Research Article

Pulmonary Outcome of Different Ventilatory Techniques During Cardiopulmonary Bypass

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Abstract
Background: Cardiac surgery is complicated by decreased postoperative respiratory muscle strength and spirometry with accompanying increased atelectasis. Different ventilator techniques is used during cardiopulmonary bypass to avoid these complications, our objective to evaluate these techniques to find the best technique which prevent pulmonary complications. **Methods**: prospective randomized study. **Patients and methods**: included ٦٠ patients, ASA II, and III, undergoing valve replacement with cardiopulmonary bypass, divided randomly into ٤ groups according to the ventilatory technique during cardiopulmonary bypass. The assessed parameters include: hemodynamics, ABGs, Pulmonary function test (FVC, FEV١, FEV١/FVC), post-operative chest x ray for atelectasis detecting, time of weaning from mechanical ventilation, length of ICU, Hospital stay, and residual respiratory symptoms. **Results:** As regard $PaCO_2$; PaO_2 showed improvement after by pass in the Group of patients received oxygen and air ١:١ with CPAP ١٠cm H_2O, and Pulmonary function: FVC%, FEV١٪, in all patients were decreased significantly in day after surgery with little decrease in patients received oxygen and air ١:١ with CPAP ١٠cm H_2O. Gradual improvement occurs appeared also ١st in patients received oxygen and air ١:١ with CPAP ١٠cm H_2O and then in other patients; FEV١/FVC%**:** little significant difference from preoperative level as most of data reflect restrictive pattern .Time needed for the pulmonary function to return to preoperative level: it was found that patients received oxygen and air ١:١ with CPAP ١٠cm H_2O reached early at ٢ to ٣ weeks. Our study revealed less incidence of Post-operative atelectasis, and residual respiratory symptoms, and least duration of the Time of extubation, length of ICU stay, duration of hospital stay in patients received oxygen and air ١:١ with CPAP ١٠cm. **Conclusion:** Static lung insufflations with oxygen, and air (٢ L/min) ١:١, and using continuous positive airway pressure at ١٠cm H_2O during cardiopulmonary bypass is the best method in prevention of post-operative respiratory complications, pulmonary outcome of different ventilatory techniques during cardiopulmonary bypass.
Key words: Ventilator techniques, Cardiopulmonary bypass and pulmonary outcome.

Introduction
Since the advent of cardiac surgery in the ١٩٥٠s, the number of cardiac procedures done world-wide has increased exponentially. Soon after cardiac surgery commenced, the contribution of postoperative pulmonary complications (PPCs) to morbidity and mortality was recognized. Cardiac surgical patients are subject to distinct surgery-related factors that predispose them to the pathogenesis of PPCs. Unique to cardiac surgery are the effects of the median sternotomy incision, topical cooling for myocardial prote-ction, internal mammary artery dissection, and the use of cardiopulmonary bypass(١).

Clinical manifestations of postoperative dysfunction (PPD) range from arterial hypoxemia in ١٠٠٪ of patients, atelectasis, bronchospasm, respireatory failure with prolonged mechanical ventilation, non-cardiogenic pulmonary edema, pulmonary embolism to acute respiratory distress syndrome, which occurs in ٠.٤٪ to ٢.٠٪ of patients with mortality rate exceeding ٧٠٪(٢).

Management of non-perfused lung during cardiopulmonary bypass has been widly neglected and may be partly reasonable Hence,

some invistigators have hypothesized that mechanical ventilation during cardiopulmonary bypass may limit postoperative lung injury by preventing these complications[٣]. The objective of the current study is to evaluate the different ventilator techniques during cardiopulmonary bypass to answer the question which ideal technique to protect against respiratory complication after CPB, evaluate the effectiveness of each method to prevent atelectasis, regain respiratory function early, weaning can be done early, shorter length of ICU, hospital stay and the least residual respiratory symptoms**.**

Subjects and Methods

Our prospective blind randomized study was carried out in cardiothorathic surgery unit, Minia university, in the period from January ٢٠١٠ to February ٢٠١٣ included ٦٠ patients, ASA II, and III, undergoing valve replacement with cardiopulmonary bypass, divided randomly into ٤ groups according to the ventilatory technique during cardiopulmonary bypass, ٤ patients (١ in each group) excluded due to reopening due to reexploration after their inclusion in the study so the total number of patients reached ٥٦ patients.

