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Impact of drains positioning on pulmonary function after coronary artery bypass grafting: an observational study

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Abstract

Introduction: Coronary artery bypass grafting (CABG) is a procedure associated with a decline in pulmonary function. Among the main causes is the presence of the drain that is usually positioned in the intercostal or subxiphoid region.

Objective: To measure the interference of drains positioning on pulmonary function in patients undergoing CABG.

Methods: Observational study that assessed preoperative pulmonary function through vital capacity (VC), maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), and peak expiratory flow (PEF). These variables were evaluated in three different moments: in the presence of two drains, when removing one, and after removing all drains.

Results: We evaluated 45 patients with a mean age of 62 ± 7 years with male prevalence of 29 (64%) individuals. The insertion of drains caused a decline in pulmonary function after surgery by reducing MIP by 48%, MEP by 11%, VC by 39%, and PEF by 6%.

Conclusion: This study has demonstrated that drains positioning after CABG surgery may produce weakness of the respiratory muscles, change ventilatory mechanics, and impair normal pulmonary function postoperatively.

KEYWORDS

Coronary artery bypass grafting; Mechanical ventilation; Postoperative pulmonary complications; Pulmonary function; Mediastinal drainage; Pleural drainage.

Introduction

Cardiovascular diseases are considered the main causes of hospitalizations and, consequently, have been increasing the mortality rate in the world. Coronary Artery Bypass Grafting (CABG) is among the most performed procedures, currently representing about 80% of surgeries performed in Brazil.[1,2] Procedures that are part of the operation, and can impair pulmonary function are sternotomy, cardiopulmonary bypass (CPB), grafts, mechanical ventilation (MV), and the placement of drains.[3,4]

The drains aim to minimize fluid accumulation in the pleural cavity, monitor bleeding, and prevent possible complications such as pericardial effusion, hemothorax, and tamponade.[5] The drains are inserted in the subxiphoid and/or intercostal region, the first inserted into the costophrenic sinus directed to the base and another inserted into the intercostal space directed to the apex of the lung.[6]

Although necessary, the presence of the drains can cause a change in pulmonary function, limiting the functioning of the respiratory muscles, modifying ventilatory mechanics, and generating an intense pain and causing postoperative discomfort.[6,7]

The deleterious effects on pulmonary function are characterized by reduced vital capacity (VC), maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), peak expiratory flow (PEF), increasing ventilatory work and pulmonary compliance. Reduction of these variables may lead to complications such as hypoxemia, atelectasis, pneumonia, pleural effusion, diaphragmatic dysfunction, and prolonged hospitalization.[8,9]

Previous studies addressing the effects of pleural and/or subxiphoid drainage on lung function have been performed in other clinical scenarios, or when performed on individuals undergoing cardiac surgery, these studies were somewhat limited or displayed a small sample size. Therefore, the present study aims to evaluate the influence of the drains positioning on pulmonary function in patients undergoing coronary artery bypass grafting.

Methodology

This is a prospective observational study, and it has been approved by the Research Ethics Committee of Faculdade Nobre de Feira de Santana (#2,518,734). All participants signed an informed consent form.

Eligibility criteria

Inclusion criteria were individuals of both genders, aged 18 years and over, and submitted to coronary artery bypass grafting via median sternotomy and cardiopulmonary bypass. Exclusion criteria were patients with hemodynamic instability, chronic or acute pulmonary disease, emergency surgery, who stay more than five days in the Intensive Care Unit, difficulty in understanding or not collaborating, cardiac arrhythmia, and bronchopleural fistula.

Study protocol

Preoperatively, patients had their pulmonary function assessed by vital capacity, inspiratory and expiratory muscle strength, and peak expiratory flow.

After these assessments, patients were referred to the operating room and later to the Intensive Care Unit (ICU). After discharge from the ICU in the postoperative period, lung function was again assessed in three moments: 1st, with the presence of subxiphoid and intercostal drains; 2nd, after the removal of one of the drains; 3rd, after the removal of all drains.

Therefore, the evaluations were carried out with the patients preoperatively and postoperatively with both drains, one drain, and after the removal of both drains.

The researchers had no influence on the conduct performed by the physiotherapy team during the study period. Patients were treated according to the hospital's routine and the physical therapy approach included deep breathing exercises, cycle ergometry, kinesiotherapy, and walking. All evaluations were performed by a blinded examinee.

The subxiphoid drain was placed in the substernal region for all patients due to the risk of pericardial effusion, whereas the intercostal drain was inserted in the sixth left intercostal space in the midaxillary line. The intercostal drain was inserted whenever the internal thoracic artery was used as a graft.

