

# Spirometric values and chest pain intensity three days post-operative coronary artery bypass graft surgery



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**Aim:** Coronary artery bypass graft surgery (CABG) is proved to have ventilatory complications and reduction in spirometric values. This study aimed to examine the hypothesis that reduction of post-operative chest pain intensity would be associated with improvement in the spirometric values for patient underwent CABG.

**Materials and method:** 26 cardiac patients recruited for this study. Their convenience to the study inclusion criteria decided their eligibility. Through 3 days after elective CABG their spirometric values were measured along with their perception to chest pain intensity using 0–10 numeric rating scale. Collected data were recorded and analyzed statistically.

**Results:** Chest pain intensity showed progressive significant ( $P = 0.0001$ ) reduction through the 3 days post-operative. On the other hand spirometric values also showed progressive improvement through the 3 days post-operative. This improvement was significant for all measured spirometric values except for the ratio of forced expiratory volume in the 1st second to the forced vital capacity ( $P = 0.134$ ). There was no significant relationship between the chest pain intensity and spirometric values. This was applied to all measured spirometric values and to the 3 days postoperative.

**Conclusion:** The current study findings rejected the examined hypothesis that reduction of post-operative chest pain intensity would be associated with improvement in the spirometric values for patient underwent coronary artery bypass graft surgery. There was no significant relationship between the chest pain intensity and any of the spirometric values at any of the 3 post-operative days.

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**Keywords:** Coronary artery disease, Saudi Arabia, Coronary artery bypass graft surgery, Spirometric values, Pulmonary complications, Chest pain intensity, Numeric Rating Scale, Risk-related factors

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## Introduction

Coronary artery disease is a common health problem in Saudi Arabia. [1,2] Coronary artery bypass graft (CABG) surgery is the revascularization procedure for patients with coronary artery disease.[3] Post-operative pulmonary complication, in the form of restrictive pattern of ventilatory function with reduction in the spirometric values, is well known after CABG [4–9]. Different risk factors have been noted. Mennella and Zangrillo (2011) categorized risk factors into patient-related factors, procedure-related factors and postoperative care-related factors [10]. Patient-related risk factors include old age especially those above 70 years [11,12], morbid obesity [13,14], smoking [12,15,16], diabetes [17], and symptomatic lung diseases [10,18,19]. Procedure-related risk factors include anesthesia [10,20,21], type of cardiac surgery [4], surgical incision [22], use of topical cooling [10,21], and cardiopulmonary bypass machine [21–24]. Postoperative care-related factors include use of pain control and narcotic medications [10,24]. The hypothesis behind post-operative chest pain as a related factor of post-operative ventilatory complications and reduced spirometric values is that pain causes chest wall dysfunction which limits the voluntary actions of the chest wall respiratory muscles and causes breathing to become rapid and shallow [4,25].

Spirometry is a fundamental and essential part of pulmonary function tests and provides the most information. In spirometry, a device called a spirometer measures specific lung volumes and capacities [26]. Spirometry has been shown to be valid, reliable, and reproducible for cardiac surgery patients [27–29].

The universal pain numeric rating scale (NRS), on which patients rate their current pain intensity from 0 (no pain) to 10 (worst possible pain), has become the most widely used instrument for pain screening [30]. The NRS is a short, easy-to-administer, validated measure of pain intensity [31,32].

This study aims to examine the hypothesis that reduction of post-operative chest pain intensity is associated with improvement in spirometric values for patients who have undergone coronary artery bypass graft surgery.

## Methodology

This study was approved by the College of Applied Medical Sciences, King Saud University. Saudi cardiac patients listed for elective coronary

### Abbreviations

CABG	coronary artery bypass graft
NRS	numeric rating scale
VC	vital capacity
FVC	forced vital capacity
FEV <sub>1</sub>	forced expiratory volume in the 1 <sup>st</sup> second
MVV	maximum voluntary ventilation

artery bypass graft (CABG) surgery at King Abdulaziz Cardiac Center, King Abdulaziz Medical City, Riyadh, Saudi Arabia were recruited for this study. Inclusion criteria were: ages between 45 and 69 years; a diagnosis of coronary artery disease; patient undergoing elective CABG for the first time through median sternotomy; a body mass index  $\leq 35\%$ ; lifelong non-smokers or have stopped smoking for at least eight weeks before the surgery; free from respiratory dysfunction; free from chest pain before CABG; and weaned from mechanical ventilator post-operative after less than 24 h. Convenient method was used to enroll patients into the study.

