

# The effect of incentive spirometry on arterial blood gases after coronary artery bypass surgery (CABG)

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## ABSTRACT

**Background:** After coronary artery bypass surgery, pulmonary complications and oxygenation disorders are common, which have an important role in mortality and morbidity. Different methods are used for the improvement of pulmonary function and oxygenation, of which incentive spirometry (IS) has been investigated here. The aim of this study is to evaluate the effects of IS on arterial blood gases after coronary artery bypass graft (CABG).

**Materials and Methods:** This was a clinical trial. Fifty patients who were candidates for CABG were chosen. The patients had been allocated to two random groups of intervention and control. The intervention was done through IS. These two groups were compared for the arterial blood gases' preoperative level, and the levels on first (after extubation), second, and third postoperative days.

**Results:** The study findings showed that on the third postoperative day, there was a significant difference between the intervention and control groups in the mean amount of arterial blood oxygen ( $82.3 \pm 4.7$  vs.  $72.7 \pm 7.1$ , respectively,  $P = 0.02$ ), arterial blood carbon dioxide ( $36.8 \pm 2$  vs.  $43.7 \pm 3.2$ , respectively,  $P = 0.007$ ), and oxygen saturation ( $96.8 \pm 1.4$  vs.  $90.5 \pm 1.4$ , respectively,  $P = 0.03$ ).

**Conclusions:** This investigation shows that using IS is significantly effective in the improvement of blood arterial gas parameters.

**Key words:** Arterial blood gasses, coronary artery bypass surgery, incentive spirometry

## INTRODUCTION

Coronary artery bypass surgery is one of the widely used treatments as every year more than 1 million coronary artery bypass surgery procedures are performed around the world.<sup>[1]</sup> The patients who have coronary artery bypass graft (CABG) are prone to pulmonary complications.<sup>[2]</sup> Pulmonary complication is highly common after the coronary artery bypass surgery and the incidence<sup>[3]</sup> is between 30% and 60%. These complications are the most significant contributor to morbidity, mortality, and expenses associated with the hospitalization.<sup>[4]</sup> Development of pulmonary complication is associated with impaired oxygenation and inconsistencies in gas exchange.<sup>[5]</sup> As the investigations have shown, arterial hypoxemia following CABG is 100%.<sup>[6]</sup> Because of the

close relation between heart and pulmonary system, any change in the pulmonary system may affect the cardiac functions. Therefore, identification of the complication and early interventions are needed to prevent the incidence of most postoperative pulmonary complications.<sup>[7]</sup> Some of the interventions are to prevent the pulmonary complication after CABG, which can be highlighted by deep breathing exercises, incentive spirometry (IS), continuous positive airway pressure, and early mobilization.<sup>[8,9]</sup> We can use some methods for the improvement in the pulmonary function, but no single method is preferred.<sup>[4,6]</sup> In this study, the IS has been used for improvement in exchange of gases and oxygenation, depending on the cooperation of the patient and easy fulfillment.<sup>[9]</sup> In most of the studies, this method has been widely used, especially in the management of patients in the postoperative period of cardiac surgery, but the results supporting the use of such equipment to reduce postoperative pulmonary complications are not

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yet established, which has led to controversies in the improvement of pulmonary function in the exchange of gases and oxygenation after coronary artery bypass surgery, and there is a need for further studies to clarify the effect of this technique.<sup>[10,11]</sup>

Afrasiabi *et al.* have studied the effect of IS on arterial blood gases after coronary artery bypass surgery. In this study, patients used the IS during 6 h after extubation and it measured the arterial blood gases preoperatively, 1 h after extubation, and 7 h after extubation. At the end of study, they reported that the use of IS has no significant beneficial effect on artery blood gas parameters.<sup>[12]</sup> Carvalho *et al.* and Overend *et al.* have stated that the evidence supporting the use of the IS to reduce postoperative pulmonary complications is not established yet, and they suggest that there is a need for more studies to clarify this subject.<sup>[10,11]</sup> Agostini and Sing, with a different viewpoint, have reported that this method can be useful in improvement of pulmonary function.<sup>[13]</sup>

Because the postoperative pulmonary complications present high rates of morbidity and mortality, increased hospital costs, and prolonged hospital stay after coronary artery bypass surgery, it is obvious that the need for the breathing exercises is important.<sup>[10]</sup>

Because there are no planned breathing exercises, on one hand, in our open heart surgery intensive care unit (ICU) nowadays, and on the other hand, there are various results and controversies among related studies in this context, researchers decided to examine the effect of IS on the gas exchange and oxygenation after coronary artery bypass surgery. To evaluate the impact of this method on oxygenation and gas exchange, the arterial blood gases can be measured because the measurement of arterial blood gases is one of the most reliable indices for determination of gas exchange and oxygenation.<sup>[14]</sup> In the postoperative cardiac surgery period, the hemodynamic monitoring and maintaining hemodynamic stability are controlled by inserted arterial line;<sup>[15]</sup> as a result, sampling for arterial blood gas analysis is really convenient. Finally, the aim of this study is to evaluate the effect of IS on arterial blood gases after coronary artery bypass surgery.