Group (I): included ١٤ patients which were disconnected from the breathing system during cardiopulmonary bypass.

Group (II): included ١٤ patients which were connected to the breathing system during cardiopulmonary bypass, and static lung insufflation with ١٠٠٪ oxygen ٢L/min

Group (III): included ١٤ patients which were connected to the breathing system during cardiopulmonary bypass, and static lung insufflation with oxygen (٢ L/min) and air (٢ L/min) ١:١

Group (IV): included ١٤ patients which were connected to the breathing system during cardiopulmonary by-pass, and static lung insufflation with oxygen (٢ L/min) and air (٢ L/min) ١:١, and using continuous positive airway pressure at ١٠cm $H_٢O$ during cardiopulmonary bypass

A carful medical history, through physical examination, full invistigations, chest X. ray, and Pulmonary function is assessed pre-operatively

The patients received their therapy (oral lasix) as a maintain for treating pulmonary congestion and those on oral digoxin (٠.٢٥ mg) continued their treatment to the morning of surgery. Diazepam ٠.٢ mg/ kg which was given orally at the night before surgery. ٢ hours before operation ٠.٢ mg diazepam given orally before surgical area for sedation.

Preoxygenation for ٣ min. then fentanyle in adose ٥ ug/Kg is given followed by propofol ٢ mg/Kg titerated to induce anesthesia which was defined as loss of response to verbal command, then cisatracronium was given at a dose ٠.١٥ mg/Kg to facilitate endotracheal intubation, ventilation was done by mask for ٢ min. then intubation by low pressure cuffed endotracheal tube of suitable size.

Maintenace was performed by continous infusion of fentanyle (١ug/ Kg/hr) till the end of by pass, in addition to isoflurane (٠.٥-١٪ MAC), shots of cisatracuronium (٠.٢mg/Kg/ hr)

Standerized management of cardiopulmonary bypass was carried in all patients. The patients were considered candadates for weaning when the following criteria were obtained: full recovery of sensorium, adequate minute ventilation, good ABG and acid base results, CPAP, and PS of ٥cm $H_٢O$, hemodynamic stability with or without minimal inotropic support, and minimal drainage from chest tube.

The assessed parameters include: hemodynamics, ABGs, Pulmonary function test (FVC, FEV١, FEV١/FVC, PEF, FEF ٢٥/٧٥٪, FEF ٧٥/٨٥), post-operative chest x ray for atelectasis detecting, time of weaning from mechanical ventilation, length of ICU, Hospital stay, and residual respiratory symptoms.

Statical analysis

Sample size: pulmonary complications associated with most patients undergoing cardiopulmonary bypass**,** with average incidince or proportion (p) is ٨٠٪, the aim is to reduce the incidince to ٤٠٪, if the confidence level of the study (t) is ٩٥٪, and chance to miss (d)= (١-٠.٩٥), the sample size is about ١٢.٤, so we increase the number of each group to ١٥ patients

for more accuracy**.** Data were checked, coded, entered, and analyzed by using SPSS (The Statistical Package for Social Sciences) version ١٧.٠ software. Statistical methods included

Paired t- test, One-way Anova, Chi square test, Mann Whiteny test.

Results

No significant difference between ٤ groups as regard patient characteristics, operative data, pre-operative laboratory investigation, Hemo-dynamics, PH, Oxygen saturation, and K level.

