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Permanence of Lung Disorders after Hospital Discharge of Patients Who Underwent Cardiac Surgery: An Integrative Review

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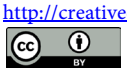

Abstract

Patients are more likely to develop lung disorders after cardiac surgery. Pulmonary dysfunction resulting from cardiac surgery in the hospital phase is well documented. However, there is a scarcity of studies related to the permanence of pulmonary disorders in the period following hospital discharge. The objective of this study was to verify in a database investigation the permanence of pulmonary dysfunctions after hospital discharge of patients who underwent cardiac surgery. A literature review with an integrative approach was carried out in the National Library of Medicine (Pubmed) and Scientific Electronic Library Online (Scielo) databases from 1978 to 2019. 4523 articles were found and after applying the inclusion and exclusion criteria, the sample was composed of 14 articles relevant to the subject and that were available in full. The results demonstrated the presence of atelectasis, pleural effusion, diaphragmatic dysfunction, respiratory symptoms such as cough, phlegm, wheezing, and dyspnea, reduced static and dynamic lung volumes, reduced diffusion capacity and respiratory muscle strength, in the period that ranged from three weeks to one year after cardiac surgery. Further studies are needed to elucidate the mechanisms that lead to the permanence of pulmonary dysfunctions after hospital discharge in patients who underwent cardiac surgery.

Keywords

Thoracic Surgery, Cardiac Surgery, Pulmonary Function Test, Respiratory Function Tests

1. Introduction

Cardiovascular diseases (CVDs) are among the main causes of death in devel-

oped countries and they remain the leading cause of illness and professional disability [1] [2], due to increased longevity, urbanization, and lifestyle habits [3]. In Brazil, they also represent the first cause of mortality and the second largest cause of hospitalization [4] [5], with important consequences such as physical disability and invalidity, which contribute to the increase in health expenses [6] [7].

Among the forms of treatment for CVDs, cardiac surgery (CS) stands out, including myocardial revascularization, valve repairs and exchanges, and the correction of congenital heart diseases as the main procedures [8]. CS and postoperative control (PO) have added, in the last decades, greater knowledge and scientific experience, with high-tech equipment and state-of-the-art drugs, making procedures faster, less invasive, and less harmful to cardiac patients. Minimally invasive interventions, without cardiopulmonary bypass (CPB) and with less surgical time are examples of this technological advance [9]. Although it is an effective procedure and it has evolved over the years, its endpoint may have cardiac, pulmonary, renal, neurological, infectious, hematological, digestive, and electrolyte complications [10] [11].

Within the set of postoperative complications related to CS, several studies report that pulmonary dysfunction is prevalent [5] [8] [11] [12] [13] [14] [15] and its etiology may result from the association of multiple surgical risk factors [3] [11] [14]. The pre-surgical risk factors listed are age, smoking, previous medical history, and preoperative pulmonary function [11]. Among the intra- and post-surgical risk factors are anesthesia, CPB time, cardiac arrest, surgical trauma, median sternotomy, pleurotomy, phrenic nerve palsy, time on mechanical ventilation, number and position of chest drains, and post-operative pain [3] [14].

Most patients undergoing CS develop postoperative pulmonary dysfunction with significant reduction in lung volumes, impaired respiratory mechanics, decreased lung compliance, and increased work of breathing [14]. The reduction in lung volumes and capacities contributes to changes in gas exchange, resulting in hypoxemia and decreased diffusion capacity [13] [14]. Atelectasis, pleural effusion, and pneumonia are pulmonary complications frequently found [12] [16] [17]. However, other complications such as hypercapnia, reintubation, and respiratory failure are also observed [14]. These pulmonary dysfunctions and complications are responsible for prolonging hospital stay, increasing hospital costs, and an important cause of morbidity and mortality in patients undergoing CS [11].

Studies related to pulmonary dysfunctions in the postoperative period of CS until hospital discharge are well established in the literature [5] [8] [11] [13] [16]. Nonetheless, few studies report the permanence of the deleterious effects on lung function resulting from CS after hospital discharge [18] [19] [20] [21] [22]. According to Belle *et al.* [23] and Johnson *et al.* [24], little is known about the outcome of abnormalities in lung function in the weeks following hospital discharge. Westerdahl *et al.* [22] stated that the reduction in lung function and

pain caused by median sternotomy are common and well documented until hospital discharge. However, few studies have assessed the deleterious effects of CS on long-term lung function.