## MATERIALS AND METHODS

This study was a clinical trial. The tested cases in this study were patients undergoing coronary artery bypass surgery in open heart ICU of Chamran and Sina hospitals in Isfahan in 2012 (No: IRCT2013050913280N1). A sample size of 25 patients per group was selected. The sample size calculation was based on standard deviation of a similar study,<sup>[16]</sup> and considered a 95% level of significance

and a power of 80%. The inclusion criteria were: Willingness to participate in the study, having undergone non-emergency open heart surgery, having neither mental and neuromuscular disorders or any severe pulmonary disease [chronic obstructive pulmonary disease (COPD)] nor renal dysfunction, mechanical ventilation for less than 24 h after admission to the open heart ICU, and the ability to use the IS machine. We excluded patients with hemodynamic instability (dangerous dysrhythmia, cardiogenic shock, severe hypotension) after surgery, those having neurological and mental disorders after operation, those who required re-intubation or re-operation, patients who were willing to quit the study, and those who died. Informed consent was got from the patients, and the Isfahan University of Medical Sciences ethics committee approved the study.

The patients were randomized to IS group ( $n = 25$ ) and control group ( $n = 25$ ). The intervention group used IS (flow-oriented) and the control group practiced usual breathing exercise (unplanned breathing exercise). Preoperatively, patients in the intervention group were informed and educated the breathing technique with IS. After that, it was done by the patients and controlled for its correctness. The intervention was started an hour after extubation, and the patients were encouraged to perform 10 times deep breathing with IS every 2 h in the daytime for three postoperative days. Patients were encouraged to inhale slowly to raise the balls in the chamber and continue inhaling and try to raise more balls; when they could not inhale any longer, we removed the mouthpiece and they were asked to hold their breath for 3 s and finally they exhaled slowly.<sup>[17]</sup> This device promotes effective inspiration by visual feedback and encourages enthusiasm among patients who use it.<sup>[18]</sup> The patients were instructed to perform deep breathing with IS in the sitting or semi-sitting position and patients held their hands on the incision to support it. The control group was not instructed to do any breathing exercise by the researchers; they only did the usual exercise (unplanned breathing exercise).

The arterial blood gases (partial pressure oxygenation, arterial saturation, and partial pressure carbon dioxide) were measured before the induction of anesthesia, on the first, second, and third postoperative days (after extubation). The background variables including age, gender, history of smoking, and history of diseases were obtained by referring to the medical records of the patients and by asking the patients.

All data were analyzed using SPSS software 18 version. The baseline data were analyzed by independent *t*-test and Chi-square test. The significance level was 0.05 for all analyses.

## Ethical considerations

Ethical and scientific protocols of this study have been approved by Isfahan University of Medical Sciences.

## RESULTS

In the 50 patients (26 men and 24 women) investigated, the statistically independent *t*-test and Chi-square test showed that there were no statistically significant differences between the groups with respect to demographic data (gender, age, weight, history of smoking) and clinical variables (diabetes, hypertension, period of mechanical ventilation) [Table 1]. As a result, the two groups were considered to be homogeneous and could be compared.

The statistically independent *t*-test showed that there were no significant differences between the two groups in

**Table 1: Demographic and clinical data**

Variables	Intervention group (n=25)	Control group (n=25)	P value
Sex (male/female)	12/13	14/11	0.62
Age (years)	58.3±7.6	56.2±6.2	0.60
Weight (kg)	67.6±5.7	65.2±6.3	0.41
Hypertension (n/%)	15/60	15/60	1
Diabetes (n/%)	12/48	13/52	0.68
Smoker (n/%)	11/44	9/36	0.74
Mechanical ventilation (h)	9.2±2	8±1.7	0.51

