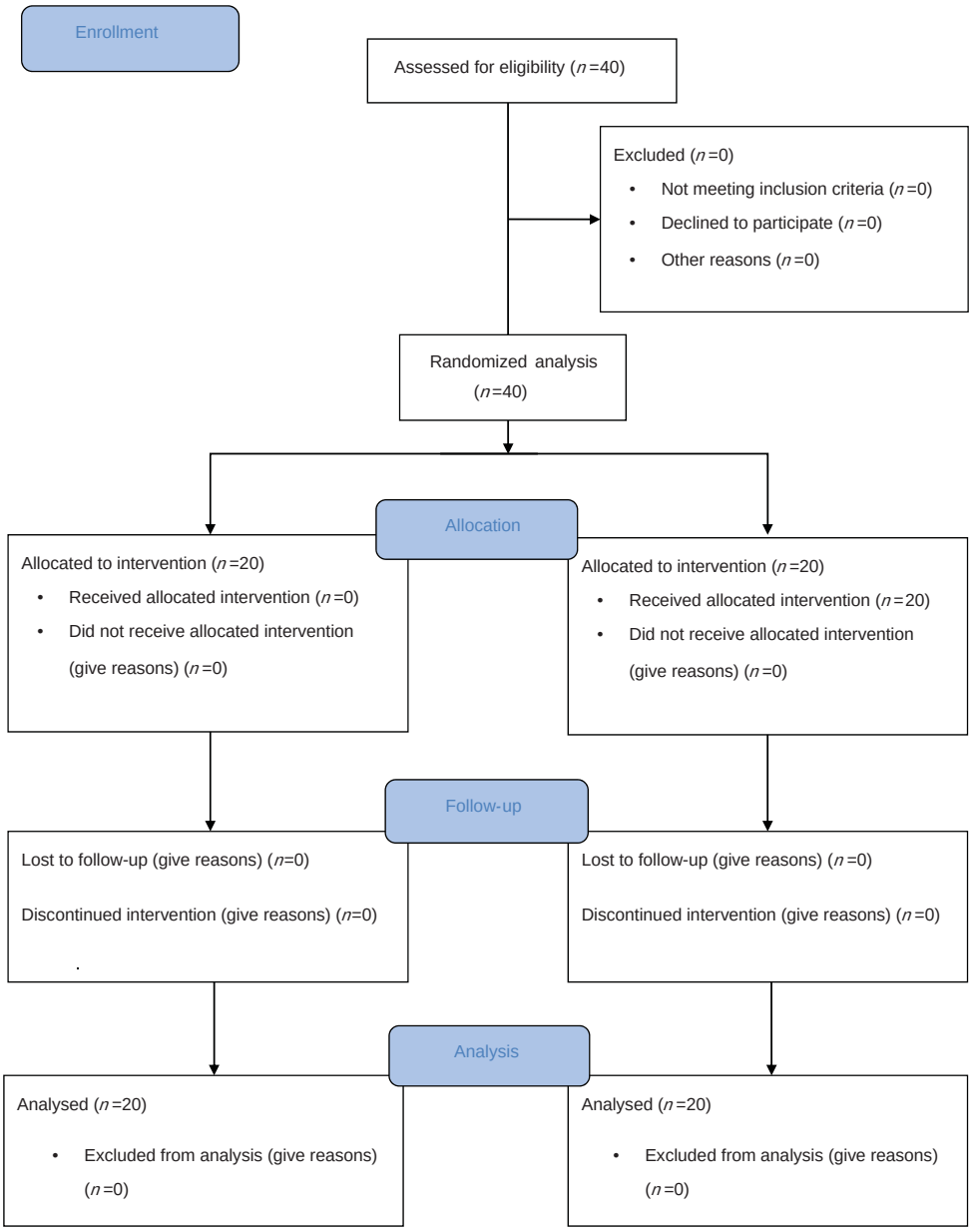

Figure 1: Participants Flow Diagram

Their study showed that de-airing quality was better in the control group.[3] In contrast to their study, our survey demonstrated that during open heart surgery, CPAP significantly increased the de-airing quality compared to when the ventilator was turned off.