Evaluation instruments

Preoperative assessment of inspiratory muscle strength, MIP, was performed using an Indumed® (São Paulo, Brazil) analogue manovacuometer. During the evaluation, a maximal expiration until the residual volume was requested, and then a maximal and slow inspiration to the total lung capacity was required; this test was done using the unidirectional valve method, being possible a flow through a hole of one millimeter, aiming to exclude the action of the buccinator, and repeated for three times, being used the highest value reached, as long as this value was not the last. MEP was evaluated using the same apparatus and the patient was instructed to perform a maximal inspiration until he reached his total pulmonary capacity, the mask was placed, and after that a maximum expiration was requested until the residual capacity was reached. The test was repeated three times and it was considered the highest value result, as long as this value was not the last.[10] Both tests were performed with the patient seated, lower limbs resting on the ground.

To assess VC, it was used the analogue ventilometer Ferraris Mark 8 Wright Respirometer (Louisville, Colorado, Unite States of America). The ventilometer was unlocked, cleared, and soon after the facial mask was placed on the face of the individual. The patient underwent deep inspiration until he/she reached his/her total pulmonary capacity, and soon after a slow and gradual expiration until reaching the residual volume. After this, the ventilometer was locked and the result observed and noted. The test was repeated three times, being considered the highest value result.[11]

Peak expiratory flow was evaluated using the peak flow of the Mini Wright® brand. During the evaluation, the patient was seated, with his head in a neutral position and a nasal clip to prevent air from escaping through the nostrils. The patient took a deep breath, until total pulmonary capacity, followed by forced expiration with the mouth in the device. After three measurements, the highest value was chosen and there could be no difference higher than 40 liters between measurements.[11]

Data analysis

For data analysis, the Statiscal Package for Social Sciences 20.0 software was used. Normality was tested by the Shapiro-Wilk Test. Data were expressed as mean and standard deviation or absolute value and percentage. In order to compare pulmonary function at different times of the research, the paired Student's t-test was used. A $p < 0.05$ was considered for statistically significant differences.

Results

During the study period, 55 patients were hospitalized for CABG, but 10 were excluded: two underwent emergency surgery, five were not able to understand the techniques and three displayed hemodynamic instability. Therefore, 45 patients were evaluated, being 29 (64%) male and with a mean age of 62 ± 7 years. Other clinical and surgical data are shown in Table 1.

We observed that all pulmonary function variables decreased after the surgical procedure. We found that the greatest decline in pulmonary function was when we compared the preoperative period with the presence of the two drains. Even after the removal of all drains, pulmonary function was not reestablished. MIP showed a 48% decrease from pre to no drain, MEP reduction 11%, VC decline 39%, and PEF 6%. These values are expressed in Table 2.

Discussion

According to the data analyzed, we noticed that there was a decline in ventilatory muscle strength and pulmonary function in the presence of pleural and mediastinal drains after surgery, with partial recovery after drains removal.

Pulmonary function was impaired by the reduction in the variables of muscle strength and vital capacity, but PEF achieved a marked fall that was directly associated with weakness of the internal and abdominal intercostal muscles, where the intercostal and subxiphoid drainage are located[6]. Decreased muscle strength at the site of insertion may be related to tissue injury and decreased blood support where the degree of muscle contraction is lower, as well as discomfort from pain.[12]

The drain friction with the pleural and intercostal nerve, along with the stress of the parietal pleura during breathing, justifies the intense pain of the patients contributing to the reduction of the variables and increasing the risk of respiratory complications.[12] In addition, the graft using the left internal thoracic artery may result in a phrenic nerve ischemia, which anatomically innervates the diaphragm, which is one of the main breathing muscles, compromising the natural functioning of the respiratory system.[6,9,13]

Diaphragmatic dysfunction may explain the reduction of 48% and 11% in MIP and MEP values, respectively. Just as there is resistance from the inspiratory and expiratory muscles amid the presence of drains, compromised diaphragm innervation increases the individual's effort in generating negative pressure during inspiration.

These factors tend to limit chest expansion, altering ventilatory mechanics, generating a shallow breathing pattern and, consequently, may cause deleterious effects such as tachypnea and dyspnea sensation.[9] In the postoperative period, patients with fear of rupture of the surgical incision, expand the rib cage little, contributing to the decline in pulmonary function.[14]

Similarly. to the present findings, previous reports have demonstrated that pulmonary dysfunction is associated with the presence of intercostal and subxiphoid drains and median sternotomy. These events promote a decline in thoracic compliance, resulting in greater elastic retraction, impairing the generation of pulmonary volumes and capacities, and may present complications such as atelectasis, pneumonia, and diaphragmatic dysfunction.[14,15]

