



Review Article

Prevention of postoperative pulmonary complications through preoperative physiotherapy interventions in patients undergoing coronary artery bypass graft: literature review

MARINA PERELLÓ-DÍEZ, RPT¹⁾, BERTA PAZ-LOURIDO, PhD^{1)*}

¹⁾ Department of Nursing and Physiotherapy, University of the Balearic Islands: Edifici Beatriu de Pinós, Carretera de Valldemossa Km. 7.5, 07122 Palma, Balearic Islands, Spain

Abstract. [Purpose] The purpose of this review is to identify which preoperative physiotherapy interventions are applied in patients undergoing Coronary Artery Bypass Graft. [Participants and Methods] A literature review was carried out using the databases EBSCOhost, Pubmed, LILACS, IBECS, Cochrane and PEDro. Taking into consideration the inclusion and exclusion criteria, 14 studies published in 2006–2017 about preoperative physiotherapy to Coronary Artery Bypass Graft in adults were selected. [Results] Preoperative physiotherapy included interventions such as inspiratory muscle training, aerobic exercise, education in breathing exercises and counselling. Most of the studies described a combination of these interventions illustrating benefits for patients as decreasing the risk of developing postoperative pulmonary complications, reducing the length of hospitalization as well as time to extubation, anxiety and depression. [Conclusion] Preoperative Physiotherapy in patients undergoing Coronary Artery Bypass Graft includes different interventions, and their effects have been evaluated mainly through a combination of them. These combined interventions, particularly those with an inspiratory muscle training component reduce postoperative pulmonary complications. More studies are needed to identify their impact for patients.

Key words: Preoperative care, Physiotherapy, Coronary artery bypass graft

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INTRODUCTION

The Coronary Artery Disease (CAD) is one of the leading causes of death in developed countries^{1, 2)}, where obesity and the lack of physical activity are among the main factors for its growing impact^{3–5)}. The benefits of Coronary Artery Bypass Graft (CABG) surgery with respect to survival and improved ventricular function is well established^{6, 7)}, but as in many other cardiac interventions, there is a risk for postoperative pulmonary complications (PPC) such as pneumonia, atelectasis, respiratory failure, pneumothorax or bronchospasm^{8, 9)}. Although global mortality caused by these complications has decreased in recent years, these are still heavily related to patient morbidity with results in longer lengths of hospitalization, which impacts on patients, families and increased medical expenses^{10–12)}. In addition to the physical repercussions, literature indicates the presence of psycho-emotional consequences as anxiety¹³⁾. Physiotherapy is considered a therapeutic option both in preoperative and postoperative care¹⁴⁾, and many hospitals have rehabilitation services with physiotherapists specialized to help these patients physically and emotionally, through exercise, education, and support^{15–17)}. Nevertheless, not all patients receive physical therapy in the preoperative stage or this is not prescribed^{15, 18)}. Therefore, the main aim of this study is to identify and introduce the different preoperative physiotherapy procedures prior to CABG surgery described in recent literature.

*Corresponding author. Berta Paz-Lourido (E-mail: bpaz@uib.es)

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PARTICIPANTS AND METHODS

A literature search was conducted from 2006 to 2017 on the databases EBSCOhost, Pubmed, IBECS, LILACS, PEDro and Cochrane, using the following descriptors: *preoperative care, physical therapy modalities, rehabilitation, physiotherapy, breathing exercises, exercise therapy, cardiac surgical procedures and coronary artery bypass graft*. In line with the aims of this review, only studies that included patients older than 18 who required CABG surgery or CABG with valvular surgery, or articles in which the physiotherapeutic procedure took place in the preoperative period were selected. Articles were selected in both Spanish and English. The exclusion criteria were studies with a pediatric population, other types of cardiac surgeries, or articles regarding only postoperative physiotherapy.

RESULTS

By the procedure explained in the method section, 128 studies were obtained. Then, with the application of inclusion and exclusion criteria, 14 articles remained for the discussion (Table 1). The selected studies were 9 randomized controlled trials (including a pilot study), one cohort study, one observational follow-up study, one descriptive case study and two systematic reviews. All studies were subjected to a critical appraisal considering the checklists provided by SIGN (<http://www.sign.ac.uk/checklists-and-notes.html>). Both systematic reviews included in this study^{19, 20} provided relevant information for clinical practice and further studies. Although the procedure used for the studies selection (at least two authors extracted the information independently) and presentation of their outcomes was good, authors did not grade the level of evidence for any of the outcomes from the small clinical trials and the reduced number of studies was also a limitation in the first review¹⁹.