This is the first study on the effects of CPAP on de-airing during CPB in open heart surgery. CPAP increases intra-thoracic pressure, which prevents the air entering from the surgical field into lung bloodstream. During CPB weaning especially after ventricular ejection beginning, air bubbles enter the heart chambers mainly through the pulmonary veins, therefore increased intra-thoracic pressure by CPAP during CPB stops the air bubble from entering into the pulmonary veins.

As mentioned above, the duration of the de-airing was shorter in the CPAP group than in the control group in the severe, moderate and mild grades.

It was observed that duration of the de-airing process from ventilation and ventricular ejection beginning until complete de-airing were significantly lower in CPAP group.

One of the important findings in this study was that in a number of patients in the CPAP group

undergoing CPAP during CPB the amount of air bubbles in left atrium never reached the severe grade.

We demonstrated that this is an easy, simple and cost-effective way for facilitating de-airing and reducing the risk of air emboli.

We hope that this study hold a way in open heart surgery for reducing of air trapping and reduce air emboli and other complication that related to air embolism.

CONCLUSION

By CPAP at 20 mbar (20 hectopascal, 15 mmHg) during CPB in open heart surgery, de-airing process can be down in better quality and in significantly shorter time.

REFERENCES

1. Walther T, Dewey T, Borger MA, Kempfert J, Linke A, Becht R, *et al*. Transapical aortic valve implantation: Step by step. Ann Thorac Surg 2009;87:276-83.
2. Bugge M, Lepore V, Dahlin A. The de-airing clamp in cardiac surgery. Eur J Cardiothorac Surg 1997;11:189-90.
3. Al-Rashidi F, Blomquist S, Höglund P, Meurling C, Roijer A, Koul B. A new de-airing technique that reduces systemic microemboli during open surgery: A prospective controlled study. J Thorac Cardiovasc Surg 2009;138:157-62.
4. Svenarud P, Persson M, Van Der Linden J. Efficiency of a gas diffuser and influence of suction in carbon dioxide deairing of a cardiothoracic wound cavity model. J Thorac Cardiovasc Surg 2003;125:1043-9.
5. Bucerius J, Gummert JF, Borger MA, Walther T, Doll N, Falk V, *et al*. Predictors of delirium after cardiac surgery delirium: Effect of beating-heart (off-pump) surgery. J Thorac Cardiovasc Surg 2004;127:57-64.
6. Tovar EA, Del Campo C, Borsari A, Webb RP, Dell JR, Weinstein PB. Postoperative management of cerebral air embolism: Gas physiology for surgeons. Ann Thorac Surg 1995;60:1138-42.
7. Gundry SR. Facile left ventricular deairing by administration of cardioplegia into the left ventricular vent. Ann Thorac Surg 1998;66:2117-8.
8. Stuart JW, Joseph SS. Decision Making and Perioperative Transesophageal Echocardiography. In: J.A. Kaplan, editor. Cardiac anesyhesia, 6th ed. Philadelphia: Elsevier Saunders; 2011. p. 383.
9. Tingleff J, Joyce FS, Pettersson G. Intraoperative echocardiographic study of air embolism during cardiac operations. Ann Thorac Surg 1995;60:673-7.
10. Orihashi K, Matsuura Y, Sueda T, Shikata H, Mitsui N, Sueshiro M. Pooled air in open heart operations examined by transesophageal echocardiography. Ann Thorac Surg 1996;61:1377-80.
11. van der Linden J, Casimir-Ahn H. When do cerebral emboli appear during open heart operations? A transcranial Doppler study. Ann Thorac Surg 1991;51:237-41.

Source of Support: Nil, **Conflict of Interest:** None declared.