Importantly, our study has shown a significant reduction in the vital capacity, which declined by 39% after surgery. This mechanism is mainly due to the deficiency of ventilatory mechanics influenced by the weakness of the respiratory muscles, sternotomy, and drains that limit the chest expansion.[9]

A recent study concluded that the positioning of the drains can reduce the forced vital capacity (FVC) and the expiratory volume in the first second (FEV1) also in patients undergoing CABG.[16] Although PEF was not part of the research by Vieira et al., They believed that this variable would also suffer negative changes based on the decrease in FVC. In addition to the presence of drains, the authors associated pulmonary dysfunction with chest wall edema and changes of the surfactant.[16]

Other publications have also shown a reduction in FVC and FEV1, with an improvement in pulmonary function from the 5th postoperative day. However, authors evaluated the positioning of the intercostal and subxiphoid drain separately.[17,18] This procedure differs from our study, since we evaluated the positioning of the two drains on pulmonary function. The presence of drains, general anesthesia, and the use of internal thoracic artery were the factors cited to justify postoperative pulmonary dysfunction.[17,18]

Some authors point out that the presence of drains can compromise the oxygenation and ventilation index in MV patients after CABG.[19,20] Our assessments took place after discharge from the ICU but Brims et al.[19] and Borges et al.[20] have demonstrated drains can influence lung function even in the first moment after cardiac surgery. These rates were worse in patients with pleural effusion, impairing ventilation-perfusion, and increasing pulmonary shunt.[19,20]

Other complications frequently observed in the postoperative period are the reduction of oxygen pressure, carbon dioxide and oxygen saturation, these reports were observed in patients who presented a ventilatory disorder due to malfunction of respiratory muscles in the presence of drains.[21] In addition, ventilatory impairment was associated with CPB, which may prolong weaning from MV due to physiological disturbance caused by the systemic inflammatory response, where through contact of blood on a non-endothelial surface occurs the activation of immunological components and the release of mediators biochemicals.[22,23]

We found that as the drains were removed, pulmonary function gradually recovered, but without returning to preoperative values. We can associate this improvement with the reduction of the impact of intercostal and subxiphoid drains, to the healing of the surgical incision, and to the breathing exercises provided by physiotherapy during the entire in-hospital process.

A variable not measured in our study was the intensity of pain, especially at the place where the drains were inserted, as well as at the sternotomy, although all patients were under full analgesia effect. Studies indicate that the intensity of pain increases during respiratory movements due to the friction of the drains with the nerves and the rib cage.[6,13,21] After removal of the drains, there is a reduction in pain that helps improve pulmonary function and consequently helps patients recover. As it is not part of our research, we consider pain assessment to be a limitation of our study.

Other limitations of our study are the small sample size, increasing the risk of type 1 statistical error, secondary outcomes not assessed as postoperative complications and length of stay, observational design, and the short follow-up of these patients.

Conclusion

The insertion of drains in the intercostal and subxiphoid space in patients undergoing coronary artery bypass grafting influenced the decline in pulmonary function, changing the ventilatory mechanics due to weakness of the respiratory muscles, which contributed to the generation of low volumes and capacities.

Conflicts of interest

The authors declare no conflicts of interest.

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Table 1 - Clinical data of patients undergoing coronary artery bypass grafting.

Variable	
Gender	
Male	29 (64%)
Female	16 (36%)
Age (years)	62 ± 7
Body Mass Index (kg.m^{-2})	24 ± 4
Comorbidities	
Systemic arterial hypertension	31 (69%)
Diabetes mellitus	22 (49%)
Dyslipidemia	19 (42%)
Cardiopulmonary bypass (min)	89 ± 15
Mechanical ventilation (h)	7 ± 3
Number of grafts	2,1 ± 0,4

Table 2 - Evolution of pulmonary function in the presence of drains after coronary artery bypass grafting.

Variable	**Preoperative**	**Two drains**	**One drain**	**No drain**
MIP (cmH$_2$O)	97 ± 20	54 ± 15[a]	54 ± 10[a]	65 ± 16[a,b]
MEP (cmH$_2$O)	81 ± 21	67 ± 18[a]	69 ± 16[a]	73 ± 17
VC (L)	49 ± 9	21 ± 7[a]	27 ± 7[a]	35 ± 8[a,b]
PEF (L.min^{-1})	370 ± 37	262 ± 27[a]	322 ± 29[a,c]	351 ± 30

MIP, maximum inspiratory pressure; MEP, maximum expiratory pressure; VC, vital capacity; PEF, peak expiratory flow.

[a] $p < 0.001$ when comparing that moment with the preoperative period.

[b] $p < 0,01$ comparing no drain with two and one drain.

[c] $p < 0,01$ comparing a drain with two drains.