In this context, the objective of the study was to verify in the databases the presence of investigations that show the permanence of pulmonary dysfunctions after hospital discharge of patients undergoing CS.

2. Methods

This study was characterized as a literature review with an integrative approach, which selected articles through the databases National Library of Medicine (Pubmed) and Scientific Electronic Library Online (Scielo). The search was carried out in March 2019, using the Health Sciences Descriptors (DeCS) in Portuguese: "*cirurgia torácica*", "*cirurgia cardíaca*", "*teste de função pulmonar*", "*teste de função respiratória*"; and in English: "thoracic surgery", "cardiac surgery", "respiratory function test", "pulmonary function test".

As an inclusion criterion, articles published between January 1978 and March 2019, published in Portuguese and English, which presented abstracts available online and digital access in full, were selected. Articles that did not meet the inclusion criteria and were found to be repeated and/or duplicated in the databases were excluded.

The studies were selected first by reading the titles for each database, following the eligibility criteria. After this selection, the study abstracts were read and then the articles that were available in full were analyzed. Those that did not correspond to the basic question of the study and that did not meet the inclusion criteria were excluded (Figure 1).

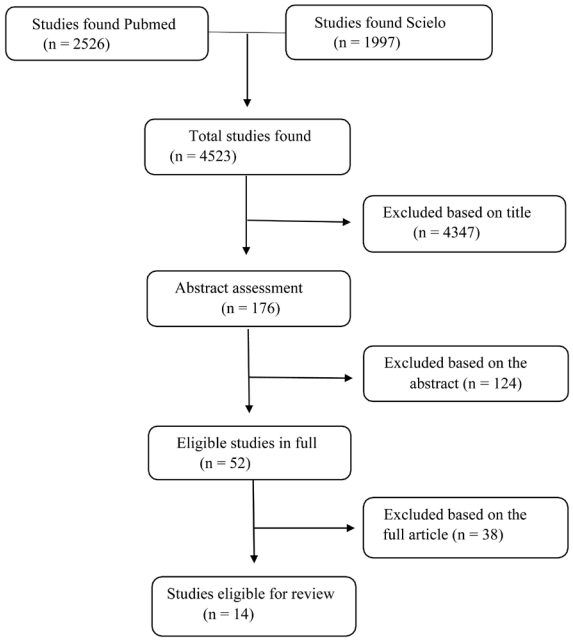

Figure 1. Flowchart for the selection of studies. **Source:** Prepared by the authors; **n:** number of articles.

The main characteristics of the articles included in this review are described in Table 1. The analyzed data were distributed in columns, with the following description: author/journal/year of publication, title, objective, method, and endpoint.

3. Results and Discussion

The results found demonstrated the persistence of pulmonary dysfunctions in patients who underwent MRS and/or valve reconstruction surgery, in a period of time that varied from three weeks to one year of PO, showing that the impairment of lung function may continue beyond hospital discharge. Some authors have demonstrated long-term changes in lung function through the analysis of static and dynamic volumes [18] [19] [20] [21] [22] [23] [25] [26] and the diffusing capacity of the lungs for carbon monoxide (DLCO) [18] [22]. Other investigators reported the persistence of pulmonary dysfunctions through the observation of diaphragmatic disorders [27] [28] [29] [30]. In turn, Landymore *et al.* [31] associated the presence of pulmonary dysfunctions with the types of grafts used in CS and Johnson *et al.* [24] correlated the dysfunctions with respiratory symptoms such as cough, discharge, wheezing, and dyspnea.

Westherdal *et al.* [22] and Braun *et al.* [18] demonstrated a decrease in static and dynamic volumes and DLCO, in relation to preoperative values after four months and one hundred and sixteen days of MRS, respectively. Shapira *et al.* [20] also found significant reductions in the values of static and dynamic volumes after three months of MRS. Similarly, Van Belle *et al.* [23] and Berriztbeitia *et al.* [19] showed a decrease in the values of static and dynamic volumes after six weeks and six to eight weeks of MRS, respectively. Shenkman *et al.* [21] noticed a greater decrease in both lung volumes after three weeks of MRS or valve surgery. Following three months of surgical intervention, Shenkman *et al.* [21] reported an increase in the studied variables without reaching preoperative values.