Patients who met the above inclusion criteria and who agreed to participate in the study were included. The 26 patients who were included in the study signed a consent form. Prior to surgery, researchers explained the aim of the study to patients and gave assurances there would be no positive or negative consequences in the health services they received or in their treatment plan as study participants. Patients received the usual pain management medications and rehabilitation protocol. Study participants were instructed on how to use the NRS 0–10 points to score their perceived intensity to chest pain with 0 indicating no pain and 10 indicating worst possible pain. Study participants were also instructed on how to follow the American Thoracic Society standardized instructions for spirometric measurements [33]. Researchers approached patients immediately post-operation, after weaning from mechanical ventilators and upon receiving permission of the surgeon in charge. For three successive immediate post-operative days, researchers used data sheets to record patient scores for chest pain and spirometric values of vital capacity (VC); forced vital capacity (FVC); forced expiratory volume in the first second (FEV<sub>1</sub>); ratio of FEV<sub>1</sub>/FVC; and maximum voluntary ventilation (MVV).

### Data analysis

Collected data were analyzed statistically using SPSS soft program version 17. Demographics of the patients were expressed in mean and standard deviation (SD) for continuous variables and

frequency for categorical variables. Dependent *t*-tests were used to compare the spirometric values between pre-operative day and first immediately post-operative day. Repeated measured ANOVA tests were used to follow the progression of chest pain intensity and spirometric values through the three immediately post-operative days. Two-tailed Pearson correlation tests were used to study the relationships between the intensity of chest pain and spirometric values for the three immediately post-operative days. *P* value of less than 0.05 was considered significant.

## Results

Study participants comprised 26 cardiac surgery patients (23 males, 88.5%) aged  $58.9 \pm 6.9$  years (Table 1). None of them was morbidly obese (BMI  $29.2 \pm 3.9\%$ ). Two thirds of them (65.4%) were either of normal weight or overweight. Patients who were lifelong non-smokers were fewer than those who quit smoking before surgery (69.2% and 30.8% respectively). All measured spirometric values showed significant reduction from the pre-operative day to the immediately first post-operative day (Table 2). Chest pain intensity showed progressive, significant ( $P = 0.0001$ )

reduction through the three post-operative days; and spirometric values showed progressive improvement through the three post-operative days (Fig. 1). This improvement was significant for all measured spirometric values except for the ratio of forced expiratory volume in the first second to the forced vital capacity ( $P = 0.134$ ). There was no significant relationship between chest pain intensity and spirometric values (Table 3). This was applied to all measured spirometric values and to the three post-operative days.

## Discussion

Although CABG surgery provides coronary artery disease patients with revascularization for their coronaries, the surgery is associated with pulmonary complications. Current study findings are in agreement with previous studies [4-9], which indicate significant reduction in spirometric values after CABG. Different risk factors are hypothesized as underlying causes for pulmonary complications and spirometric values reduction post CABG. Age was one of these factors, especially for patients above 70 years [11-12].

Table 1. Demographics of Saudi cardiac patients who participated in the study.

Variable	N	Mean	SD
Age (year)	26	58.9	6.9
Body mass index (%)		29.2	3.9
Mechanical ventilation duration (hour)		8.3	2.4
Variable	Sub-Titles	N	%
Gender	Male	23	88.5
	Female	3	11.5
Smoking habit	Lifelong non-smoker	18	69.2
	Quit smoking	8	30.8
Body weight	Normal	6	23.1
	Overweight	11	42.3
	Obese	9	34.6

Table 2. Comparison between spirometric values: pre-operative and day one post-operative coronary artery bypass graft surgery (N = 26).

Variable	Operation day	N	Mean	SD	P
Vital capacity	Pre-operative	26	2.5	0.9	0.0001
	Day one post-operative		1.0	0.3	
Forced vital capacity	Pre-operative	26	2.4	0.6	0.0001
	Day one post-operative		1.0	0.4	
Forced expiratory volume in the first second	Pre-operative	26	2.1	0.6	0.0001
	Day one post-operative		0.9	0.3	
Ratio of forced expiratory volume in the first second to forced vital capacity	Pre-operative	26	91.4	6.0	0.029
	Day one post-operative		86.2	12.8	
Maximum voluntary ventilation	Pre-operative	26	67.6	21.7	0.0001
	Day one post-operative		28.5	9.4	