Table 1. Characteristics of selected studies (n=14)

Author and year of publication	Number of participants	Study design	Intervention	Results
Humphrey et al., 2015	1	Descriptive – Case study	Application of general recommendations from previous review studies to a descriptive case analysis	Most of the recommendations were useful for the analyzed case, although is relevant adapting those to individual patient condition. The preoperative care should include of aerobic exercise as well as respiratory exercises such as IMT ^a .
Shakuri et al., 2014	60	Randomized controlled trial	Breathing exercises, education on the use of incentive spirometer, and effective coughing. Includes mobility exercises and muscle strengthening with aerobic exercise at low intensity. Once a day during the 15 days before cardiac surgery.	The preoperative respiratory physiotherapy can have a positive effect on the improvement and quality of respiratory performance, improving the FVC ^b .
Snowdon et al., 2014	2,689	Systematic review	17 studies using education, physical exercise, counselling, IMT ^a and complex interventions (breathing exercises and multidisciplinary intervention).	A preoperative intervention, specially IMT ^a , reduces postoperative pulmonary complications (PPC) and hospital stay in older patients.
Sobrinho et al., 2014	70	Randomized controlled trial	Breathing exercises and Theshold-IMT [®] at an intensity of 40% of the initial MIP ^c , 3 series of 10 repetitions, resting 2 minutes intervals between each series. Once a day during preoperative period.	The pulmonary physiotherapy program restores greater readiness MIP ^c and MEP ^d and decrease length of hospital stay after surgery.
Valkenet et al., 2013	346	Cohort study	IMT ^a for 20 minutes daily, with initial inspiratory load of 30% and an increasing of 5% according to Borg's scale, education in postoperative techniques. Once a day during the two weeks before cardiac surgery.	The IMT ^a can be part of preoperative physiotherapy before CABG, but its effect in preventing pneumonia in high risk patients is not conclusive.
Hulzebos et al., 2012	856	Systematic review	8 studies using breathing exercises, aerobic exercise and IMT ^a .	Preoperative physiotherapy reduces PPC (atelectasis and pneumonia) and length of hospital stay.
Rosenfeldt et al., 2011	117	Randomized controlled trial	Holistic therapy consisting of light physical exercise with a mental stress reduction program.	Taking into consideration the limited effects reported in this study, it is recommended an intervention longer than 2 weeks in the preoperative period.

The trial quality of the selected studies was ranged from good to poor in the other review²⁰⁾ which considered a larger number of studies but with a considerable heterogeneity among them.

With regard to other selected articles, the inclusion of information on the design of the study and data analysis helped to understand the results of the interventions. This was relevant for the purpose of this review, although it differed among to the studies. In one of the studies²¹⁾ it was reported a 95% confidence interval for the results regarding PPC [0.30–0.92] and both groups were comparable at baseline. This was not possible for other studies²²⁾, so there was a difference in the composition of the groups regarding gender in the domiciliary program. The sample size was limited in other the articles²³⁾ although quality of life and psychosocial parameters were included in their intervention assessment. In another study²⁴⁾, participants were stratified for low risk or high risk of developing PPC, while for others, the duration of the intervention was among its limitations²⁵⁾. One of the studies considered only patients with a high risk of postoperative PPC²⁶⁾, and another one was selected because of the application of general recommendations regarding preoperative physiotherapy to a concrete descriptive case²⁷⁾. Among the trials, one study²⁸⁾ was conducted according to the principles of CONSORT statement 2001. Other studies stand out because the outcomes were clearly described³⁰⁾, stated the clinical relevance of the study in terms of Relative and Absolute Risk Reduction³¹⁾ and all data entry and analysis were blind to group allocation³²⁾.

DISCUSSION

Findings in this review show that preoperative physiotherapy is used to reduce PPC after CABG¹⁹⁾. Most of the research studies refer to the effect of combined interventions described in the selected articles; such as inspiratory muscle training (IMT), aerobic exercise, education in general issues regarding the surgical process or breathing exercises and counselling. These interventions are all aimed to prevent different PPC, although their focuses and mechanisms of action differ²⁰⁾.

Table 1. Continued.