Rachwalic [25] and Vaydia *et al.* [26] observed persistent pulmonary dysfunction through the analysis of static and dynamic lung volumes in patients who underwent valve surgery and both reported a decrease in lung volumes. Two and a half months after valve surgery, Rachwalic [25] indicated that there was a 20% reduction in static and dynamic volumes and, in six months, they found that these values remained 5% below preoperative levels. Vaydia *et al.* [26] corroborated these findings when they concluded that 17 of the 31 patients in their study had reduced spirometric values three months after the surgical intervention

Other investigations have shown pulmonary dysfunction through the analysis of diaphragmatic disorders [27] [28] [29] [30]. Baltieri *et al.* [27], in a case report of a patient undergoing MRS, demonstrated partial resolution of diaphragmatic dysfunction after 10 weeks of transcutaneous electrical diaphragmatic stimulation. Dimopoulou *et al.* [28] studied 63 patients who underwent two different cardiac cooling techniques (saline and "*ice-slush*") during CS and they concluded that after 30 days, eight out of 10 patients still had reduced latency time

Table 1. Results of studies on the permanence of pulmonary dysfunctions after hospital discharge of patients who underwent cardiac surgery.

Author/Journal/Year	Title	Objetive	Method	Outcome
Baltieri *et al.* [27] Revista Brasileira de Cardiologia, 2012	Transcutaneous electrical diaphragmatic stimulation in diaphragmatic paralysis after cardiac surgery	Observe the influence of TEDS on diaphragmatic paralysis after MRS	n = 1 Submitted to MRS Pre-operatively assessed by X-ray, 30 physical therapy sessions without TEDS and another 20 physical therapy sessions with TEDS (total = 50 sessions or 10 weeks) of physical therapy in the PO of MRS	30 sessions without TEDS = there was no symptomatic improvement of diaphragmatic dysfunction and the previous image remained on the chest X-ray 20 additional sessions (10 weeks) with TEDS = partial resolution of diaphragmatic paralysis was observed
Rachwalik [25] Clinical and Experimental Medicine Letters, 2008	Spirometric changes after valve surgery	Elucidate the degree of recovery of spirometric values after 6 months of open CS	n = 26 Those who underwent valve surgery Preoperatively assessed, 5 days, 2.5 months, and 6 months of PO	2.5 months = 20% reduction in TV, FEV1, FEF25%, FEF50% FEF75% 6 months = all variables persisted 5% below preoperative values
Westerdahl *et al.* [22] Respiratory Medicine, 2003	Pulmonary function 4 months after coronary artery bypass graft surgery	Describe lung function and pain 4 months after MRS	n = 25 Those who underwent MRS Preoperatively assessed, 4 days and 4 months of PO	4 months = TV, IC, FEV1, FRC, TPC, DLCO, PEF were reduced from 6 to 13% in relation to preoperative values
Berrizbeitia *et al.* [19] Chest, 1998	Effects of sternotomy and coronary bypass surgery on postoperative pulmonary mechanics	To determine the effect of median sternotomy and types of grafts on lung function in the PO of MRS	n = 55 Those who underwent MRS Preoperatively assessed and 6 to 8 weeks of PO	6 to 8 weeks = reduction in FVC, %FVC, FEF 25% - 75%, % FEF 25% - 75%, more evident in patients who used IMA as a graft
Dimopoulou *et al.* [28] Chest, 1998	Phrenic nerve dysfunction after cardiac operations	Electrophysiologically determine risk factors for the development of phrenic nerve dysfunction after CS	n = 63 Those who underwent MRS and valve surgery Preoperatively assessed, 24 hours, 7 days, and 30 days of PO	30 days = 8 out of 10 patients still had a reduction in the latency time of phrenic nerve conduction
Shenkman *et al.* [21] Acta Anaesthesiologica Scandinavica, 1997	The effects of cardiac surgery on early and late pulmonary function	Assess the immediate and late effects of CS on pulmonary function tests	n = 50 Those who underwent MRS or valve surgery Preoperative assessment, 3 weeks and 3.5 months of PO	3 weeks = greater reduction in FEV1, FEF 50%, FEF 75%, FVC, MVV, and PEF 3 months = increased variables but they did not reach preoperative values
Johnson *et al.* [24] Journal of Cardiothoracic and Vascular Anaesthesia, 1996	Respiratory function after cardiac surgery	Relating pulmonary dysfunction to the presence of respiratory symptoms in patients who underwent CS	n = 138 Those who underwent MRS or valve surgery Assessed on admission and 8 weeks of PO	8 weeks = respiratory symptoms (cough, discharge, wheezing, and dyspnoea) are correlated with the presence of atelectasis and with reduced respiratory muscle strength, and spirometric values
Vaidya *et al.* [26] The Journal of Cardiovascular Surgery, 1996	Spirometric changes after open mitral surgery	Assess spirometric values after valve reconstruction surgery	n = 31 Those who underwent valve reconstruction surgery Preoperative assessment and 3 months of PO	3 months = 17 out of 31 patients had low-value spirometry