Table ١: Patient characteristic in the study groups

	Group I (n= ١٤) (Control)	**Group II (n= ١٤) (oxygen)**	**Group III (n= ١٤) (oxygen+air)**	**Group IV (n= ١٤) (oxygen+air +CPAP)**	**P-value**
Age (yr.) mean±SD	٢٧.٨٦±٨.٥	٢٦.٠٧±٨.٢٧	٢٥.٧١±٩.١	٢٨.٢١±٨.٤	NS
Weight (kg) mean±SD	٦٣.٥٧±٦.٢	٦١.٣٦±٧.٣	٦٢.٢٩±٦.٢	٦٧.٨٦±١٠.٥	NS
Height (cm) mean±SD	١٦٤.٣±١٠.٨	١٦٠.٢±٧.٧	١٦٣.١±٨.٩	١٦٧±٨.١	NS
Sex (n)% Males/females	٧/٧ (٥٠/٥٠٪)	٦/٨ (٤٣/٥٧٪)	٦/٨ (٤٣/٥٧٪)	٥/٩ (٣٦/٦٤٪)	NS
EF%	٦٤.٣٦±٣.٨	٦٣.٧٩±٣.٧	٦٣.٥٧±٣.٧	٦٢.٨±٣.٤	NS
Smoking (n)%					NS
Smoker	٥ (٣٥.٧٪)	٤ (٢٨.٦٪)	٤ (٢٨.٦٪)	٤ (٢٨.٦٪)	
Non-smoker	٧ (٥٠٪)	١٠ (٧١.٤٪)	٨ (٥٧.١٪)	٩ (٦٤.٣٪)	
x-smoker	٢ (١٤.٣٪)	٠ (٠٪)	٢ (١٤.٣٪)	١ (٧.١٪)	

n: number, EF: Ejection fraction, DM: diabetes mellitus

Table ٢: Operative data in the study group.

Type of Operation (n)%	**Group I (n= ١٤) (Control)**	**Group II (n= ١٤) (oxygen)**	**Group III (n= ١٤) (oxygen+air)**	**Group IV (n= ١٤) (oxygen+air +CPAP)**	**P-value**
Mitral replacement	٩ (٦٤.٣٪)	٨ (٥٧.١٪)	١٠ (٧١.٤٪)	١٠ (٧١.٤٪)	NS
Aortic replacement	٣ (٢١.٤٪)	٣ (٢١.٤٪)	٣ (٢١.٤٪)	١ (٧.١٪)	
Mitral & aortic replacement	٢ (١٤.٣٪)	٣ (٢١.٤٪)	١ (٧.١٪)	٣ (٢١.٤٪)	
Aortic clamping time (min) mean±SD	٣٢.٢٩±٥.٦	٣٣.٠٧±٧.٣	٢٨.٧٩±٥.٣	٣٣.٤٣±٥.٧	NS
CPB time (min) mean±SD	٤٧.٣٦±٥.٧	٤٨±٧.٩	٤٣.٧±٤.٨	٤٨.٥±٦.٢	NS
Operative time (min) **mean**±SD	١١٣.٨±٨.٣	١١٤.٠٧±١٠.٥	١١٠.٥±٧.٩	١١٥.٢٩±٨.٦	NS

As regard $PaCO_2$; PaO_2 showed improvement after by pass in the Group of patients received oxygen and air ١:١ with CPAP ١٠cm H_2O, this improvement proceeded to ١, ٦ hours post operatively when compared with other techniques while this improvement was not enough to affect PH,