Author and year of publication	Number of participants	Study design	Intervention	Results
Savci et al., 2011	43	Randomized controlled trial	Threshold-IMT® for 30 minutes loaded at 30%, increasing between 15% and 45% based on patient's tolerance. Twice per day for 10 days (5 in preoperative period and 5 in postoperative period).	IMT ^a accelerates recovery of inspiratory muscle strength, functional capacity and increases quality of life and psychosocial status after CABG.
Ferreira et al., 2009	30	Randomized controlled trial	Threshold-IMT® loaded at 40% of MIP. 5 sets of 10 deep breathings during 1 minute, 3 times per day. Intervention for 2 weeks before surgery.	This program was safe for patients and improved FVC ^b and the maximum voluntary ventilation, although the clinical benefits were not demonstrable.
Furze et al., 2009	204	Randomized controlled trial	Information about cardiac myths and misconceptions, what to expect during the hospital stay and subsequent recovery period. Includes relaxation exercises and encouraging strategies to increase physical activity.	This combined program is useful for secondary prevention, and more effective to reduce depression and improve physical functioning than only counselling.
Garbossa et al., 2009	57	Randomized controlled trial	Education in ventilatory exercises (with pamphlets), general advices and instructions about the surgery procedure. Intervention 24 hours before surgery.	This intervention reduced anxiety levels, particularly in the preoperative period.
Yáñez-Brage et al., 2009	263	Observational follow-up study	Education in respiratory techniques to be developed in the postoperative period (in incentive spirometry, deep breathing exercises, assisted coughing).	Preoperative physiotherapy was effective to prevent atelectasis, reducing the risk of atelectasis by 52% when compared to those patients who did not receive it (Relative Risk Reduction of 52%).
Hulzebos et al., 2006	279	Randomized controlled trial	Threshold-IMT® loaded at 30% every day during, at least, 2 weeks and education in respiratory exercises. Intervention in patients at high risk.	IMT ^a improved strength and endurance of respiratory muscles and reduced the incidence of PPC, the length of hospital stays and morbidity.
Hulzebos et al., 2006	26	Randomized controlled pilot study	Threshold-IMT® loaded at 30% every day during, at least 2 weeks. Intervention in patients at high risk.	It was a feasible, safe and well tolerated program by the patients and reduced the incidence of atelectasis.

^aIMT: inspiratory muscle training; ^bFVC: forced vital capacity; ^cMIP: maximal inspiratory pressure; ^dMEP: maximal expiratory pressure.

Inspiratory muscle training (IMT): IMT is a procedure used to increase the inspiratory muscle strength developed with a Threshold[®], through offering resistance to inspiration^{21–26}. The training is done with a % loaded according to the maximum inspiratory pressure (MIP) of the patient varying between 30–40%^{21, 22, 24–26} or 15%²³. Studies using IMT reported strength and endurance improvement of the inspiratory muscles and an increase in patient resistance to the side effects of surgery, better quality of sleep and psychosocial conditions and a decrease of PPC (atelectasis and pneumonia due to the decreased time to extubation^{19–22, 26}). It was also observed that a shorter length of mechanical ventilation decreases the length of hospitalization and the risk of death in older patients²⁰. Furthermore, an improvement in pulmonary function^{21, 23, 25} and an increase in functional capacity (FC)²³ were noted.

Aerobic exercise: Participation in aerobic exercise (AE) in preoperative physiotherapy was found to be useful for improving quality of life and to reduce the length of hospitalization^{19, 27}. The application guide described in these studies suggests four times per week, from 2 to 8 weeks at 40–70% of the FC of the patient. Other studies combined methods consisting of AE and relaxation techniques²⁸ at 40–60% of MHB (Maximum heart beat) for two weeks. Nevertheless, authors suggest the need for a longer application time in the preoperative period and continuing in the postoperative period for at least 6 weeks. This was also found in other studies²⁰, since the AE has been shown to increase physical fitness, but there is still a need for specific studies related to PPC.

Education intervention: Education on the preoperative physiotherapy consisted of providing knowledge of respiratory techniques, the sternotomy process, the difficulty of coughing due to pain and anesthesia, the intensity and distribution of the pain, as well as the importance of early mobilization, all done 24 hours before the surgery²⁹. Outcomes from this study, refer to effects in the reduction of anxiety in this period which is itself of capital importance since the most anxious patients suffered more pain and a longer duration of hospitalization. Regarding the timing of training on respiratory techniques, other studies outline two different options: it may be carried out 15 days before the operation (15 sessions)³⁰ or the same day of hospital admittance³¹. In both studies, the respiratory exercises consisted in a set of 10 repetitions of deep and diaphragmatic breaths^{30, 31} with puckered lips (pursed lip breathing)³⁰, pulmonary expansion with three tactile stimulation levels³¹ and instructions for training in use of the Respiflow^{®30, 31} (slowly with a passive expiration, 5 series of deep inspirations with 30–60 seconds of rest in between)³¹. Furthermore, techniques of assisted coughing^{30, 31}, how to sit and turn in the bed, early mobilization exercises, and the adherence to the treatment were explained. Among the effects of regarding PPC, a positive effect was reported on the respiratory efficiency with an increase of the FVC (Forced Vital Capacity), as well as an increase in walking distance³⁰ and a decrease in the atelectasis incidence³¹.