n: Number

**Table 2: Arterial blood gas analysis (means±SD)**

Groups Variables	Intervention group		Control group		P value
	Mean	SD	Mean	SD	
PaO <sub>2</sub>					
Preoperative	73.9	8.2	75.7	8.2	0.62
1 <sup>st</sup> po day	80.4	4.3	81.2	2.6	0.20
2 <sup>nd</sup> po day	77.1	8.1	79	5.1	0.45
3 <sup>rd</sup> po day	82.3	4.7	72.7	7.1	0.02
SaO <sub>2</sub>					
Preoperative	94.4	1.5	93	2.6	0.46
1 <sup>st</sup> po day	94.3	1.9	95	1	0.27
2 <sup>nd</sup> po day	92.9	2	92.4	1.6	0.32
3 <sup>rd</sup> po day	96.8	1.4	90.5	2.1	0.03
PaCO <sub>2</sub>					
Preoperative	41.3	3.1	40.7	3.2	0.86
1 <sup>st</sup> po day	40	1.3	40.2	1.7	0.53
2 <sup>nd</sup> po day	39.7	3.5	40.5	2.9	0.42
3 <sup>rd</sup> po day	36.8	2	43.7	3.2	0.007

Po: Postoperative, PaO<sub>2</sub>: Partial pressure of arterial oxygen, PaCO<sub>2</sub>: Partial pressure of arterial carbon dioxide, SaO<sub>2</sub>: Arterial oxygen saturation, SD: Standard deviation

terms of arterial blood gases (PaO<sub>2</sub>, SaO<sub>2</sub>, and PaCO<sub>2</sub>) preoperatively and on the first and second postoperative days ( $P > 0.05$ ) [Table 2].

According to the statistically independent *t*-test, the mean arterial blood gases (PaO<sub>2</sub>, SaO<sub>2</sub>, and PaCO<sub>2</sub>) showed significant differences between the two groups on the third postoperative day ( $P < 0.05$ ), as in the intervention group, PaO<sub>2</sub> and SaO<sub>2</sub> were significantly more than the values in the control group ( $82.3 \pm 4.7$  vs.  $72.7 \pm 7.1$ ,  $P = 0.02$ ), ( $96.8 \pm 1.4$  vs.  $90.5 \pm 1.4$ ,  $P = 0.03$ ), and PaCO<sub>2</sub> was significantly lower too ( $36.8 \pm 2$  vs.  $43.7 \pm 3.2$ ,  $P = 0.007$ ) [Table 2].

## DISCUSSION

After CABG, the respiratory exercises consist of deep breathing exercise, IS, intermittent positive pressure, and early mobilization, which are practiced with the aim of improving pulmonary function.<sup>[9]</sup>

In the present study, the results showed that the IS caused significant improvement in the arterial blood gas parameters (PaO<sub>2</sub>, SaO<sub>2</sub>, and PaCO<sub>2</sub>) on the third postoperative day. A systematic review was conducted by Agostini *et al.* of seven studies about IS after thorax surgery. Three studies reported that IS can improve gas exchange and others stated that IS is ineffective after thorax surgery. Finally, they concluded that IS can promote oxygenation and gas exchange after thorax surgery.<sup>[13]</sup> So, it supports the results of this study. Mordian *et al.* showed planned breathing exercise (IS and deep breathing together) significantly improved PaO<sub>2</sub> and SaO<sub>2</sub> on the postoperative day of coronary artery bypass surgery.<sup>[19]</sup> Indeed, it cannot explain exactly which method (IS and deep breathing) was more effective in the improvement of oxygenation and gas exchange, but it also does not deny these exercises (IS and deep breathing exercise) causing improvement in pulmonary function with respect to gas exchange and oxygenation. On the other side, there are controversial results reported by the studies conducted. Afrasiabi *et al.* indicated that the IS does not have significant effect on improvement of arterial blood gases.<sup>[12]</sup> Afrasiabi *et al.* measured the arterial blood gases only 6 h after extubation; in our study also, there were no significant differences in the mean arterial blood gas parameters between the two groups on the second postoperative day, but there was a significant difference in the mean arterial blood gas parameters between the groups on the third postoperative day. Also, Brage stated that improvement in blood oxygenation by respiratory exercises is temporary and is reversible after a short time; so, for improvement in oxygenation repetitive exercises are needed.<sup>[20]</sup> Carvalho *et al.* in systematic review

study reviewed 30 studies in relation to IS. They reported that there was no power evidence to support the use of IS after CABG, and there is a need for studies to clarify the effect and justify the use of this technique.

Finally, it can be stated that the usage of IS caused significant improvement in the arterial blood gas parameters (PaO<sub>2</sub>, SaO<sub>2</sub>, and PaCO<sub>2</sub>) after coronary artery bypass surgery.

The main limitation in this study is no having an real control group because if the patients did not use any respiratory exercises, it would mean we do not meet ethical principles. So, the control group followed the usual respiratory exercises (unplanned respiratory exercise).

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