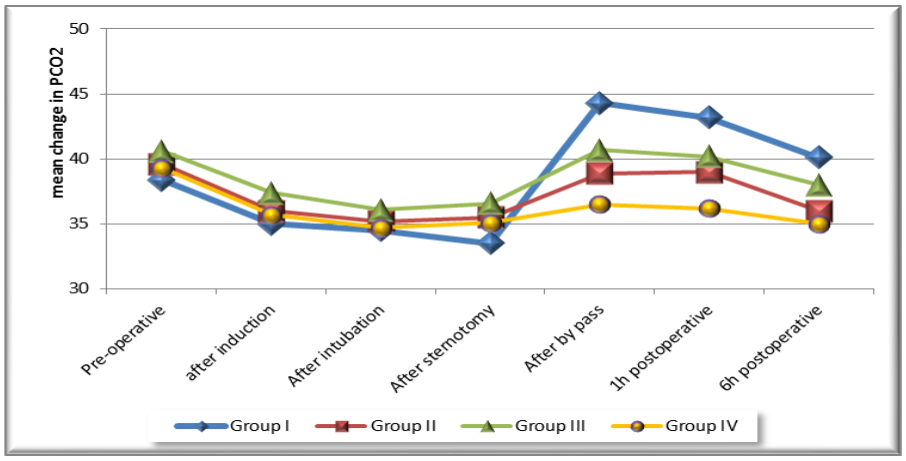


Figure ١: Changes in $PaCO_2$ (mmHg) among the study groups

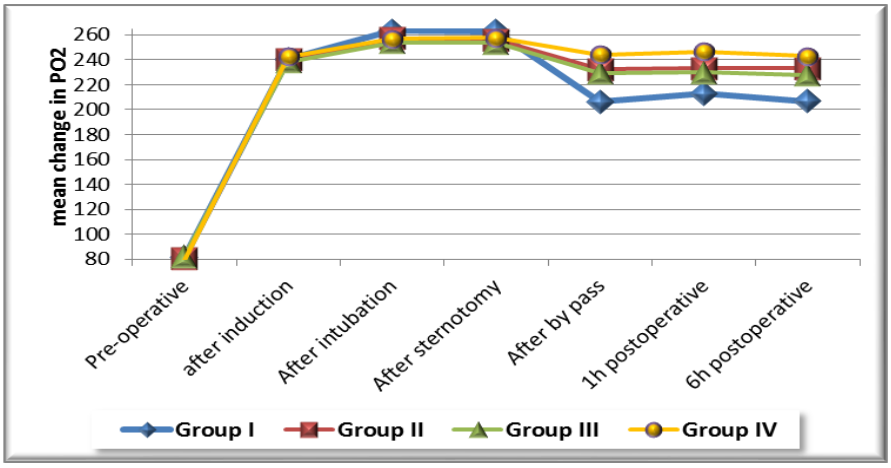
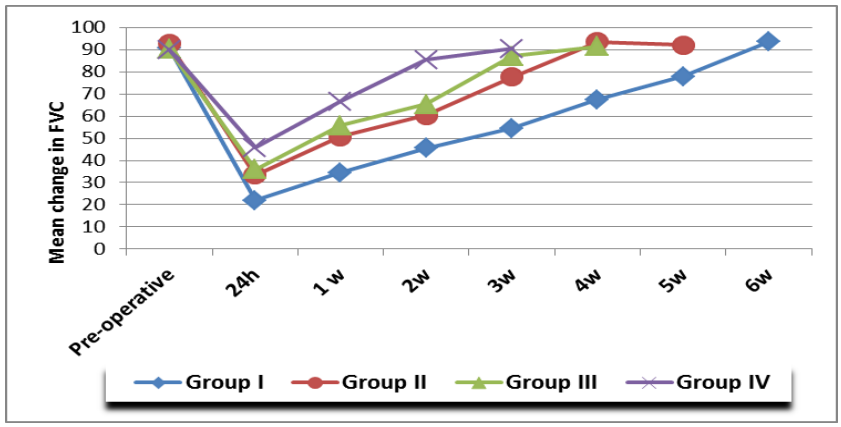


Figure ٢: Changes in PaO_2(mm Hg) among the study groups

As regard Pulmonary function: FVC%, FEV١٪, in all patients were decreased significantly in day after surgery with little decrease in patients recieved oxygen and air ١:١ with CPAP ١٠cm H_2O. Gradual improvement occurs appeared also ١st in patients recieved oxygen and air ١:١ with CPAP ١٠cm H_2O and then in other patients; FEV١/FVC%: little significant difference from pre-operative level as most of data reflect restrictive pattern in which the both FEV١, and FVC decreased so the ratio between them remain normal.