Counselling: It was described as general information regarding the surgical procedures including telephonic supervision, but without any specific training accompanied by a physiotherapist^{20, 32}. This intervention seems to be relevant for decreasing anxiety and depression, avoiding negative preconcepts, and increasing physical activity and mobility.

In conclusion, preoperative physiotherapy in patients undergoing CABG includes different interventions such as IMT, respiratory exercises, aerobic exercise, education and counselling. The IMT interventions are addressed to improve oxygen saturation, gas exchange and to reduce postoperative complications while psycho-emotional strategies based on education and counselling seem to contribute to a reduction in preoperative anxiety and depression. Less studies refer to the effects of aerobic exercises. Since many preoperative physiotherapy programs are based on combined interventions, further research is needed to identify the benefits of the different interventions including a detailed description of the process. This will allow transferability to clinical practice with benefits for patients and families and will help to avoid additional medical expenses.

Conflict of interest

The authors report no conflicts of interest.

REFERENCES

- 1) Heron M: Deaths: leading causes for 2014. Natl Vital Stat Rep, 2016, 65: 1–96. [Medline]
- 2) Benjamin EJ, Blaha MJ, Chiuve SE, et al. American Heart Association Statistics Committee and Stroke Statistics Subcommittee: Heart disease and stroke statistics-2017 update: a report from the American Heart Association. Circulation, 2017, 135: e146–e603. [Medline] [CrossRef]
- 3) Logstrup S, O’Kelly S: European cardiovascular disease statistics: 2012 edition. Brussels, Belgium: European Heart Network 2012.
- 4) Ferreira-González I: The epidemiology of coronary heart disease. Rev Esp Cardiol (Engl Ed), 2014, 67: 139–144. [Medline]
- 5) O’Donnell CJ, Elosua R: [Cardiovascular risk factors. Insights from Framingham Heart Study]. Rev Esp Cardiol, 2008, 61: 299–310 (In Spanish). [Medline] [CrossRef]
- 6) Wijns W, Kolh P, Danchin N, et al. Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) European Association for Percutaneous Cardiovascular Interventions (EAPCI): Guidelines on myocardial revascularization. Eur Heart J, 2010, 31: 2501–2555. [Medline] [CrossRef]
- 7) Taggart DP, Thomas B: Thomas B. Ferguson Lecture. Coronary artery bypass grafting is still the best treatment for multivessel and left main disease, but patients need to know. Ann Thorac Surg, 2006, 82: 1966–1975. [Medline] [CrossRef]
- 8) Magnusson L, Spahn DR: New concepts of atelectasis during general anaesthesia. Br J Anaesth, 2003, 91: 61–72. [Medline] [CrossRef]
- 9) Schuller D, Morrow LE: Pulmonary complications after coronary revascularization. Curr Opin Cardiol, 2000, 15: 309–315. [Medline] [CrossRef]
- 10) Sharafkhaneh A, Falk JA, Minai OA, et al.: Overview of the perioperative management of lung volume reduction surgery patients. Proc Am Thorac Soc, 2008,

5: 438–441. [Medline] [CrossRef]