Continued

Van Belle *et al.* [23] Respiratory Medicine, 1992	Postoperative pulmonary functions abnormalities after coronary artery by-pass surgery	Assess the effects of MRS on lung function after 1 and 6 weeks of PO	n = 34 Those who underwent MRS Preoperatively assessed, 1 week and 6 weeks of PO	6 weeks = significant persistence of reduction in TPC, FEV1, and TV in relation to preoperative values
Efthimiou *et al.* [29] Annals Thoracic Surgery, 1991	Diaphragm paralysis following cardiac surgery: role of phrenic nerve cold injury	Compare the frequency and natural history of diaphragmatic paralysis in patients who underwent CS with or without *"ice/slush"**	n = 100 Those who underwent MRS Group I (n = 50)—with "*ice-slush*"*, Group II (n = 50)—without "*ice-slush*"* Assessed by X-ray, 1 week, 1 month, and every 6 months of PO	1 month = 12 patients in Group I had diaphragmatic paralysis 1 year = 5 patients in Group I had diaphragmatic paralysis
Landymore *et al.* [31] European Journal of Cardio-thoracic Surgery, 1990	Pulmonary complications following myocardial revascularization with de internal mammary artery graft	Determine the incidence and etiology of pulmonary complications after MRS with IMA graft	n = 106 Those who underwent MRS and valve surgery Group I (control)—saphenous graft, Group II—IMA with pleural dissection Group III—IMA without pleural dissection Assessed with 3 months of PO, by X-ray	3 months = 53% of Group II patients had persistent loss of left lung volume related to atelectasis and left pleural effusion
Shapira *et al.* [20] Annals Thoracic Surgery, 1990	Determinants of pulmonary functions in patients undergoing coronary bypass operations	Determine the immediate and late effect of median sternotomy on lung function	n = 29 Those who underwent MRS Preoperatively assessed, at hospital discharge, and 3 months of PO	3 months = some minor reductions were found for IC, TPC, FEV1, FEF 25% - 75%, PEF, FVC, and SVC
Curtis *et al.* [30] The Annals of Thoracic Surgery, 1989	Elevated hemidiaphragm after cardiac operations: incidence, prognosis, and relationship to the use of topical ice slush	Determine the incidence and prognosis of elevated hemidiaphragm in patients who underwent CS with *"ice/slush"**	n = 745 Those who underwent MRS with *"ice-slush"** Preoperatively assessed, 1 month, and 1 year of PO	1 month = 79 out of 99 patients (79.8%) had diaphragmatic elevation 1 year = 14 out of 64 patients (21.9%) had diaphragmatic elevation
Braun *et al.* [18] Chest, 1978	Pre and postoperative pulmonary function abnormalities in coronary artery revascularization surgery	Assess the preoperative pulmonary status and late PO of patients who underwent MRS	n = 19 Those who underwent MRS Preoperatively assessed, 1 to 2 days, 2 weeks and mean 116 days of PO	116 days = reduced VC, TPC, IC, FRC and diffusion capacity