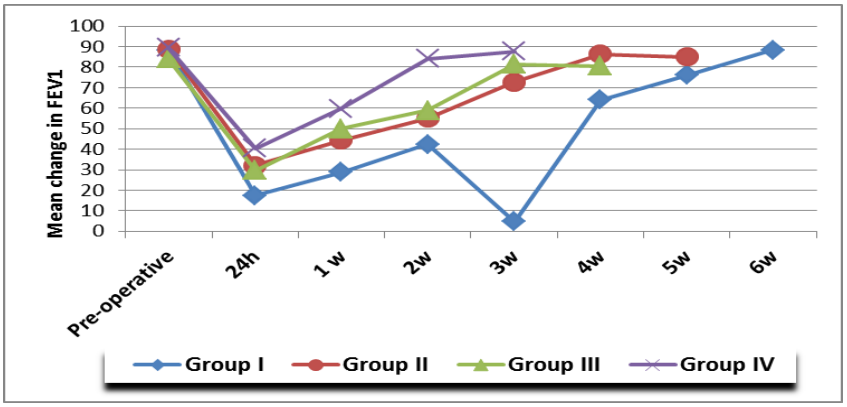


Figure ٣ and figure ٤: Changes in FVC, FEV١ in the study group

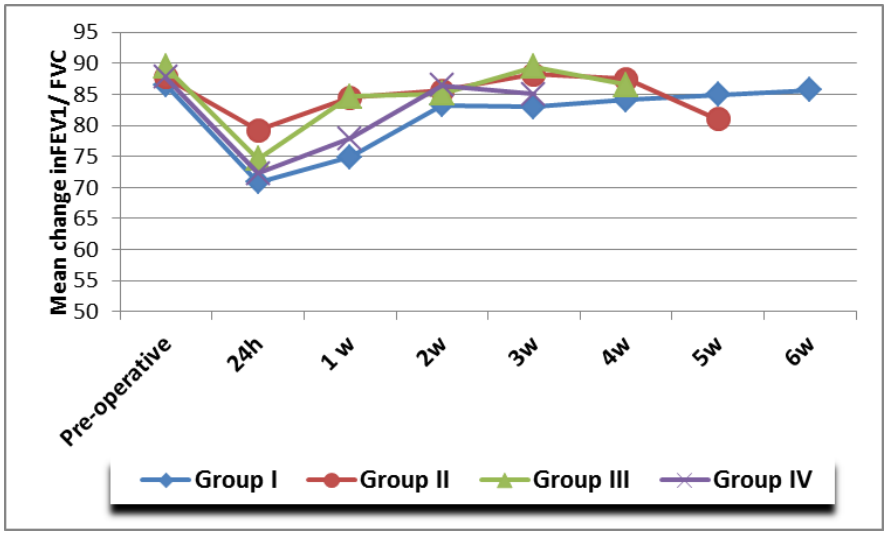


Figure ٥: Changes in FEV١/FVC in the study groups

Time needed for the pulmonary function to return to preoperative level: it was found that patients recieved oxygen and air ١:١ with CPAP ١٠cm H٫O reached early at ٢ to ٣ weeks, then patients recieved oxygen and air ١:١ at ٣ to ٤ weeks, then patients recieved oxygen at ٣ to ٥ weeks, then lastely patients disconnected from the breathing circuit at ٥ to ٦ weeks.

Analysis of pulmonary function: data reflect normal pattern preoperative then restrictive, and mixed obstructive restrictive pattern till reache

the normal level. Our study revealed less incidence of Post-operative atelectasis, and residual respiratory symptoms, and least duration of the Time of extubation, length of ICU stay, duration of hospital stay in patients recieved oxygen and air ١:١ with CPAP ١٠cm H_2O, then patients recieved oxygen and air ١:١, then patients recieved oxygen, then then lastely patients disconnected from the breathing circuit.