- 11) Weissman C: Pulmonary complications after cardiac surgery. *Semin Cardiothorac Vasc Anesth*, 2004, 8: 185–211. [Medline] [CrossRef]
- 12) Osinaike BB, Okikiolu B, Olusesin O: Prolonged intensive care unit stay after coronary artery bypass graft surgery: role of perioperative factors. *Niger Postgrad Med J*, 2015, 22: 213–216. [Medline] [CrossRef]
- 13) Ramos MI, Cardoso MJ, Vaz F, et al.: [Influence of the grade of anxiety and level of cortisol on post-surgical recovery]. *Actas Esp Psiquiatr*, 2008, 36: 133–137 (In Spanish). [Medline]
- 14) Mampuya WM: Cardiac rehabilitation past, present and future: an overview. *Cardiovasc Diagn Ther*, 2012, 2: 38–49. [Medline]
- 15) Fidan D, Unal B, Critchley J, et al.: Economic analysis of treatments reducing coronary heart disease mortality in England and Wales, 2000–2010. *QJM*, 2007, 100: 277–289. [Medline] [CrossRef]
- 16) Achttien RJ, Staal JB, van der Voort S, et al. Practice Recommendations Development Group: Exercise-based cardiac rehabilitation in patients with coronary heart disease: a practice guideline. *Neth Heart J*, 2013, 21: 429–438. [Medline] [CrossRef]
- 17) Spruit MA, Singh SJ, Garvey C, et al. ATS/ERS Task Force on Pulmonary Rehabilitation: An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med*, 2013, 188: e13–e64. [Medline] [CrossRef]
- 18) Reeve J, Denehy L, Stiller K: The physiotherapy management of patients undergoing thoracic surgery: a survey of current practice in Australia and New Zealand. *Physiother Res Int*, 2007, 12: 59–71. [Medline] [CrossRef]
- 19) Hulzebos EH, Smit Y, Helders PP, et al.: Preoperative physical therapy for elective cardiac surgery patients. *Cochrane Database Syst Rev*, 2012, 11: CD010118. [Medline]
- 20) Snowdon D, Haines TP, Skinner EH: Preoperative intervention reduces postoperative pulmonary complications but not length of stay in cardiac surgical patients: a systematic review. *J Physiother*, 2014, 60: 66–77. [Medline] [CrossRef]
- 21) Hulzebos EH, Helders PJ, Favié NJ, et al.: Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. *JAMA*, 2006, 296: 1851–1857. [Medline] [CrossRef]
- 22) Ferreira PE, Rodrigues AJ, Évora PR: Effects of an inspiratory muscle rehabilitation program in the postoperative period of cardiac surgery. *Arq Bras Cardiol*, 2009, 92: 275–282. [Medline]
- 23) Savci S, Degirmenci B, Saglam M, et al.: Short-term effects of inspiratory muscle training in coronary artery bypass graft surgery: a randomized controlled trial. *Scand Cardiovasc J*, 2011, 45: 286–293. [Medline] [CrossRef]
- 24) Valkenet K, de Heer F, Backx FJ, et al.: Effect of inspiratory muscle training before cardiac surgery in routine care. *Phys Ther*, 2013, 93: 611–619. [Medline] [CrossRef]
- 25) Sobrinho MT, Guirado GN, Silva MA: Preoperative therapy restores ventilatory parameters and reduces length of stay in patients undergoing myocardial revascularization. *Rev Bras Cir Cardiovasc*, 2014, 29: 221–228. [Medline]
- 26) Hulzebos EH, van Meeteren NL, van den Buijs BJ, et al.: Feasibility of preoperative inspiratory muscle training in patients undergoing coronary artery bypass surgery with a high risk of postoperative pulmonary complications: a randomized controlled pilot study. *Clin Rehabil*, 2006, 20: 949–959. [Medline] [CrossRef]
- 27) Humphrey R, Malone D: Effectiveness of preoperative physical therapy for elective cardiac surgery. *Phys Ther*, 2015, 95: 160–166. [Medline] [CrossRef]
- 28) Rosenfeldt F, Braun L, Spitzer O, et al.: Physical conditioning and mental stress reduction—a randomised trial in patients undergoing cardiac surgery. *BMC Complement Altern Med*, 2011, 11: 20. [Medline] [CrossRef]
- 29) Garbossa A, Maldaner E, Mortari DM, et al.: Effects of physiotherapeutic instructions on anxiety of CABG patients. *Rev Bras Cir Cardiovasc*, 2009, 24: 359–366. [Medline] [CrossRef]
- 30) Shakuri SK, Salekzamani Y, Taghizadieh A, et al.: Pulmonary physiotherapy effect on patients undergoing open cardiac surgery. *Russian Open Medical Journal*, 2014, 3(3). [CrossRef]
- 31) Yáñez-Brage I, Pita-Fernández S, Juffé-Stein A, et al.: Respiratory physiotherapy and incidence of pulmonary complications in off-pump coronary artery bypass graft surgery: an observational follow-up study. *BMC Pulm Med*, 2009, 9: 36. [Medline] [CrossRef]
- 32) Furze G, Dumville JC, Miles JN, et al.: “Prehabilitation” prior to CABG surgery improves physical functioning and depression. *Int J Cardiol*, 2009, 132: 51–58. [Medline] [CrossRef]