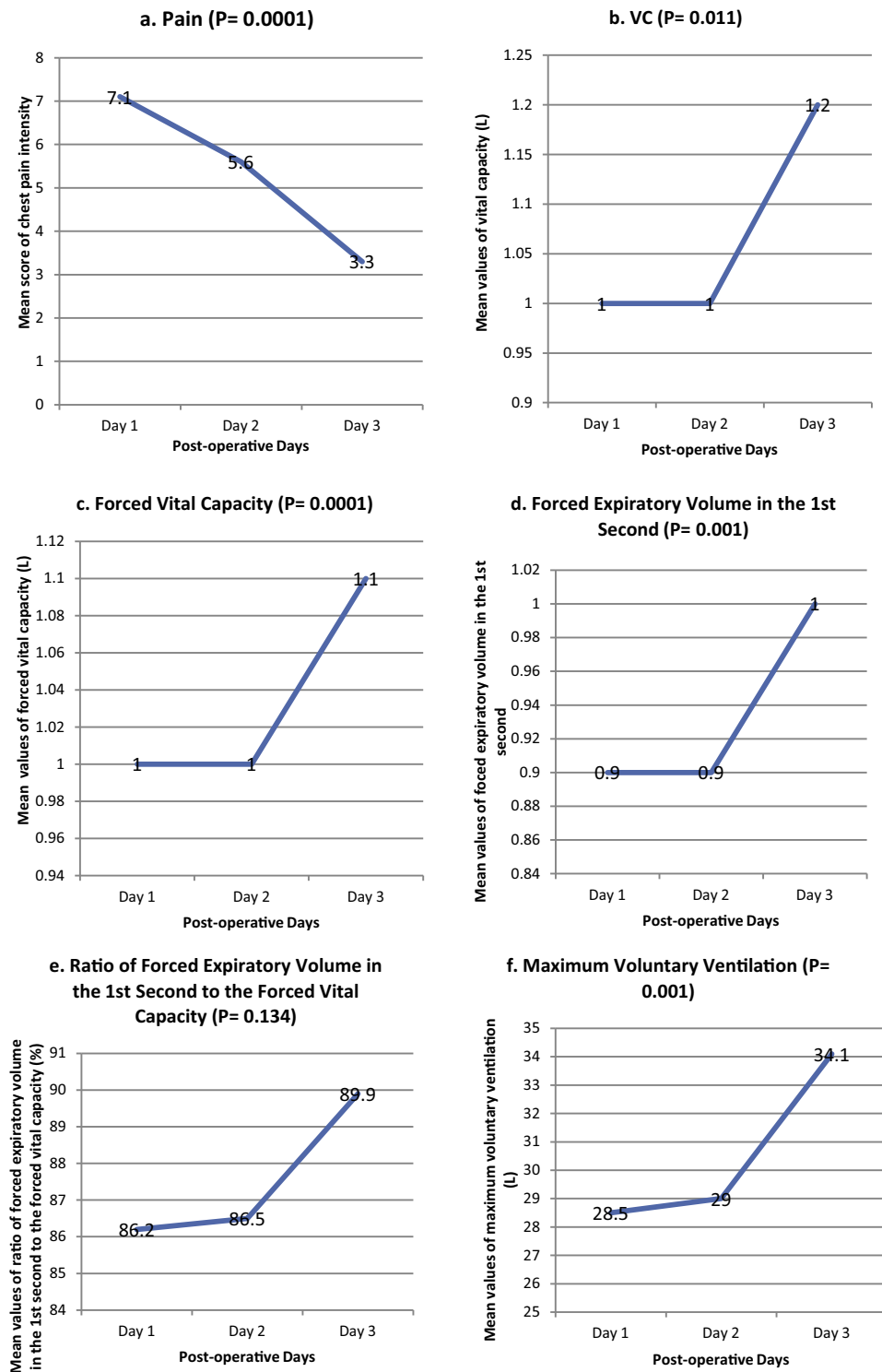


Figure 1. (a-f) Progression of chest pain intensity and spirometric values through the 3 days post-operative coronary artery bypass graft surgery (N = 26).

In our study, the age criteria for participant inclusion was 45–69 years. The mean age (58.9 years) of our study participants indicates that any reduction in spirometric values could not be explained as age-related physiological

changes. Other demographic characteristics of participants were also outside the selection criteria, including obesity (morbidly obese patients were excluded) and smoking habit (smokers were excluded).

Table 3. Relationship between chest pain intensity and spirometric values in the 3 days post-operative coronary artery bypass graft surgery (N = 26).