TEDS—transcutaneous electrical diaphragmatic stimulation; CS—cardiac surgery; n—sample; MRS—myocardial revascularization surgery; X-ray—X-ray; PO—postoperative; TV—tidal volume; FEV1—forced expired volume in the 1st second; FEF 25%—forced expiratory flow 25%; FEF 50%—forced expiratory flow 50%; FEF 75%—forced expiratory flow 75%; IC—inspiratory capacity; FRC—functional residual capacity; TPC—total pulmonary capacity; DLCO—diffusing capacity of the lungs for carbon monoxide; MEF—peak of maximum expiratory flow; PO—postoperative; FVC—forced vital capacity; % FVC—percentage of forced vital capacity; FEF 25% - 75%—forced expiratory flow 25% - 75%; % FEF 25% - 75%—percentage of forced expiratory flow 25% - 75%; IMA—internal mammary artery; MVV—maximum voluntary ventilation; VC—vital capacity; IMA—internal mammary artery; SVC—slow vital capacity. * ice-slush—topical myocardial cooling technique used during cardiac surgery.

of phrenic nerve conduction. Efthimiou *et al.* [29] verified 100 patients, divided into two groups: 50 individuals in Group I, with "*ice-slush*" and 50 in Group II, without "*ice-slush*". After one month and one year of PO of CS, 12 and 5 patients in Group I, respectively, had diaphragmatic paralysis. In turn, Curtis *et al.* [30] observed diaphragmatic elevation in 79 patients in the first month and in 14 patients after one year; in both situations, patients were submitted to CS with "*ice-slush*".

Landymore *et al.* [31] related pulmonary dysfunction to the type of graft used in CS, dividing 106 patients into three groups: Group I (control)—saphenous graft; Group II—internal mammary artery graft (IMA) with dissection of the pleura; and Group III—IMA graft without dissection of the pleura. The authors concluded that 53% of Group II patients had loss of left lung volume related to atelectasis and left pleural effusion after three months of CS. When analyzing the work by Johnson *et al.* [24] conducted with 138 patients who underwent MRS and valve surgery, it was possible to notice the presence of atelectasis and reduced respiratory muscle strength correlated with the presence of cough, discharge, wheezing, and dyspnea, after eight weeks of PO.

As for the observation time of pulmonary dysfunctions after CS, a large variation was found between the researchers analyzed. Most investigations have verified these endpoints over a period of three weeks to four months [18]-[28] [31] and only two studies have extended the follow-up time of patients by up to one year [29] [30]. Due to the heterogeneity of the methodological design of the studies in relation to the observation time of the endpoints, it was not possible to establish a comparative analysis to determine which type of pulmonary dysfunction could have persisted longer in the PO of CS.

Regarding the period of publication of the articles, nine selected works (64, 3%) are from the 1990s, with the most recently published article referring to 2012. No data were found in the researched literature that allowed to explain the reason for the accumulation of investigations in the 1990s and the lack of studies on the subject in the last fifteen years.

With regard to the quantity and origin of publications, this study revealed that almost all of the selected articles (92.8%) were produced internationally. Only one case report [27] was found, written in Portuguese, a fact that suggests that there is a shortage of similar publications in Brazil and/or in Portuguese that deal with the permanence of pulmonary dysfunctions after hospital discharge in patients who underwent CS.

This study found that patients who underwent CS develop reduced pulmonary function and that these events may persist beyond hospital discharge. Therefore, it is necessary to assess the importance of continuing respiratory physical therapy protocols started in the hospital phase. Westerdahl *et al.* [22] claim that no method of postoperative therapy has been used to prevent and treat changes in lung function in the long term, and it is also unclear how long after CS breathing exercises should be recommended. Likewise, Forshag and Cooper [32] suggest that an acceptable endpoint for breathing exercises will be

when the patient's lung function returns to preoperative levels or to a stable baseline.

4. Conclusion

The study concluded that pulmonary disorders remained beyond hospital discharge in patients who underwent CS. Such dysfunctions were observed in all selected studies and their duration varied from three weeks to one year of PO of CS. There seems to be a lack of research on the late effects of CS on lung function; there, more studies are needed to elucidate the mechanisms that lead to persistent changes in lung function after discharge from patients who underwent CS.

Collaborators' Participation

The authors developed and organized all parts of the text in conjunction.

Conflicts of Interest

The authors of this work declare that there are no conflicts of interest.

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