Table ٣: Incidence of postoperative atelectasis and residual respiratory symptoms in the studied groups

	Group I		Group II		Group III		Group IV		
	N٠	%	N٠	%	N٠	%	N٠	%	
Atelectasis (day after)	١٤	١٠٠٪	١٠	٧١٪	٦	٤٢٪	٢	١٤٪	*
Residual respiratory symptoms (after ١ week)	١٤	١٠٠٪	١٠	٧٤٪	٧	٥٠٪	٣	٢١٪	*

* significant difference between all groups

Table ٤: Time of extubation (Hours), duration of ICU stay (days) and total hospital Stay (days)

	Group I	Group II	Group III	Group IV	
Time of extubation (hours)	٦.١±٢	٣.٥±١.٥	٢.٥±١.٥	١.٧±١.٣	*
Duration of ICU stay(days)	٣.٤±١.٧	٢.٩±.٩	٢.٤±.٦	١.٢±١.٨	*
Total hospital stay(days)	٥.٤±١.٧	٤.٩±.٩	٤.٤±.٦	٣.٢±١.٨	*

*significant difference between all groups

Discussion

These results correlated with Abdelmeguid et al., [٤] whom evaluated the effect of application of different pattern of positive ventilator pressure either during or after CPB, on lung function on ٣٠ patients undergoing coronary artery revascularization. After chest closure a significant increase in $PaCO_2$, and decrease in PaO_2 as compared with after induction level in all groups without significant difference between the three groups. Johnson D et al., ١٩٩٦[٢] studied one hundred thirty-eight patients undergoing elective cardiac surgery with CPB, without using any mechanical ventilatory techniques. They found Spirometry and negative inspiratory pressure decreased and atelectasis increased from admission to discharge. These disturbances had only incompletely resolved at ٨-week follow-up. These results agreed with our study but lasts longer time in return of pulmonary functions.

Changes from admission to ٨-week post-operative values in atelectasis, pleural effusions, were measured. These physiologic changes were compared with changes in respiratory symptoms of cough, wheeze, phlegm, and dyspnea on walking up a slight hill noted from admission to ٨-week follow-up by step ward logistic regression.

The effect of lung ventilation with ٥٠٪ oxygen in air or nitrous oxide versus ١٠٠٪ oxygen on oxygenation index after CPB is studded by Sinha et al., ٢٠٠٦ and it was designed to assess the use of ١٠٠٪ oxygen or ٥٠٪ oxygen in air or nitrous oxide after cardiopulmonary bypass (CPB) on atelectasis, as evidenced by the oxygenation index It included that Significant deterioration in arterial oxygenation and an increase in the extubation time occurred with the use of ١٠٠٪ O_2 after CPB, whereas better oxygenation was evident with the use of ٥٠٪ O_2 in air and this is supported with our study.

Continuous positive airway pressure at ١٠ cm H_2O during cardiopulmonary bypass improved postoperative gas exchange is proved by Loeckinger et al., ٢٠٠٠[٥] through studying post bypass pulmonary dysfunction including

atelectasis and increased shunting which is a common problem in the intensive care unit. On the other hand; some studies suggest that static inflation of the lungs during cardiopulmonary bypass offers no advantages over lung deflation also some studies don't support the use of inflation with pressure as a mechanism of improving lung function after cardiac surgery[٦].

But all these studies depend on the respiratory changes intra-operatively, early post-operative, but not extended to late post-operative period, while in our study no changes as regard haemodynamics, PH, O_2 saturation, and minor changes intaoperative and minor changes in postoperative in PO_2, PCO_2, but major changes late in pulmonary functions, residual atelectasis, residual respiratory symptoms, time of extubation, length of I.C.U , and hospital stay.

Conclusion

Static lung insufflations with oxygen, and air (٢ L/min) ١:١, and using continuous positive airway pressure at ١٠cm H_2O during cardiopulmonary bypass is the best method in prevention of post-operative respiratory complications.

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