Variable	Chest pain intensity post-operative					
	Day 1		Day 2		Day 3	
	r	P	r	P	r	P
Vital capacity	0.033	0.874	-0.171	0.404	-0.114	0.579
Forced vital capacity	0.070	0.735	-0.291	0.150	-0.053	0.797
Forced expiratory volume in the 1st second	-0.013	0.949	-0.312	0.121	-0.081	0.694
Ratio of forced expiratory volume in the 1st second to forced vital capacity	0.012	0.955	0.032	0.877	-0.028	0.894
Maximum voluntary ventilation	0.128	0.532	-0.017	0.935	0.084	0.684

CABG surgery was partly selected because coronary artery disease is a common health problem [1,2] in Saudi Arabia, and partly to unify the type of surgical procedure performed on all participants. Median sternotomy was the incision type and topical cooling was used for all patients. Moreover, none of the participants spent more than 24 h on mechanical ventilation. The usual pain control medications were applied to all patients. Controlling the above procedures and post-operative care related risk factors were purposeful. The aim was to limit the scope of known risk factors caused by chest pain as single cause for spirometric values reduction after CABG. Normal mechanics of breathing include thoracic cage inflation for normal ventilation, normal deep breathing patten and normal spirometric values. Cutting of skin, muscles and pleura, retraction of muscles and ligaments, and pleural and septal nerve irritation from thoracic drains during CABG cause post-operative chest pain [34]. This pain interrupts the normal mechanics of breathing and results in poor ventilation confirmed by commonly occurring atelectasis [4] after CABG and alteration of breathing pattern into shallow rapid breathing [4,25]. Reduction of spirometric values is the logical consequence of poor ventilation and abnormal breathing pattern. It would be possible to say that pain causes the mechanical disturbance of the ventilatory function and culminates in the reduction of spirometric values. This raises the question of a reverse equation: if pain is decreased, would spirometric values improve?

We examined whether reduction of chest pain intensity would be followed by an increase in spirometric values. Results showed a continuous reduction of chest pain intensity as perceived and scored by patients using NRS. In the first post-operative day, the mean score of chest pain intensity was 7.1. This decreased to 5.6 and 3.3 in the second and third post-operative days. Meanwhile, spirometric values started to increase from

the first post-operative day, progressively to the second and third days. This increase was significant for all spirometric values except for the FEV<sub>1</sub>/FVC ratio. This could be explained by the fact that the restrictive pattern of ventilatory complication is the dominant one after CABG. In restrictive patterns, the FEV<sub>1</sub>/FVC does not change because both ratio components, FEV<sub>1</sub> and FVC, are decreased. Therefore, reduction of FEV<sub>1</sub>/FVC ratio was modest due to CABG, and its improvement after CABG was equally modest.

Although chest pain intensity significantly decreased after CABG and spirometric values were significantly improved, study findings showed no relationship between the level of chest pain intensity and any of the measured spirometric values. Moreover, this was true for the three post-operative days. Our findings therefore reject the study hypothesis, and posit two reasons for this. Firstly, the intensity of chest pain was almost moderate [35] in the first and second post-operative days, and mild on the third day. The range of chest pain intensity through the three post-operative days was limited from 7.1 to 3.3. Only two patients were subjected to the maximum 10-point chest pain intensity on the first day and none of them reached a 0-point chest pain intensity score on the third day. A limited range of chest pain intensity or continuation of pain even if mild on the third day may reflect an unclear relationship with the spirometric values. Secondly, the spirometric values improved regardless of a return to pre-operative values. Again, though significant, the improvement was limited. Both chest pain intensity and spirometric values were within limited range. Perhaps three post-operative days were not enough time to follow the progression of chest pain intensity and spirometric values after CABG. Longer duration may cause more expansion to the range of the two studied variables and might demonstrate a relationship between them, if any exists.



Rudra and Das (2006) and Tenenbein et al. (2008) introduced another important point of view. Their studies showed that lower pain and higher ventilatory function were associated with high epidural anesthesia in patients after CABG when compared with patients who received standard pain control medication in the first few days after surgery [36,37].

### Study limitations

In the current study, all patients received traditional pain control medications, and this may be the cause of the limited range of chest pain intensity improvement. Using one protocol for pain control could be one of our study limitations. Implementing two protocols, such as epidural anesthesia and traditional medication, for chest pain control after CABG might provide a clearer picture. Elongating the follow-up duration might also be helpful. Another limitation was the number of participants. The rigorous inclusion criteria used to control the risk factors of ventilatory complications after CABG was the reason behind this limitation.

### Conclusion

The findings of this study reject the examined hypothesis that reduction of post-operative chest pain intensity would be associated with improvement in the spirometric values for patients who underwent coronary artery bypass graft surgery. During three post-operative days, chest pain intensity was significantly decreased and the spirometric values, except FEV1/ FVC ratio, were significantly improved. Nevertheless, there was no significant relationship between chest pain intensity and any of the spirometric values during any of the three post-operative days.

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